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# RESULTS OF DISSEMINATING THE SYSTEM OF RICE INTENSIFICATION WITH FARMER FIELD SCHOOL METHODS IN NORTHERN MYANMAR

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SUMMARY

This four-year evaluation of the introduction of the System of Rice Intensification (SRI) in northern Myanmar through Farmer Field School (FFS) methods found that these agronomic and pedagogical strategies gave positive results in a complementary way, although their individual contributions to the documented improvement in rice productivity could not be partitioned. The rice production of 612 farmers who had participated in 30 FFSs was tracked, along with that of farmers in the same communities who learned through farmer-to-farmer interaction. Average SRI yields on FFS study-fields in the wet season, without any supplementary irrigation, were 6.4 t ha$^{-1}$ compared with farmers' prior average yields of 2.1 t ha$^{-1}$. Three years after one third of the farmers in a community had received FFS training, almost all of its farmers were using SRI methods. This study confirmed many previously reported benefits from SRI practices, particularly important for limited-resource households.

## INTRODUCTION

Few evaluations of the System of Rice Intensification (SRI) have been done on a large scale and over a number of years because SRI is a relatively recent innovation(Laulanié, 1993; Stoop *et al.*, 2002). This article presents the results of a four-year evaluation of SRI in northern Myanmar. Beginning in 2001, SRI methods (http://ciifad.cornell.edu/sri/) were introduced into more than 200 upland communities throughout Kachin and Shan States by a local non-governmental organization (NGO), the Metta Foundation (www.metta-myanmar.org). Working together with local church and other organizations, Metta used farmer field school (FFS) methods (www.fao.org/docrep/006/ad487e/ad487e02.htm) to introduce several agricultural innovations. Because irrigation facilities are unavailable in the region, farmers practiced a rainfed form of SRI, which was originally developed for irrigated rice production.

From 2001 to 2003, Metta conducted 258 FFSs in the two states and trained more than 5000 rice-growing farmers, both men and women, offering SRI as the lead innovation. With on-going FFS training and further dissemination by FFS graduates in their own and neighbouring communities, the number of farmers using SRI reached over 20 000 by the start of 2005. That number has continued to increase through on-going FFS training and farmer-to-farmer interaction, reaching ∼29 000 by the end of 2006.

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Recent controversy over whether SRI methods can surpass best management practices (McDonald *et al.*, 2006) has diverted attention from the original objective of this innovation developed in Madagascar (Laulanié, 1993). Its purpose was to enable resource-limited rice-growing farmers to raise their production and incomes without relying on purchased external inputs, which they have difficulty buying. This will remain an important challenge for as long as poverty and hunger persist in the world, especially because the costs of petroleum-based energy, fertilizer and agrochemicals are more likely to rise in the future than to return to earlier low levels (Uphoff, 2003).

This article focuses on what benefits resource-limited households can obtain from SRI methods, especially when introduced through a methodology (FFS) that promotes farmer experimentation and ongoing innovation to make best use of available local resources. Such households have benefited little to date from Green Revolution technologies and lack the physical and financial access to markets needed for acquiring new seeds and inputs and for engaging profitably in market transactions. While physical and economic conditions in northern Myanmar may be more constraining than those that confront many of the world's rice farmers, they are representative of the constraints that face hundreds of millions of poor rural households.

The comparison here is not with what may be considered 'best management practices' (McDonald *et al.*, 2006). Such practices are heavily input-dependent and not accessible to most small and poor farmers. Doberman (2004) and Sheehy *et al.* (2004) doubted whether SRI could improve significantly upon such farmers' current rice production and income, and Moser and Barrett (2003) considered it unlikely that SRI could be adopted widely. These conclusions had neither large nor longitudinal data bases, however. The evaluation presented here, on the other hand, is based upon extensive and multi-year data gathering (Kabir, 2006).

## MATERIALS AND METHODS

### *The System of Rice Intensification*

SRI raises productivity not by relying on external inputs, e.g. new seeds and fertilizer, but by changing the way farmers manage their rice plants, soil, water and nutrients (Uphoff, 2007). SRI's alternative practices elicit more productive phenotypes from available rice genotypes, whether local landraces or improved varieties. While chemical fertilizers do enhance rice yields when used with other SRI practices, adding to the soil decomposed biomass and/or manure to the extent available can give even better results. Agrochemical sprays are seldom needed or are not cost-effective because SRI rice plants are usually resistant to damage by pests and diseases. They also resist abiotic stresses such as lodging and drought because of their well-developed root systems. Also, reduction in water requirements is a particular benefit of SRI (Satyanarayana *et al.*, 2007), although this is not relevant for rainfed SRI as in this case.

The basic SRI practices, always to be adjusted to local conditions, are:

- Transplanting young seedlings, 8–12 days or at least less than 15 days old, i.e. before the start of their fourth phyllochron (Stoop *et al.*, 2002).

- Planting seedlings singly, one per hill, and widely spaced, in a square pattern, with careful handling and shallow placement. These two practices together contribute to the growth of larger and deeper/taller root systems and canopies.
- No continuous flooding of rice paddies, keeping the soil moist but not saturated. In northern Myanmar, where irrigation facilities are lacking, farmers need to be persuaded not to keep their rice fields flooded in the conventional style during the rains, but just to maintain an optimal level of moisture that keeps soil relatively aerated. This encourages deeper root growth that enables the plants to withstand later water stress.
- When rice paddies are not kept flooded, weeds become more of a problem. Use of a simple mechanical hand weeder is recommended because this aerates the soil while it removes weeds. If such weeders are not available, other means of weed control can be used. So far, few farmers in Myanmar have been able to use these weeders, so their SRI yields could probably be raised further with this soil-aerating practice.
- Application of as much organic matter to the soil as is available. While fertilizer is beneficial when applied with the other SRI practices, best SRI results have been achieved with organic fertilization.

These changes lead to rice plants having larger and better-functioning root systems; the differences in size and colour are clearly visible. Differences in root growth can be quantified by measuring root-pulling resistance (RPR; Ekanayake *et al.*, 1986). Rice grown with SRI methods has RPR 4–10 times greater per plant (Barison, 2002).

Changes in the soil micro flora and fauna are induced by having soil that is more aerobic and has more organic matter. This is less easily quantified, but a comparison of microbial populations in rice rhizospheres done for Tamil Nadu Agricultural University found SRI plant rhizospheres to have 20 % more total bacteria, almost four times more azospirillum, and almost twice as many azotobacter and phosphobacteria (Gayatri, 2002). Such organisms fix N and solubilize P along with producing other benefits for plant health and productivity (Doebbelaere *et al.*, 2003).

*Farmer Field Schools*

Starting in the 1980s, an innovative methodology for promoting, improving and disseminating integrated pest management (IPM) practices was developed in Indonesia (Matteson *et al.*, 1994; Oka, 1997). Known as the Farmer Field School, this system has been introduced in most countries of Asia and in a number of African and Latin American countries with FAO support. Rather than using typical didactic methods of teaching, FFS methods emphasize hands-on learning in small groups of farmers. A FFS typically enrolls 20–25 farmers, divided into sub-groups. They meet regularly during a crop season, critically observing and evaluating the crop throughout its entire cycle.

In an organized but informal setting, farmers conduct their own experiments, debate different explanations for their observations and results, practice communicating their conclusions and develop improved practices that suit their own local conditions. Graduates from FFSs understand what they have learned more acutely than if taught the same information in a more passive mode. Usually they are motivated to share their new knowledge with other farmers, so that there is a multiplier effect from the training. In Indonesia, where >1 million rice-growing farmers have been trained in IPM methods, FFS alumni set up their own FFSs in turn to spread their learning more widely (van den Berg, 2003; van de Fliert, 2006).

The FFS approach is well-suited for SRI dissemination because SRI is not seen as a technology to be 'transferred' to farmers; rather it is presented instead as a set of insights, principles and practices to be adapted to farmers' own situations. FFS programmes in Indonesia, Cambodia, the Philippines and Vietnam have already begun to incorporate SRI into their training for rice-based farming systems based on positive field results. Although one can speak of SRI *adoption*, in reality there is usually a process of *adaptation* based on farmers' own evaluations which leads to significant changes in the ways that they grow rice.

There are still some objections that SRI has not been demonstrated and tested sufficiently under controlled conditions, and we accept that much more work can and should be done to establish a fully-satisfactory scientific basis for the practices and for the results reported. It is paradoxical, however, that scientists often get lower yields with SRI methods in on-station trials than farmers are obtaining with the same methods on their own fields, reversing the usual situation (Neupane, 2003; Rickman, 2003). Here we present on-farm evaluations of SRI, considering these most realistic.

*Study area*

Kachin State is the northernmost state of Myanmar, bordered by Shan State to the south, by China to the north and east, and by India to the west. The climate in the region ranges from tropical to subtropical, with average daily maximum air temperatures varying from 16 °C in winter to 35 °C in the summer dry season. The rainy season begins in June/July and lasts up to four months, with average rainfall from 125 to 375 mm month$^{-1}$ and with most rain falling in July/August. Given this distribution of rainfall and lack of irrigation facilities, rice is cultivated mostly during a single season and under rainfed conditions.

Rice is grown mostly in flat valleys with elevations 150–1000 m asl. Few soil analyses and evaluations have been done in this part of Myanmar. Soils in most of the plains are sandy loam or clay loam in texture, with quality varying across the region but not very much. Soil pH is in the range 6.5 to 7, with 6 in a few locations where the soil colour is red. Most of the state's soils are generally deficient in available P, and K content is less than usually desired. There is little history of farmers using chemical fertilizer in their rice paddies except in areas bordering China.

Traditional Kachin society was based on shifting cultivation; however, growing lowland rice has played a major role in local residents' lives for many generations, being their primary source of food security as well as income. Living standards remain low, constrained by the poor rice yields reported below. Lowland rice production is currently not much more than a break-even operation (Table 3), and large numbers of rural households are in food-deficit for 2–3 months a year, having to struggle to find ways to feed themselves. The usual rice cultivation practices in Kachin are mostly antithetical to SRI concepts and recommendations. Farmers start with seedlings 50–60 days old, planting them densely and often several days after uprooting from seedbeds. Few nutrients are applied to the soil, which remains flooded most of the time when there is heavy rain. Weeding is not a frequent practice. Clearly there is much scope for improvement, but thus far, efforts to introduce 'improved' methods have had little acceptance in the region.

The poverty in northern Myanmar is compounded by various problems in the area, including civil strife and ethnic conflict in recent decades. Lack of transportation and communication infrastructure means that rural people there have difficulty finding remunerative opportunities even in neighbouring areas. While the vibrant local culture and strong ethnic identity among Kachin and Shan people is an asset, this by itself cannot overcome the burdens of poverty and hunger which the Metta Foundation has sought to lift by whatever means would be most effective and cost-effective, including the SRI and FFS reported on here.

*Study methods*

Metta's programme in northern Myanmar started with 29 FFSs in 2001, followed by 55 more in 2002 and 174 more in 2003, with 5202 farmer-participants (4080 male, 1122 female). During 2004 and 2005, another 294 FFSs were conducted by Metta with more than 5000 participants. Farmer-trainees in the first three years constituted the group from which a random sample was drawn for this study. Each year 10 FFS groups were selected from the first three cohorts of FFS trainees in Kachin State. Thus, 30 FFS groups with 612 farmer-participants were studied, more than a 10 % sample from the large number of schools conducted and farmers trained.

The selection of FFSs was not perfectly random in that some consideration was given to physical accessibility so that the planned data collection could be more thorough, and so that subsequent interaction with farmers could be more continuous. As the full population of farmers who received FFS training is known, there is no reason to believe that the farmers in the FFSs selected for study were systematically different from other FFS alumni in Kachin where all communities are relatively poor and remote.

The farmers in the 10 FFSs selected each year were studied both while they participated in the school and then to the end of the 2004 season. The first 10 FFSs from the 2001 cohort ($n = 202$) thus had three years of follow-up, with two years of follow-up for the 10 FFSs from 2002 ($n = 198$) and one year for the third set of 10 from 2003 ($n = 212$). Because some FFS participants began using SRI methods on their own farms while still in FFS training, the SRI data obtained from these farmers added an additional season of data for consideration (Table 4).

All measurements were made using standard methods, and the same methods were used for both SRI and standard practices. The productivity and profitability differences seen in the data are large, having substantive as well as statistical significance. HK, an agronomist who previously served as rice production specialist with the International

Table 1. Average yields on FFS study-fields, 2001–2003.

| | | Rice yield (t ha$^{-1}$) | | | | |
|---|---|---|---|---|---|---|
| Year | No. of FFSs | Baseline | *s.d.* | FFS yield | *s.d.* | % increase |
| 2001 | 10 | 2.11 | .533 | 5.50 | 1.572 | 161 |
| 2002 | 10 | 1.89 | .470 | 6.77 | 3.433 | 247 |
| 2003 | 10 | 2.25 | .657 | 7.13 | 2.413 | 211 |
| Mean | $n = 30$ | 2.08 | .561 | 6.50 | 2.618 | 208 |

Source: Authors' data, from Kabir (2006).

Institute of Rural Reconstruction (IIRR) in the Philippines, has been a consultant with Metta Development Foundation since 2000. He helped establish its FFSs in northern Myanmar and introduced SRI there, having learned about it from NU, who visited IIRR in 1998. NU visited Myanmar in 2002 and served as an advisor for HK's research when the latter embarked on a PhD thesis evaluating both SRI and FFS interventions. That thesis (Kabir, 2006) provides more information on the research methods and findings than can be reported here.

## RESULTS

### *Yield of rice – SRI vs standard practice*

FFS methodology begins with farmers trying out new methods on a study-field in their home area where they can gain experience with the methods and see resulting differences in yield or other characteristics. First-year study-fields ranged in size from 500 to 4000 m$^2$, but it soon became clear that both FFS and non-FFS farmers took results from larger fields more seriously. So from 2002 on, most study-fields were 4000 m$^2$.

Table 1 summarizes the yields over a three-year period from 30 FFS study-fields where farmers used SRI methods to compare results with their own yields when using standard practices. Average SRI yield on FFS study-fields was $>3$ times greater than farmers' baseline yield of 2.1 t ha$^{-1}$, which was typical of rice yields in Kachin State. The lower increase in 2001 is attributable to the FFS facilitators' limited experience with SRI methods in the first year. Subsequent yields are more representative of what can be attained from SRI methods when they are used as recommended.

### *Production increase per household with SRI methods*

Farmers who observed SRI performance on FFS study-fields were encouraged to use the methods on their own fields the following year. The size of holding varied considerably, from 0.5 to 3.0 ha, with the average area being 1.5 ha. FFS graduates did not necessarily use SRI methods on their whole paddy area, however, because of lack of confidence or because of labour, water control or other constraints. Also, they often did not use all of the recommended practices. The most common practice was to use young seedlings, planted singly, at wider spacing. Application of compost was

Table 2. Mean rice production increase per FFS household, 2002–2004.

| | | Production of rice per family (kg) | | | | |
|---|---|---|---|---|---|---|
| Year | *n* | Before FFS | *s.d.* | After FFS | *s.d.* | Added yield |
| 2002 | 202 | 2188 | 319.8 | 4152 | 313.1 | 1964 |
| 2003 | 198 | 1948 | 149.9 | 4186 | 266.7 | 2238 |
| 2004 | 212 | 1995 | 141.4 | 4218 | 286.9 | 2223 |
| 2002–04 | 612 | 2043 | 234.9 | 4186 | 281.1 | 2143 |

Source: Authors' data, from Kabir (2006).

common, although the amount used could not be considered high. We have no data on the nutrient content of the compost, and applications varied considerably among farmers in any case. Even so, whether using SRI methods in full or only partially, and on all of their paddy area or on just part of it, FFS graduates were able on average to double their household's production of rice after receiving SRI training (Table 2).

*Changes in cost of production and net return*

Both farmers' costs of production and their returns from production were computed and compared in physical terms (kg of rice). During this period, rice prices were unstable due to heavy fluctuation of currency values, and other local prices fluctuated as well, so it was best to demonetize inputs and outputs. More accurate conclusions about net returns can be drawn this way, comparing actual volumes rather than financial totals. Such a calculation tells us concretely how much rice-equivalent input was required to produce how much rice output.

Costs of production included farmers' expenditure on seeds, seedlings, ploughing, and on the labour needed for transplanting, weeding, harvesting and threshing of rice from 2002 to 2004. The value of land rental was also included; however, no cost of irrigation was calculated since rice was grown only in the wet season when farmers do not apply irrigation water. The costs of all purchased inputs were recorded and totalled up in terms of the amount of rice required to pay for them according to prevailing market prices at the time. Farmers' net income was considered as the amount of rice left for a household after paying for all of the costs of production and harvesting.

When costs of production are assessed in this realistic way, it is apparent that rice cultivation in Kachin State using traditional methods is not much more than a break-even operation (Table 3). This helps to explain the pervasive poverty of households in the region. Given that rice production with standard methods is only marginally profitable, achieving higher yields with SRI methods that entail little or no increase in the costs of production raises farmers' net return from rice cultivation immensely, from 296 kg $ha^{-1}$ before FFS training to 2584 kg $ha^{-1}$ after FFS, as seen in Table 3. Farmers' cost reduction could have been greater if, like more 'modern' farmers, they had been using more purchased inputs, particularly chemical fertilizer and new seed varieties.

Another way to evaluate the effects of SRI methods is to assess changes in the costs of production: what volume of rice can be produced from some certain expenditure

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Table 3. Costs of rice production and net returns in real terms (kg ha$^{-1}$), 2002–2004.

| | | Production cost (kg ha$^{-1}$) | | | Rice yield (kg ha$^{-1}$) (see Tables 1 and 4) | | Net income (kg ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | *n* | Before FFS | After FFS | % Change | Before FFS | After FFS | Before FFS | After FFS | Increase |
| 2002 | 202 | 1865 | 1791 | −4.0 | 2110 | 4271 | 245 | 2480 | 2235 |
| 2003 | 198 | 1713 | 1797 | 4.9 | 1890 | 4078 | 177 | 2281 | 2104 |
| 2004 | 212 | 1794 | 1798 | 0.2 | 2250 | 4764 | 456 | 2966 | 2510 |
| Mean | 612 | 1791 | 1795 | 0.2 | 2087 | 4379 | 296 | 2584 | 2288 |

Note: Costs of production and yields are both expressed in the same physical terms, i.e. kg of rice.
Source: Authors' data, from Kabir (2006).

of rice? Before FFS training, in order to produce 2 t of rice on 1 ha of land, farmers needed to invest inputs worth 1791 kg of rice. After training, using SRI methods with the same level of investment, they could produce twice the amount of rice. The impact on household net income from rice was an eight-fold increase (Table 3).

Farmers' net returns from SRI would have been even greater, and their costs of production could have been further reduced, if they had used all of the SRI methods and had achieved yields similar to those seen on the FFS study-fields. The figures reported here are averages. In fact, some farmers did achieve on their own fields the SRI yield levels reported in Table 1, and those who effectively used all of the SRI practices together with other yield-enhancing practices actually surpassed the FFS demonstration levels (Table 5). The figures reported in Table 3 are based on averages for a large number of farmers ($n = 612$) who did not use all of the practices equally or always fully. Thus the average used for net income calculations is lower than that reported from the FFS study-fields.

Using all of the SRI practices effectively to achieve yields higher than those on FFS study-fields did not require any significant additional cost. The major extra cost with SRI is the planting of young seedlings in line, which initially requires some additional labour. This was compensated for by savings from reduced seed requirement and from less labour needed for seedbed preparation, seedling production and uprooting, and weeding. Farmers who applied manure or compost made no extra expenditure because they used their own manure or collected biomass. The other practices of SRI require no additional costs, so the enhancement of yield represents pure profit.

*Yield stability after FFS graduation*

An important question is whether these yield increases hold up after being introduced. In this study, we could only assess trends up to four years, but the data in Table 4 indicate that SRI yields have been stable and have even increased further with practice. About 20 % of FFS participants began using SRI methods in their own fields at the same time that they were learning the methods, so these farmers provide a longer time-line to consider than just the on-farm yields beginning after graduation. No yield decline was seen in any of the four years of the study at any of the study sites with a total of 612 farmers, so the yield gains with SRI appear robust.

Table 4. Mean SRI rice yields (t ha$^{-1}$) on farmers' own fields during same year as their FFS training and in the 1–3 years after FFS graduation, to 2004.

| | Average yield in same year as FFS | | | Average yields in years after FFS graduation | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| FFS years | *n* | | *s.d.* | *n* | Year 1 | *s.d.* | Year 2 | *s.d.* | Year 3 | *s.d.* |
| 2001 | 41 | 3.75 | 0.89 | 202 | 4.27 | 0.72 | 4.47 | 0.80 | 4.54 | 0.65 |
| 2002 | 35 | 3.56 | 1.08 | 198 | 4.08 | 1.21 | 4.64 | 1.30 | – | – |
| 2003 | 33 | 3.07 | 1.07 | 212 | 4.76 | 1.12 | – | – | – | – |

Source: Authors' data, from Kabir (2006).

*Use of new technologies and subsequent yield increases*

In addition to the set of practices known as SRI, several other means for improving rice production were introduced to FFS participants. These included compost use, preparation and use of indigenous micro-organisms to enhance soil biota, green manures, and various practices for control of insects and diseases. Since it turned out that SRI methods improve the rice crop's resistance and resilience, the pest and disease control measures taught were not particularly attractive to FFS trainees.

The practices that proved to be most popular, apart from SRI, were (a) selection of *better-quality seed*, a simple practice involving the submergence of rice seeds in a bucket of briny water and discarding those that float because they have lower weight and density, and (b) planting of *better-suited rice varieties*, i.e. varieties that are most productive under local conditions.

To understand and evaluate farmers' practices post-FFS training, a 20 % sub-sample of the whole group was followed more closely than the others after completion of FFS training (two FFSs per year). These farmers ($n = 124$) were interviewed several times during the subsequent year to see what practices they were actually using and to determine what were their results. This sub-sample was reasonably representative of the whole sample and one that could be interviewed repeatedly.

All of these farmers adopted one or more of the new practices, but only 10 % of our sample adopted all three. Table 5 shows how much yield increase, over farmers' pre-FFS yields, was associated with these improved practices, either separately or in combination with other practices.

Simply improving the genetic material added 18 % to yield, while selecting better-quality seed added 28 %. Using both practices together increased yield by 69 %, indicating considerable synergy between them (23 % more yield was achieved by using them jointly rather than separately). SRI methods by themselves, on the other hand, gave farmers a 143 % increase in yield, more than twice as much yield enhancement as was achieved with the other two improved practices combined.

Using *either* of these two practices together with SRI enhanced yield by a further 30 %, while using *both* of them together with SRI methods added greatly to yield. If all three improved practices were used together, this produced a harvest 3.5 times what farmers were achieving with their previous methods. Use of the three practices together generated a 35 % synergistic 'bonus' compared with their separate adoption.

Table 5. Increases in on-farm yields associated with the use of improved practices learned in FFS, separately and together with other practices, in year after FFS.

| | 2002 | | 2003 | | 2004 | | 2002–2004 | | |
|---|---|---|---|---|---|---|---|---|---|
| Practice | *n* | % increase | *n* | % increase | *n* | % increase | *n* | % increase | *s.d.* |
| Better-suited variety only (5 % of sample) | 2 | 20 | 2 | 15 | 2 | 20 | 6 | 18 | 2.1 |
| Higher-quality seed only (15 %) | 6 | 30 | 6 | 25 | 6 | 28 | 18 | 28 | 2.6 |
| Higher-quality seed + better variety (15 %) | 8 | 70 | 4 | 65 | 6 | 70 | 18 | 69 | 10.0 |
| SRI only (13 %) | 4 | 150 | 6 | 150 | 6 | 130 | 16 | 146 | 2.1 |
| Higher-quality seed + SRI (35 %) | 18 | 200 | 14 | 190 | 12 | 170 | 44 | 186 | 12.3 |
| Better variety + SRI (8 %) | 2 | 200 | 4 | 180 | 4 | 180 | 10 | 186 | 8.4 |
| Higher-quality seed + better variety + SRI (10 %) | 4 | 250 | 4 | 270 | 4 | 240 | 12 | 253 | 13.0 |
| Total | 44 | | 40 | | 40 | | 124 | | |

Note: *n:* the total number of farmers from two FFS studied in a 20 % sample of whole study sample.
% increase: % increase in yield (t $ha^{-1}$) in that year over farmers' previous yield.
Source: Authors' data, from Kabir (2006).

Table 6. Number of non-FFS farmers associated with the 2001 FFS cohort in the same villages and their production increases (%), 2002–2004.

| | FFS farmers | | Non-FFS farmers | | | | | |
|---|---|---|---|---|---|---|---|---|
| FFS sites | *n* | 2002 | *n* | 2002 | *n* | 2003 | *n* | 2004 |
| Nawng Hkying | 24 | 82 % | 20 | 50 % | 32 | 45 % | 46 | 43 % |
| 10 Miles | 20 | 95 % | 25 | 39 % | 35 | 42 % | 42 | 40 % |
| Gat Sha Yang | 18 | 102 % | 15 | 40 % | 22 | 45 % | 30 | 42 % |
| N-gan | 22 | 147 % | 23 | 60 % | 28 | 49 % | 32 | 50 % |
| Nawng Hkyi | 20 | 59 % | 30 | 45 % | 38 | 43 % | 48 | 52 % |
| Gara Yang | 15 | 87 % | 26 | 45 % | 39 | 45 % | 51 | 43 % |
| Ja Pu | 23 | 74 % | 32 | 34 % | 38 | 37 % | 49 | 38 % |
| Awng Mye Tit | 18 | 100 % | 26 | 61 % | 35 | 56 % | 47 | 51 % |
| Mai Sak Pa | 23 | 76 % | 23 | 45 % | 32 | 48 % | 43 | 50 % |
| Lawa Yang | 19 | 105 % | 18 | 68 % | 29 | 65 % | 38 | 63 % |
| Total | 202 | | 238 | | 328 | | 426 | |
| Mean | 20 | 90 % | 24 | 49 % | 33 | 48 % | 43 | 47 % |

Source: Authors' data, from Kabir (2006).

*Spread effects of FFS training to benefit non-FFS farmers*

One of the premises of FFS methodology is that farmers once trained can and will share their learning with neighbouring farmers who have not themselves participated in the FFS experience. SRI is an innovation particularly appropriate for FFS channels of dissemination because it requires no purchase or delivery of special inputs, only the dissemination of knowledge about alternative practices that put a farmer's resources to use differently, with good effect.

The 10 FFSs selected from the 2001 cohort were monitored from 2002 to 2004 to see how many other farmers in their respective communities adopted the new practices and to know what production increases, if any, were achieved on the basis of the knowledge disseminated. Table 6 shows how many non-FFS farmers were using

Table 7. Percentage of farmers in Kachin communities benefiting from FFS training.

| | Percentage of farmers of the community benefiting from FFS | | | |
|---|---|---|---|---|
| FFS sites | 1st year | 2nd year | 3rd year | 4th year |
| Nawng Hkying | 34 | 63 | 80 | 100 |
| 10 Miles | 31 | 69 | 85 | 95 |
| Gat Sha Yang | 36 | 66 | 80 | 96 |
| N-gan | 40 | 82 | 91 | 98 |
| Nawng Hkyi | 29 | 74 | 85 | 100 |
| Gara Yang | 23 | 62 | 82 | 100 |
| Ja Pu | 32 | 76 | 85 | 100 |
| Awng Mye Tit | 27 | 66 | 79 | 97 |
| Mai Sak Pa | 35 | 70 | 83 | 100 |
| Lawa Yang | 33 | 64 | 83 | 98 |
| Mean | 32 | 69 | 83 | 98 |

Source: Authors' data, from Kabir (2006).

the new practices in these communities in each of the following three years. The first year after the FFS training was concluded, the number of farmers using the improved practices in these communities more than doubled because FFS graduates helped other farmers learn the new methods. By the third year, the number of farmers using the new methods had more than tripled.

The combined number of FFS farmers and non-FFS farmers per village using new methods by 2004 was 63, equal to the average total number of farmers in these 10 villages. The yield increases of non-FFS farmers, not formally trained, were not as great as those of FFS trainees, about 50 % compared to about 100 %. But these increases came with no further expenditure of resources by the programme as this spread of innovative methods and enhancement of yield was managed entirely by the communities themselves. There could be further yield improvements over time as farmers gain skill and experience. The cost-effectiveness of a FFS strategy for promoting SRI and associated improved practices is thus remarkable. Within three years, given an innovation as obviously and quickly and profitable and beneficial as SRI, training one third of village farmers could lead to practically 100 % adoption (Table 7).

## DISCUSSION

From these data, we see that the assumptions on which FFSs are based – that active learning processes will be effective and that farmer-to-farmer diffusion will result – worked essentially as expected, at least with an innovation as evidently advantageous as SRI. At the same time, the expectations of productivity increase created by previous reports on the results of SRI practice were clearly supported. A concern about disadoption of SRI has been raised in the literature (Moser and Barrett, 2003), but this has not been seen among Myanmar farmers who were introduced to SRI through FFS methods as they have not given up the new methods after gaining experience with them.

The main reason cited by Moser and Barrett for disadoption or low adoption of SRI was its initial labour-intensity. However, this has not been experienced as a widespread

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problem. A study of the impacts of rainfed SRI use in a poor tribal region in India, discussed below, documented an 8 % *reduction* in labour requirements with SRI (Sinha and Talati, 2007). Other evaluations in Cambodia, China and Madagascar have also found SRI reducing rather than adding to labour requirements, either right away or within a few years (Anthofer, 2004; Barrett *et al.*, 2004; Li *et al.*, 2005).

The results reported here were achieved in a relatively remote part of Myanmar, among rural households that have little access to conventional improved technologies and have been by-passed by most of the technologies produced by agricultural research in recent decades. SRI has emerged at an opportune time, when NGOs and governments seeking to assure food security for the poor and vulnerable are looking for more productive and readily adoptable technologies. The most intractable food security situations usually need to be improved *in situ*, following self-reliant strategies that minimize input-dependence.

That methods developed originally for irrigated rice cultivation could be so beneficially adapted to rainfed conditions is a welcome finding since some of the most persistent rural poverty around the world is found in unirrigated areas. An Indian NGO (PRADAN) working in West Bengal state under conditions of severe poverty and food insecurity, similar to those in Kachin State, has reported similar results obtained there with rainfed SRI. Households in Purulia district lack irrigation facilities, and most (with average yields of 2.2 t $ha^{-1}$) have been producing only enough rice to meet their basic food needs for 6–9 months a year. In 2004, SRI experience in Purulia was evaluated by the India Programme of the International Water Management Institute (IWMI). Its team calculated that SRI yield increases and concomitant cost reductions raised farmers' net returns $ha^{-1}$ by 67 %, even in a year when half the farmers surveyed had been affected by severe drought (Sinha and Talati, 2007). One SRI plot gave a harvested yield of 15 t $ha^{-1}$, not calculated from crop-cut sampling. With SRI methods, rainfed yields in 2005 averaged 7.7 t $ha^{-1}$ ($n = 163$), results similar to those reported here from northern Myanmar (PRADAN, 2006). In 2006, with over 1100 farmers using SRI methods in Purulia district, SRI yields averaged >7 t $ha^{-1}$ (PRADAN, 2007).

These Indian results and those from Myanmar cannot be considered as the final word on SRI, as much more needs to be known about this system before drawing firm and broadly generalized conclusions. However, the experience of over 600 upland farmers in northern Myanmar reported here, documented with data gathering over a four-year period, should warrant more scientific research on SRI, investigating the reasons for these results as well as their effects. The dismissive conclusion of McDonald *et al.* (2006) was based on a demonstrably unrepresentative sample and on flawed methodology; e.g. they classified as SRI results, yields where no more than three of the six practices recommended for SRI had been used, calling this a 'close approximation', as if somehow 50 % equals 100 %. More systematic comparison trials present different conclusions about the use of SRI methods, e.g. in the Gambia (Ceesay *et al.*, 2006).

The conclusion put forward here is not that farmers everywhere should adopt SRI methods, but that there is strong empirical justification for trying out these methods pragmatically, evaluating them in a variety of environments, especially where poverty and food insecurity are challenges that have resisted previous efforts. Science and practice can proceed in tandem with SRI, rather than sequentially, since it entails little cost and no foreseeable risks, involving neither use of chemicals nor genetic modifications. We have documented substantial potential economic and environmental net benefits from SRI use that are relatively greater for those households most in need of more food and increased incomes.

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