Rice grain yield - a comparison between direct seeding and transplanting in Lao PDR

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Abstract
Direct seeding is increasingly replacing the traditional method of transplanting within dry-season irrigated rice production in the People's Democratic Republic of Lao (Lao PDR). This change has been driven by increasing labour shortages, as members of the family farming unit move to off-farm employment in the larger provincial centres, and through subsequent increases in the labour cost for transplanting. One of the disadvantages of direct seeding compared to transplanting is a perceived reduction in grain yield. Seventy-six farmers from three districts in the central province of Savannakhet that had transplanted and direct seeded rice within the one farm in the same season were surveyed. The survey was part of the development of a cropcheck database that was conducted over three years, to identify key practices influencing grain yield. The results highlighted that there was a significant difference in the amount of fertiliser applied between the two sowing methods in one district. However, there was no significant difference in the grain yield between the sowing methods with an overall average of 3407 kg/ha for the broadcast direct seeded crops and 3550 kg/ha for the transplanted crops. It is of note that within districts, farmers that produced high grain yields from transplanting were often the farmers that produced a high yield from direct seeding.

Key Words
Sowing method, Fertiliser application, Weed management, Lao PDR

Introduction
Transplanting is the most popular method of lowland rice establishment in irrigated areas (Akkas Ali et al 2006). However, transplanting is time consuming because it involves the establishment of a seedling nursery area before preparing the rest of the field and planting the seedlings in the field at an appropriate time. Sipaseuth (pers comm 2011) identified three key drivers contributing to increased adoption of direct seeding over transplanting. Firstly, there is an approximate 80-90% saving in time taken to sow the crop. Secondly, there is an increasing shortage of labour in rural areas to carry out transplanting and finally, there is an increasing cost of hiring labour for farm operations.

As part of an Australian Centre for International Agricultural Research (ACIAR) project farmers in three districts, Champone, Songkhon and Xaybuli of the central Lao PDR province of Savannakhet were surveyed over three consecutive dry-seasons commencing in 2008/09. The survey for comparison of direct seeding and transplanting was conducted as part of an investigation to determine if the cropcheck extension methodology, of benchmarking crop practices against high yielding crops, could be used to assist rice farmers in the adoption and management of new direct seeding technology.

During the 2009/10 dry season farmers in the selected villages changed from direct seeding back to transplanting as a means of controlling weeds. Farmers consider it much easier to control weeds in the transplanted system where plants are spaced at 20cm x 20cm apart compared with the high density plant populations used in direct seeding, especially broadcasting. Subsequently the project decided in 2010/11 to survey farmers who had transplanted and used some form of direct seeding within the same farm to gain further understanding of the differences between the two rice cultivation systems.

Methods
District selection
Three districts were chosen for the survey in the central province of Savannakhet based on differences in grain yield and also experience with broadcast direct seeding technology. Champhone is an area that has some soil salinity issues which is considered by farmers as one of the main limitations to rice grain yield. Consequently fertilizer inputs are reduced because of lower yield expectations. Direct seeding is a relatively new technology to the area with a farmer average 4 years of experience with the technology. Songkhon was outside of the original project area however was included because of farmer experience with direct seeding (average 7 years). Songkhon is also different to the other district because it receives frequent (annually in many areas of the district) and widespread flooding in the wet season resulting in no wet-season cropping.

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Xaybuli is the area with the least experience with direct seeding (average 2 years) and has the highest levels of soil fertility between the districts. Xaybuli also has the greatest level of agricultural diversification of the three districts.

The three districts are irrigated in the dry season with gravity-fed water from a local reservoir in Champhone and irrigation water pumped from local rivers in Songkhon and Xaybuli. Within each of the districts the irrigation water is delivered on rotation with a 7-10 day period between delivery cycles. In some areas this results in periods when paddies have no water on them depending on soil type and position within the toposequence. The period of ponded and non-ponded water between irrigation water cycles has implications for weed management and nutrient availability. The use of pumps in Songkhon and Xaybuli sometimes has implications for sowing date because of late floods delaying the re-installation of pumping equipment.

The direct seeded crops surveyed used the broadcast method. In these areas seed was pre-germinated by soaking it for 24-36 hours and draining it for 24-36 hours, to start the germination process, before being broadcast by hand into the field.

Data collection

In the 2010/11 dry season rice farmers, 25 in each of two villages and 26 in a third village in the Champhone, Songkhon and Xaybuli districts of Savannakhet Province in Lao PDR, were surveyed. The aim of the survey was to identify grain yield and management differences between the transplanted and direct seeded (broadcast) rice crops which had been sown on the same farm.

The survey had been developed in the preceding two dry seasons with input from growers and researchers following each season. The survey detailed factors that were considered important in maximising grain yield such as: ground preparation practices, variety, sowing time, sowing rate, field position in the toposequence, fertiliser application rate, number of fertiliser applications and timing of the applications, weed control method and number of control operations, problems with pest and diseases, harvesting date and threshing date. A weed assessment was done by Australian project staff using a scale of 1 to 9 where 1 was no weeds only rice and 9 was no rice only weeds present.

District Agriculture and Forestry Office staff and project personnel assisted farmers to complete the information on management practices and resource inputs. This was done on a one-on-one basis with staff visiting the villages up to 3 times throughout the season.

Grain yield was determined from the whole paddy area of each sowing method that had been included in the survey.

Data Analysis

A two-way analysis of variance, examining the effect of district and sowing method, was conducted using GenStat 14th Edition. Farmers within a district were considered replicates.

Results

Summary of the survey results

The variety TDK8 was the most common variety used in both systems with 43% of direct seeded crops and 41% of transplanted crops. The other varieties used, in order of decreasing occurrence, were TDK1, TSN3, TDK11, TDK4 and Kokhor10 (transplanting only). Farmers tended to use the same variety in both sowing methods with only 10.5% of fields having a different variety between the two sowing methods.

The sowing date of the direct seeded plants and nursery of the transplanted crops was the same with an average sowing date of 15 December. However, on average the start of transplanting occurred on 12 January (27 days after sowing) which involves removing the plants from the nursery and placing them into the fields for the remainder of the season. At this time roots and leaves are trimmed for ease of handling. Between all districts the duration of transplanting was 13 days (average).

The weed assessment was conducted between 61 and 95 days after sowing of the surveyed crops, which was after the weed control operations (hand weeding) were completed. The result showed that within the scoring system there was a significant ($p<0.05$) difference in the presence of weeds with the direct seeding having more weeds than the transplanted crops, scores of 3.80 and 2.57 respectively. There was also a significant ($p<0.05$) difference between the districts with Champhone having the lowest level of weeds (score of 2.33). Songkhon and Xaybuli were significantly higher than Champhone but not different from each other with scores of 3.58 and 3.69 respectively. Herbicides are generally not used in the production systems in Lao PDR.

Harvest of the crops occurred within 1 day between the two sowing methods with an average harvest date of 1 May for direct seeding and 2 May for transplanted. It is not known whether this is a true reflection that

there is no difference in maturity despite the different establishment or simply that all areas were harvested in the one operation.

Fertiliser application

Between the districts there were significant differences in the amount of fertiliser applied. Champhone had the lowest fertiliser application rate and Xaybuli had the highest with 109 kg/ha and 386 kg/ha respectively. There was no significant difference in the fertiliser application rate between the two sowing methods in Champhone and Xaybuli where the average fertiliser rate applied varied by only 11.9 kg/ha and 4.4 kg/ha respectively (Table 1). However, in Songkhon an average rate of 278.3 kg/ha was applied to the direct seeded crops compared with 147.0 kg/ha applied to the transplanted crops. The difference in fertiliser application rate in Songkhon was significant.

Table 1: Fertiliser application and irrigated grain yield of direct seeded and transplanted rice and their average from the 2010/11 dry season in three districts of the Savannakhet province of Lao PDR.

District	Fertiliser application rate (kg/ha)			Grain yield (kg/ha)		
	Direct seeding	Transplanting	Average	Direct seeding	Transplanting	Average
Champhone	103.5 ± 18.8	115.4 ± 18.8	109.5	2469 ±244.0	2697 ±244.0	2583
Songkhon	278.4 ± 18.4	147.0 ± 18.4	212.7	3922 ±239.1	3881 ±239.1	3901
Xaybuli	388.3 ± 19.2	383.9 ± 19.2	386.1	3830 ±249.2	4074 ±249.2	3952
Average	255.2	212.1	233.7	3407	3550	3479
LSD(5%) m	30.3*			ns		
LSD(5%) d			37.5*			488*
LSD(5%) mxd			53.7*			ns

Note: m, sowing method; d, district; mxd, sowing method by district interaction

Within the information collected it is not possible to determine specific nutrient application rates because farmers often use a mix of products, however it does also show a change in fertiliser types between the two sowing methods. In the direct seeded method 46% of farmers used a fertiliser mix consisting of urea and 16N-20P (high analysis), 39.6% used urea only (although most of these were in Xaybuli district) and 14.4% only used the high analysis. In transplanted crops 48.7% used the urea and high analysis mix, 25% high analysis only, 13.2% urea, 11.8% organic fertiliser and 1.3% a product known as 15-15-15.

Grain yield

The grain yield of Champhone district (2583 kg/ha) was significantly lower than both Songkhon and Xaybuli (3901 kg/ha and 3952 kg/ha respectively) which were not significantly different to each other (Table 1).

Despite the yield potential differences between the districts there was no significant difference in grain yield between the direct seeding and transplanting sowing methods (Table 1). In Champhone and Xaybuli the transplanted crops had grain yields 228 kg/ha and 244 kg/ha higher than the direct seeded crops, respectively. In Songkhon the direct seeded method had a grain yield 42 kg/ha higher than the transplanted crops.

In each of the districts there was an overall trend of farmers that produced high grain yields with one sowing method also produced high grain yield with the other sowing method. In Songkhon and Xaybuli this correlation in grain yield between the two sowing methods was significant with r values of 0.74** and 0.55** respectively. The correlation was not significant in Champhone.

Discussion

The results from the grower surveys conducted as part of this project showed no difference in grain yield between the broadcast direct seeding method and the traditional transplanting method in irrigated dry-season rice production. This is consistent with other results such as Mitchell et al (2004) and Naklang et al (1996) although their results were in rainfed rather than irrigated rice. Sipaseuth et al (2002) identified the major limitations of plant establishment under direct seeded rice, particularly for the rainfed crop in the wet season, as inadequate moisture at seeding, having high levels of standing water at seeding and excess moisture at seeding in low lying and poorly draining areas. In the irrigated dry-season the ability to control water reduces the risk associated with plant establishment in the direct seeded system.

In the survey area crops were grown with good management practices. A sowing date of mid-December represents a time that offers farmers an opportunity for achieving high district grain yield. Transplanting seedlings at age of 27 days after sowing provides good quality seedlings to handle the transplanting shock.

The weed scores after hand weeding was completed show rice is dominant within the fields. The higher number of weeds in the direct seeded crops is consistent with the reason why farmers had changed back to transplanting, for the ease of weed control. Smith et al (2011) show that there is a need to keep direct seeded crops weed free for up to 100 days after sowing using 2 hand weeding operations. New direct seeding technology, such as row-seeding using drum seeders, will allow better weed control in the direct seeded crops.

Fertiliser application increased as yield expectations of the farmers within the districts increased. In Songkhon farmers applied 89% more fertiliser in the direct seeded crop because they believed fertiliser uptake by young seedlings in the main paddy was poor. A participatory fertiliser trial in the district may assist farmers improving their fertiliser management. The weed score also increased in the same manner as fertiliser application suggesting that the more fertile soil conditions also favoured weed growth as well as rice growth and grain yield. Fertiliser application is also limited by farm profitability with many farmers simply unable to afford to purchase fertiliser or good quality fertiliser at least, an issue that was raised during discussion group meetings with the farmers.

The correlation between high yields in one system and high yields in the other suggests differences in farm management skills regardless of the sowing method; differences in levels of inputs; or highlights underlying yield potential differences due to soil fertility changes within the districts. With the limited change in varieties between the two sowing methods it also supports the finding of Fukai et al (2004) and Sipaseuth et al (2002) that plant type is suitable for both sowing methods with good management. Although Hayashi et al (2007) found that differences in plant type were needed between the different sowing methods.

Conclusion

The grain yield information from farmer fields where broadcast direct seeding and transplanting had been conducted on the same farm shows that in the 2010/11 dry season there was no significant difference in grain yield between the two sowing methods. However, there needs to be comprehensive economic analysis conducted to determine if one sowing methods offers an economic advantage over the other due to differing production costs, such as labour and fertiliser costs.

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