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Research Paper

Securing Food Security: System for Rice Intensification Method to Produce More with Less Resources in North Sumatra, Indonesia

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ABSTRACT: *Food security is a big challenge in realizing sustainable development goals (SDG) to achieve zero hunger by 2030. Producing more with less, while preserving and enhancing the livelihoods of small-scale and family farmers is a crucial challenge for the future. Therefore, substantial improvements in resource-use efficiency and gains in resource conservation will need to be achieved globally to meet the growing and changing food demand and halt and reverse environmental degradation. Community service activities in Deli Serdang Regency, North Sumatra, Indonesia, aim to increase rice production through participatory extension education and training with direct implementation in participating farmers' farming areas (demonstration plots) of the SRI method (system of rice intensification) including: (i) simple seed screening techniques, (ii) rice replanting techniques, (iii) proper fertilization (type, quantity and time of application), and (iv) simple techniques of processing straw (rice production waste) into organic fertilizer. Results obtained: (i) the SRI method can increase the productivity by up to 62% (8.75 tons /ha) and reduce costs of using seed by 75 - 80% (10 kg/ha), soil processing and use of synthetic fertilizers reduced by 50%. Rice cultivation using the SRI method needs to be expanded from the demonstration plot level to the farm level by involving more farmers in one area. By doing so, this method will be adopted more quickly by North Sumatra rice farmers. Furthermore, the analysis carried out should include soil analysis to see the improvement in soil quality as a result of using organic fertilizers and the composition of soil nutrients as a reference for determining the more precise use of synthetic fertilizers.*
KEYWORDS: *Food Security, low-external-input-technique, system of rice intensification (SRI), North Sumatra*

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I. INTRODUCTION

Food security is a big challenge in realizing sustainable development goals (SDG) to achieve zero hunger by 2030. FAO [1] projected that the demand for food and other agricultural products increases by 50 % between 2012 and 2050. Due to factors such as population growth, urbanization, and per capita increases in income, demand will undergo structural changes. At the same time, the natural resource base upon which agriculture depends will become increasingly stressed. Producing more with less, while preserving and enhancing the livelihoods of small-scale and family farmers, is a key challenge for the future. Therefore, substantial improvements in resource-use efficiency and gains in resource conservation will need to be achieved globally to meet the growing and changing food demand and halt and reverse environmental degradation.

Referring to the definition of food security as follows [2]: "food security exists when all people at all times, have access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life", [3] further elaborate that access involves having both physical access to a place where food is available and economic access (having a socially legitimate claim to the food). Having access to food requires that the food be available.

Food availability itself can be achieved through post-harvest handling efficiency in addition to increasing production. According to [4], roughly one-third of the edible parts of food produced for human consumption gets lost or wasted globally. In Sub-Sahara Africa and South/Southeast Asia, per capita food losses and waste reached 460 kg/year and losses in these regions are largest during post-harvest handling and storage.

Furthermore, [3] argued that the availability and the access dimension of food security become linked inextricably. Availability reflects the supply side of the food security equation, while access reflects effective demand. It is a cost of food to the consumer relative to her income, not the physical availability per se, that is crucial in determining food security. Since the food system is a major employer of the poor in South Asia and Sub-Sahara Africa, increasing productivity of this system is linked in another critical way to food access. Increasing productivity in the food system increases these workers' income, improving their ability to access food through the market. Broad-based growth of agriculture and the rest of the food system is thus critical to improving food security (regarding off farm income see ([5], [6] and [7]).

System of rice intensification (SRI) is one cultivation method to increase productivity in paddy farm. [8] described SRI as one of the most interesting examples of low-external-input-technique (LEIT) to emerge in recent years. The innovation was pioneered by a French priest working in Madagascar. He found that if rice is transplanted earlier than usual with the seedlings very widely paced and subjected to alternate wetting and drying periods, remarkably high yields are possible. The farmer must learn a series of management techniques complemented by organic manure and extra weeding early in the season. The innovation has been promoted in various countries in Asia and Africa. The agricultural research establishment was initially quite skeptical of SRI, but it appears that high yields are possible in some cases, with some saving in water use. In Indonesia, the first trial of SRI patterns/techniques was carried out by the Agricultural Research and Development Institute in Sukamandi, West Java, during the 1999 dry season [9]. So far, this method has been socialized in various places in Indonesia, but the socialization of SRI has not been accompanied by efforts to strengthen the institutional capacity of organic input services; as a result, SRI farmers have to buy organic fertilizer from entrepreneurs at high prices. [10] and [11] found the same thing in applying low-external-input-sustainable-agriculture (LEISA) on sweet potato plants, namely institutional support and the availability of information sources become obstacles.

This article's information is the result of research-based community service activities entitled science and technology for the community in the form of the introduction and application of simple technology that is locally available and easy to implement by rice farmers in the SRI package. Activities are carried out in a participatory and holistic manner. Extension education to increase knowledge is followed directly by practice by participating farmers (skills improvement) and applied on farms (demonstration plot).

II. METHODOLOGY

So far, there is no standard package for the SRI method, but in general, it ranges from ([12], [9] and [10]): (i) seedlings are moved to the field (transplanted) earlier, (ii) seedlings planted individually rather than in clumps, (iii) wide spacing, (iv) soil conditions remain moist but not flooded (intermittent irrigation), (v) weeding more frequently, (vi) use of organic fertilizers (compost) to improve the soil structure so that paddy can grow well and nutrients are supplied to plants adequately. Besides, the [13] provided additional notes in seed testing with salt solutions and accelerated decomposition of organic matter using local microorganisms. This package was introduced through a combination of extension education, training and participatory demonstration of the plot.

2.1. Participatory approach

Participatory Action Research (PAR) is a methodological approach that provides a set of action-research techniques useful for agroecological transition, which has been applied mostly in Latin America. PAR can be used to design and implement, in conjunction with farmers and local people, management and social organization proposals that increase agricultural sustainability. PAR considers that any development process undertaken will be biased if it does not incorporate this process's beneficiaries as protagonists. In general, PAR approaches seek to generate liberating knowledge based on widespread knowledge, and that explains the global situation (system approach) to start or consolidate a strategy of change (transition process). When applied to an agroecological transition, PAR promotes technological change and, at the same time, improves the ecological sustainability of farming systems. It starts from a participatory and holistic diagnosis of the initial situation of the farm and the local community and defines an objective, realistic situation using sustainability criteria [14]. It is worth noting that PAR is often combined with various methods as applied by de Jager in studies of soil fertility management monitoring nutrient flows in Africa, e.g. [15], [16] and [5].

2.2. Extension education method

Some of the extension activities carried out include:

(i) Introduction of seed screening

(ii) Education on the management of rice harvest waste (straw), if left unchecked, will become a nest for rats, and if it is burned, it will damage decomposing microorganisms.

(iii) Extension of the impact of using organic fertilizers on soil friability and fertility.

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2.3. Farming Training and Demonstration Methods (demonstration plot)

The training method's intension is that the participating farmers can carry out activities individually or in groups during the activity and repeat activities after the community service program ends. The training activities carried out include:

(i) SRI Method Paddy Seed Screening Training.
The seeds to be used are selected by immersing the seeds in a salt solution. The amount of salt used is based on the chicken eggs' condition, which are first put in the salt solution. When the eggs float, the addition of salt in the solution is stopped. Furthermore, the seeds are soaked in a salt solution, and good seeds are those immersed in a salt solution.

(ii) Training on SRI Method of Paddy Seed Nursery.
The seed nursery is carried out in lowland rice fields, which are part of the cultivated land. The land is cleared and levelled, then the seeds are spread evenly and, after ten days, transferred to the farm.

(iii) Training on Soil Processing with SRI Method.
The land that will be processed first is given organic fertilizer as much as 2 tons / 1000 m² (demonstration plot), equivalent to 20 tons/ha and given 1-3 cm water for five days. Soil processing is carried out using a hand tractor only once.

(iv) Training on planting space of SRI Method.
The spacing of rice used was 30 x 30 cm with the one free space for every four rows (in Indonesian term legowo 4: 1) system, and plastic ropes were used to determine the spacing.

(v) Training on SRI Method of Paddy Replanting.
Rice seeds from the nursery are taken using a tablespoon so that the roots of the rice seeds are not cut off because the rice seeds are still small and fragile. The seedlings that have been pulled out are immediately replanted two each.

(vi) Training on SRI Method of Paddy Fertilization.
Synthetic fertilizers such as urea, phosphate (SP-36) and potassium (KCl) are given in addition to organic fertilizers. Doses of SP-36 and KCl, respectively 7.5 kg/1000 m² (demonstration plot) equivalent to 75 kg/ha were given before planting on the same day of planting. While the dose of urea 20 kg/1000 m² (demonstration plot) equivalent to 200 kg / ha is given 3 times each 1/3 of the dose and the application is every 2 weeks.

(vii) Training on Paddy Water Supply with SRI Method.
Water is given as high as 3 cm and dried once every 3 days, the frequency of giving water is carried out during the planting period.

(viii) Training on Making Organic Fertilizer (Compost).
Organic fertilizer is made after harvest by collecting rice straw, chopping it and mixing it with fine bran and then doused with EM-4 decomposer that has been dissolved in a sugar solution and stirred until evenly distributed, covered with black plastic. Once every three days, the haystack is stirred evenly, closed again, and the temperature is monitored every morning and evening. The monitor is carried out by inserting a hand equipped with gloves into a haystack. If it is still warm, the pile is not ready to use. After 21 days, the haystack is ready to be used as compost.

III. RESULTS AND DISCUSSION

Through a focus group discussion (FDG), the farmers identified the conventional paddy cultivation method as they have been practiing so far. Then, in a participatory manner, an agreement was built regarding the SRI package to be implemented. The results of identification and the package to be applied are presented in table 1. The SRI package is targeted to reduce synthetic fertilizers by up to 50% and vice versa using organic fertilizers composted by themselves from rice harvest waste.

Table 1. Comparison of Conventional and the SRI Method of Paddy Cultivation.

• Use of seeds 40-50 kg/ha • Seedlings in the nursery for 20-25 days • Spacing 15 x 15 cm • Number of seedlings 5-6 plants/hole • Soil processing with a hand tractor two times • Not using organic fertilizers; synthetic fertilizers/ha: Urea 400 kg, SP-36 and KCl 150 kg each. • Production per planting season is 5.4 tons/ha	• Use of 10 kg/ha of seeds • Seedlings in the nursery for ten days • Spacing 30 x 30 cm, empty row after every 4 rows • Number of seeds two plants/hole • Soil processing with a hand tractor once • Use of fertilizer/ha: 20 tons of organic fertilizer, 200 kg of Urea, SP-36 and KCl 75 kg each

Source: Focus Group Discussion of Participant Farmers.

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In the seed screening training, farmers produced 1 kg of seeds which were used for the paddy field demonstration plot with an area of 1000 m² (Figure 1). Of the certified seeds that farmers bought in the market, about 10% did not pass the screening as good seeds (not immersed in salt water). Farmers have thus been able to distinguish between the seeds selected for the SRI method and conventional rice seeds (table 2).

Figure 1. Seed Screening Technique Using Saltwater

Table 2. Visually Differences Between Conventional SRI-Method Paddy Seeds.

No.	Description	Conventional Paddy Seed	Paddy Seed of SRI Method
1	Source	Certified seeds are used directly.	Certified seeds are selected using the SRI method.
2	Seed Need	40-50 kg/ha or 4 kg/1000 m² (demonstration plot).	10 kg/ha or1 kg/1000 m² (demonstration plot).
3	The hardness of the seeds when pressed between the fingers using the nails and weighed	From 1 kg of labelled seeds, ± 700g (70%) hard seeds and ± 300g (30%) less hard seeds were obtained	From 1 kg of selected seeds, approximately ± 900g (90%) hard seeds were obtained and ± 100g (10%) less hard seeds.
4	Seed uniformity	The seeds are not uniform with various sizes and shapes such as long, short, big, small and flattened.	The seeds are uniform, with most seeds being about the same size and shape. .
5	Seed volume per kg	More	less

Source: Participant Farmers Observation.

Farmers can quickly implement the SRI method of lowland paddy seed nursery because they sow the seeds every planting season but leave them for longer before replanting. In table 3, it can be seen that farmers can distinguish between the SRI method of paddy seedlings and the conventional one.

Table 3. Differences Between Conventional and SRI Method of Paddy Nursery.

No	Description	Conventional Paddy Nursery	Paddy Nursery of SRI Method
1	Nursery area for 1 ha paddy cultivation	400 m²	A quarter of conventional nursery (100 m²)
2	Nursery	In cultivation area	In cultivation area or outside
3	Water condition	Logged	Muddy
4	Workforce	six working days	two working days
5	Management	More difficult due to the broader area.	Easier due to the narrower area.
6	Age of seedling	20-25 days	ten days

Source: Participant Farmers Observation.

Farmers can cultivate the soil well until the soil conditions on the demonstration plot turn into mud. They also said that applying organic fertilizers and water before tillage made it easier to process the soil into sludge. Training spacing 30 x 30 cm with empty row after every four rows and planting two seeds per planting, the farmers can do it without significant difficulties. The cropping system that is applied can produce a more significant number of tillers so that the number of plants per clump will be more significant.

The results of the composting technique to produce organic fertilizer and proper fertilizer application show that farmers can implement it and understand that there are differences in the type, dose and time of fertilization between the conventional and the SRI method. The farmer's observation is displayed in table 4.

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Table 4. Fertilization Differences Between Conventional and SRI Method of Paddy Cultivation.

No	Description	Conventional Paddy Cultivation	SRI Method
1	Organic Fertilizer	✓ None	✓ A dose of 2 tons / 1000 m² (demonstration plot) is equivalent to 20 tons / ha. ✓ Given five days before tillage and inundation.
2	Urea	✓ A dose of 40 kg / 1000 m² (demonstration plot) is equivalent to 400 kg / ha. ✓ Application of two stages with a dose of ½ each. ✓ Given at two weeks and five weeks after planting.	✓ A dose of 20 kg / 1000 m² (demonstration plot) is equivalent to 200 kg / ha. ✓ Appliction of three stages with a dose of 1/3 of each administration. ✓ Given every two weeks, namely the age of two, three and five weeks after planting.
3	Phosphate (SP-36) and Potassium (KCl)	✓ Each dose of 15 kg / 1000 m² (demonstration plot) is equivalent to 150 kg / ha. ✓ Giving by mixing SP-36 with KCl, given once at the age of 2-3 weeks after planting.	✓ A dose of 7 kg / 1000 m² (demonstration plot) is equivalent to 75 kg / ha. ✓ Aplication by mixing SP-36 with KCl, given once before planting on the same day as planting.

Source: Participant Farmers Observation.

Farmers usually burn rice straw before tilling the land because they do not know its benefits. The processing of straw into compost can be carried out by participants and then used as organic fertilizer to become a source of plant nutrients to reduce synthetic fertilizers (Figure 2).

Figure 2. Making Organic Fertilizer From Rice Straw Using Composting Techniques.

The extension activity is going well, where farmers know a correlation between rats and the availability of a food source in the form of straw containing leftover. Furthermore, they can produce compost from straw to reduce the use of synthetic fertilizers.

The yield of the demonstration plot for lowland paddy using the SRI method with an area of 1000 m² was obtained, which was 875 kg, equivalent to 8.75 tons/ha. Compared with the average production of 5.39 tons/ha, there is an increase in production of 3.45 tons/ha, equivalent to 62% per planting season.

Regarding the application of SRI as an example of LEIT in lowland paddy cultivation, there are two notes, namely: (i) the gap between the production potential is still quite large, even though the production has been increased to 62% because the results of field tests in West Java rice production can reach 12 tons/ha [17] so that what is achieved by the application of the SRI method in North Sumatra is still 72% of the potential that can be reached, (ii) the constraints in developing the LEIT are mainly due to the high need for organic matter, not applicable to rice cultivation because the unutilized paddy biomass (production waste) is much greater than paddy grains as a harvest. Thus, the problems in developing LEIT found in sweet potato [11] or other crops such as maize [14] is not valid in paddy cultivation.

The introduction of SRI for farmer communities in Indonesia, particularly in North Sumatra, can run more smoothly because farmers are not faced with entirely new components of innovation, such as introducing synthetic fertilizers and pest management in the era of the green revolution. Innovations in the SRI method based on indigenous technology [9]. Two new things crucial in the SRI method [13], seed selection and accelerated composting of organic matter using local microorganisms as decomposers, are simple techniques that can be easily understood and applied by farmers.

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IV. CONCLUSION AND FUTURE AGENDA

The implementation of rice cultivation using the SRI method in this community service activity concludes the following:

Participant farmers can accept and apply the SRI method of paddy cultivation techniques and their components, including seed screening techniques, processing of paddy harvest waste into organic fertilizer and planting techniques with earlier replanting and the number of seeds of only two plants per planting hole, proper fertilization (type, quantity and time of application) and more expansive planting space.

Lowland rice production using the SRI method can increase productivity by up to 62% (8.75 tons/ha) and at the same time reduce costs of using seed by 75 - 80% (10 kg/ha), soil processing and use of synthetic fertilizers (Urea, Phosphate and Potassium) reduced by 50%.

The processing of rice harvest waste reduces the attack of rat pests, and the resulting organic fertilizers will improve the soil's quality/fertility.

Rice cultivation using the SRI method needs to be expanded from the demonstration plot level to the farm level by involving more farmers in one area. This method will be adopted more quickly by North Sumatra rice farmers. Furthermore, the analysis carried out does not end at physical relations only (increased yields and reduced use of seeds and fertilizers) but also includes farm analysis (increased income in monetary value) and soil analysis to see the improvement in soil quality as a result of using organic fertilizers as well as the composition of soil nutrients as a reference for determining the more precise use of synthetic fertilizers (the use of Urea, Phosphate and Potassium should be determined scientifically, not based on agreement).

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