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## **Adoption of rice straw pellet organic fertilizer among rice farmers: A case study in Nong Phak Nak Subdistrict, Suphan Buri Province, Thailand**

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**Abstract** The findings revealed that, prior to the training, most of the participants did not use organic fertilizer even though they had basic awareness, this was probably mainly due to perceived production complexity and delayed nutrient release. It was that there was a highest level of quality of the instructional video materials (mean = 4.46). Besides, farmers' knowledge significantly increased after the training ( $t = 19.47$ ,  $p < 0.05$ ). This implied that there was a large training effect on the acquired knowledge (Cohen's  $d > 3.0$ ). As a whole, the participant satisfaction with the training program was found at a highest level (mean = 4.32). This was particularly on training content and practical activities. As a whole, findings showed that participatory training combined with appropriate instructional media effectively enhanced participant knowledge, satisfaction, and adoption of rice straw pellet organic fertilizer. Results showed the practical implications for extension in agricultural programs to promote organic fertilizer application which produced from local resources in rice farming systems.

**Keywords:** Rice straw pellet organic fertilizer, Participatory training, Agricultural extension, Adult learning, Sustainable rice farming

### **Introduction**

Rice cultivation is a basic factor of food security in rural areas in Asian countries, including Thailand. The intensive rice cultivation systems are increased in using chemical fertilizers to increase yield productivity. It is led to increase production costs and leading to decrease soil fertilization and environmental changes (Tilman *et al.*, 2011; FAO, 2017). Long term sustainability of rice production depended on farming systems included alternative practices for appropriate the productivity balance with economic and environmental sustainability.

Rice straw has remained resource after harvest as the residues from rice production. In Thailand, the rice straw is usually disposed by burning the rice

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fields resulted to air pollution, gas emissions, and the loss of organic matter in cultivated soil. (Department of Rice, 2022; Gadde *et al.*, 2009). The effective utilization of rice straw has priority concerned as the local and national policy. The rice straw is converted to organic fertilizer through fermentation process which can be reduced the environmental impacts and enhanced the circular agriculture through resource efficiency for Bio Circular Green (BCG) economy to support sustainable development goals framework (FAO, 2021).

Organic fertilizers are made by plant residues (rice straw) and animal dungs through fermentation process. It is become a role to increase organic matter in cultivated soil by revitalized soil biology, chemistry and physical properties, (Lal, 2015; Zhen *et al.*, 2014). These benefits of organic fertilizer which is applied by the farmers remains that may be limited. The constraints of organic fertilizer application recorded slowly nutrient release as compared to the chemical fertilizers which may possible not have enough basic knowledge for organic compost production and without an appropriated degradibg microbes to release the available plant nutrient. (Knowler and Bradshaw, 2007; Pattanapant and Chaiprasert, 2019). These factors found that organic fertilizer promotion is needed not only scientific basis but the extension strategies.

Participatory and community learning approaches are recognized to be an effective methods to promote agricultural innovations. Participatory Action Research (PAR) is mixed with adult learning theory (andragogy) and experiential learning, which is emphasized to the learners before practicing and learning process (Knowles, 1984; Kolb, 1984; Erwin, 1976). The smallholders and aging farming communities are approached as particularly learning by practicing and exchanging to enhance the understanding, trust, and long-term adoption. suggests that the participatory extension is suggested by empirical evidence to improve the skill of farmers and to encourage for learning and to facilitate the knowledge contribution for communities (Pretty, 1995).

Suphan Buri province is one of majority province for rice cultivating areas in Thailand where rice production becomes the primary livelihood for supporting several households. The management of rice straw is continued after harvesting periods. The observations indicated that many farmers possessed a high level of knowledge for compost production and application in Nong Phak Nak subdistrict, but the farmers are still applied chemical fertilizers. These reasons included the perceived of organic compost production, which lack of equipments. The farmers are needed a strongly demand for practical training for organic compost production to focus on the easy forms for application as pellet forms.

These challenges are clearly shown for integrating the technical knowledge and participatory extension to promote organic compost production to the farmers.

The objectives were to to promote the organic fertilizer production and utilization from rice straw fermentation in the form of pellets which enhanced farmers' knowledges and skills, increased the adoption of organic fertilizer, and reduced chemical fertilizer application in order to encourage the sustainable use of locally available resources.

## **Materials and methods**

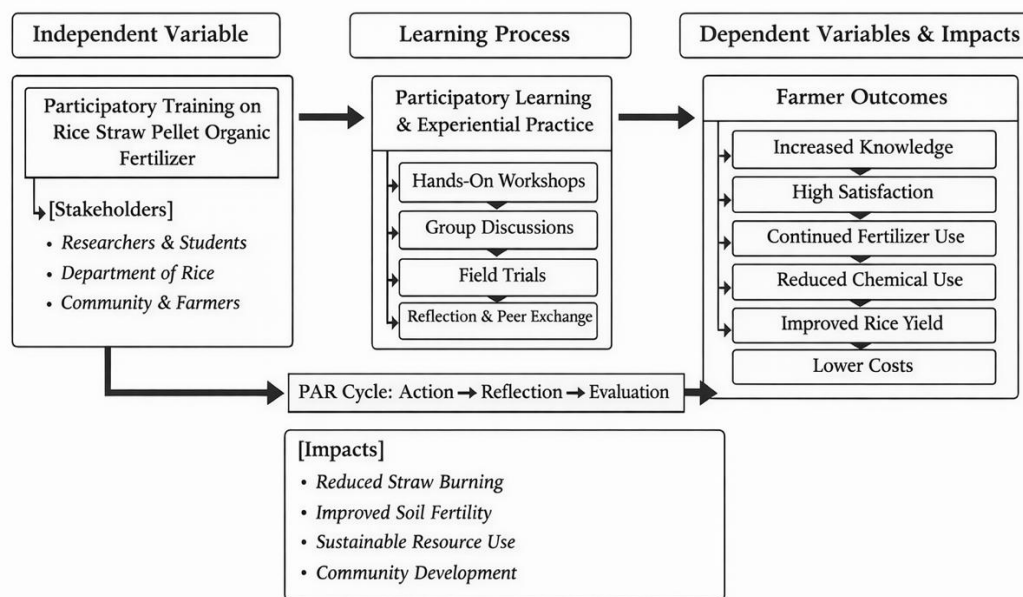
### ***Conceptual framework of the study***

The investigation was done by using a conceptual framework with integrating participatory management, adult learning theory (andragogy), and experiential learning, and implemented by the Participatory Action Research (PAR). The framework was explained how participatory training activities are done on organic fertilizer pellets formulated from rice straw fermentation. The compost production using rice straw as a main component that influenced farmers' learning outcomes and of organic fertilizer adoption data. The framework was combined in participatory management theory, which emphasized to get data from stakeholders (Erwin, 1976). The researchers, government officials, and community members were collaboratively identified the problems which related to rice straw management to bev organic fertilizer.

The adult learning theory was used to support the instructional design by recognizing the farmers, adult learnersto learn, to prefer the problem-centered learning, and to motivate with the practical training (Knowles, 1984). The training was done to emphasize on self-directed learning, hands-on practice, and immediate application to operate these principals.

The experiential learning theory was conducted to learn the organic fertilizer process by learning through experience, and active experimentation (Kolb *et al.*, 1984). These approachs were conducted in group discussions, workshops, field trials and peer knowledge exchange.

The independent variable was the participatory training on organic fertilizer made in pellet forms. The process of learning was done with intervening mechanism, consisting of participatory learning and practices. The dependent variables were farmers' knowledge, satisfaction with the training, and post-training outcomes (decreasing chemical fertilizer application, and applying organic fertilizer made from rice straw fermentation to increase yield, and low production costs. These outcomes were gathered the data to contribute the impacts from rice straw burning reduction, soil fertility improvement, and community development.



**Figure 1.** Conceptual framework of the study

### ***Research design***

This study employed an applied design integrating research in both qualitative and quantitative approaches. The research was conducted using the Participatory Action Research (PAR) framework to promote the production and utilization of rice straw pellet organic fertilizer among rice farmers. The PAR approach emphasized on active participation and collaboration among researchers, farmers, government agencies and academic institutions throughout the research process, enabled the development of context specific and practical solutions.

### ***Located of the study***

The study was conducted in Nong Phak Nak Subdistrict, Sam Chuk district, Suphan Buri province, Thailand. The target group consisted of members of the Ban Pong Daeng community rice seed production enterprise. Participants were selected by using purposive sampling based on their involvement in rice farming and willingness to participate in the research activities. Total of 37 rice farmers participated as the primary research participants. In addition, key stakeholders were involved in the research process, they were researchers and agricultural

education students from the department of agricultural education, six officials from the Rice Product Development Division, Department of Rice, and community leaders representing the local enterprise. The stakeholders were collaborated to support the knowledge for exchanging and facilitating the implementation of research activities.

### ***Research procedures***

The investigation was implemented the PAR cycle as follows: -:

Phase 1 was the data to determine the farmers' knowledge, encountered problems, and related to organic fertilizer made by rice straw fermentation which applied in rice production. Data were gathered from documentary review, structured interviews, and field observations. The survey was focused on organic fertilizer application, organic fertilizer adoption, and demands of farmers for extension support. The findings designed as an appropriated training activities to address the actual community demand.

Phase 2 was getting the data for the development and implementation of a hands-on training program on organic fertilizer made from rice straw fermentation and application. The training content and activities were conducted by researchers, government officials, and farmer representatives with the focus groups.

The organic fertilizer production process was conducted according to report of Soytong (2018), who suggested that rice straw utilization was raw material in combination with animal dungs, lime, and bio-decomposer.

Training activities were conducted with learning experiences and adult learning principles which emphasized on demonstrations, hands-on practice, group discussions, and the instructional video materials. The participants were repeatedly access. Acquisition of knowledge was evaluated by pre-test and post-test before and after the training program (Soythong, 2018; Knowles, 1984; Kolb *et al.*, 1984).

Phase 3 was gotten the data by evaluation in six months after the training program. Data were gathered to assess the continuity of organic fertilizer made by rice straw fermentation, changing in fertilizer management, yield, decreasing chemical fertilizer application, and knowledge dissemination among farmers All data were obtained by interviews, observations, and group discussions with participating farmers.

### ***Research instruments***

The research instruments in this study included a structured training program and instructional materials on rice straw pellet organic fertilizer production, knowledge assessment, a satisfaction questionnaire, and an expert evaluation form. The knowledge assessment comprised 20 true–false items were administered before and after the training to measure the changes in farmers’ knowledge. Content validity was established through expert review by five specialists using the Index of Item-Objective Congruence (IOC), yielding values between 0.60 and 1.00. Farmers’ satisfaction with the training content, learning activities, and instructional materials was evaluated using a questionnaire with acceptable internal consistency, as indicated by a Cronbach’s alpha coefficient of 0.83, and assessed the quality of the instructional video materials using an expert evaluation form to complete three media producing experts and two experts of fertilizer production.

### ***Data collection and data analysis***

Quantitative data were computed by descriptive statistics, included mean and standard deviation summarize the farmers’ attributes, training satisfaction, and expert evaluation of instructional media. A paired-sample t-test was compared the farmers’ knowledge scores before and after the training program for statistical significance set at  $P = 0.05$ .

Qualitative data were gathered from interviews, group discussions and observations which computed statistical analysis.

The statistical analysis was done to evaluate the magnitude of training effect. Cohen’s  $d$  based on pooled standard deviation and Cohen’s  $d_{z}$  for the paired-sample design were used to calculate, then and interpret by using conventional benchmarks which the larger values indicated a stronger training effect.

The interpretation of the farmers’ satisfaction levels was a proposed by Best (1977), as follows:

| Score | Scale Limits | Description |
|-------|--------------|-------------|
| 5     | 4.21–5.00    | Highest     |
| 4     | 3.41–4.20    | High        |
| 3     | 2.61–3.40    | Moderate    |
| 2     | 1.81–2.60    | Low         |
| 1     | 1.00–1.80    | Lowest      |

## Results

Collectively, these findings demonstrated the effectiveness of the participatory training program on rice straw pellet organic fertilizer.

The farmers applied organic fertilizer in rice cultivation during Phase 1 of the study (Table 1). The results indicated that only 35.00% of farmers applied organic fertilizer in combination with chemical fertilizer (WHICH FERMULATION), while the majority (65.00%) was not using organic fertilizer at all. This finding suggested that despite farmers' engagement in rice cultivation, the adoption of organic fertilizer remained limited prior to the intervention.

**Table 1.** Farmers' use of organic fertilizer in rice cultivation (Phase 1)

| Fertilizer use practice                                       | Number<br>(n=37) | Percentage<br>(%) |
|---------------------------------------------------------------|------------------|-------------------|
| 1. Using organic fertilizer combined with chemical fertilizer | 13               | 35.00             |
| 2. Do not use organic fertilizer                              | 24               | 65.00             |
| Total                                                         | 37               | 100.00            |

The farmers identified several key issues related to organic fertilizer use (Table 2). The major problem was the slow release of nutrients from organic fertilizer compared with chemical fertilizer, resulting to delay visible effects on crop growth. In addition, main constraints included the lack of production equipment and the perceived complexity of the production process. Regarding extension needs, the farmer participants expressed strong demand for study visits, hands-on training, and exhibitions, with the production of rice straw pellet organic fertilizer were identified as the priority knowledge area.

**Table 2.** Major problems and needs for extension related to organic fertilizer using

| Issue                      | Key findings                                                                                                      |
|----------------------------|-------------------------------------------------------------------------------------------------------------------|
| 1. Major problem           | Organic fertilizer releases nutrients more slowly than chemical fertilizer, resulting in delayed visible effects. |
| 2. Main constraints        | Lack of production equipment and perceived complexity of production process.                                      |
| 3. Extension needs         | Study visits, hands-on training, and exhibitions.                                                                 |
| 4. Priority knowledge area | Production of rice straw pellet organic fertilizer.                                                               |

Results of the quality evaluation of the instructional video materials were conducted by five experts (Table 3). The instructional video was rated at the highest level of quality ( $\bar{x}$  = 4.46, S.D. = 0.19). Among the evaluation aspects, academic usefulness received the highest mean score ( $\bar{x}$  = 4.80, S.D. = 0.29),

followed by content completeness and instructional design. Although the lowest mean score was observed for alignment with training objectives ( $\bar{x}$  = 4.26, S.D. = 0.43), this aspect was still rated at the highest level.

**Table 3.** Quality evaluation of instructional video materials by experts (n = 5)

| Evaluation aspect                                      | $\bar{x}$ | S.D. | Description |
|--------------------------------------------------------|-----------|------|-------------|
| 1. Content completeness                                | 4.46      | 0.18 | Highest     |
| 2. Alignment with training objectives                  | 4.26      | 0.43 | Highest     |
| 3. Training activities and procedures                  | 4.40      | 0.27 | Highest     |
| 4. Instructional media design (visuals, sound, format) | 4.40      | 0.43 | Highest     |
| 5. Academic usefulness                                 | 4.80      | 0.29 | Highest     |
| Overall                                                | 4.46      | 0.19 | Highest     |

The result showed the comparison of farmers' knowledge scores before and after participation in the training program (Table 4). The mean pretest score was 10.95 (S.D. = 0.65), while the mean posttest score increased to 15.89 (S.D. = 0.86) out of a full score of 20. The paired sample t-test revealed a statistically significant difference between pretest and posttest scores ( $t = 19.47$ ,  $p < 0.001$ ), indicating that the training program significantly improved farmers' knowledge of rice straw pellet organic fertilizer production and utilization.

**Table 4.** Comparison of farmers' knowledge scores before and after training (n = 37)

| Test     | Full score | $\bar{x}$ | S.D. | t     | p    |
|----------|------------|-----------|------|-------|------|
| Pretest  | 20         | 10.95     | 0.65 | 19.47 | 0.00 |
| Posttest | 20         | 15.89     | 0.86 |       |      |

\* Statistically significant level at 0.05

In addition to statistical significance, the magnitude of the training effect was examined using effect size analysis. The results showed a very large effect with Cohen's  $d = 6.48$  based on pooled standard deviation and Cohen's  $d_{\text{paired}} = 3.20$  for the paired sample design. These findings indicated that the hands-on, participatory training program substantially enhanced farmers' knowledge and understanding.

The farmers' satisfaction with the training program are presented in Table 5. The farmers reported a highest level of satisfaction ( $\bar{x}$  = 4.32, S.D. = 0.13). When examined by dimensions, satisfaction with training activities was rated at a highest level ( $\bar{x}$  = 4.33, S.D. = 0.26), followed by training content ( $\bar{x}$  = 4.32, S.D. = 0.18) and training media and equipment ( $\bar{x}$  = 4.31, S.D. = 0.20). Regarding item level, a highest satisfaction score was found to be "overall satisfaction with the training" ( $\bar{x}$  = 4.65, S.D. = 0.48), indicating positive perceptions toward the training program.

**Table 5.** The farmers' satisfaction with the training program on rice straw pellet organic fertilizer (n = 37)

| Evaluation items                                                                      | $\bar{x}$   | S.D.        | Description    |
|---------------------------------------------------------------------------------------|-------------|-------------|----------------|
| <b>Training content</b>                                                               |             |             |                |
| 1. The training content was interesting                                               | 4.27        | 0.56        | Highest        |
| 2. The training content addressed community needs                                     | 4.68        | 0.47        | Highest        |
| 3. The training content could be applied in daily life                                | 4.08        | 0.54        | Highest        |
| 4. The training content is clear                                                      | 4.22        | 0.47        | Highest        |
| 5. Knowledge could be disseminated to others                                          | 4.41        | 0.55        | Highest        |
| <b>Subtotal</b>                                                                       | <b>4.32</b> | <b>0.18</b> | <b>Highest</b> |
| <b>Training activities</b>                                                            |             |             |                |
| 6. Training activities were appropriate in time span.                                 | 4.24        | 0.54        | Highest        |
| 7. Training activities encouraged the farmers                                         | 4.30        | 0.62        | Highest        |
| 8. The training met participants' expectations                                        | 4.59        | 0.49        | Highest        |
| 9. Balance between theoretical and practical training was appropriate                 | 4.32        | 0.47        | Highest        |
| 10. Training enabled participants to understand procedures and practice independently | 4.22        | 0.58        | Highest        |
| <b>Subtotal</b>                                                                       | <b>4.33</b> | <b>0.26</b> | <b>Highest</b> |
| <b>Training media and equipment</b>                                                   |             |             |                |
| 11. Training materials and equipment were appropriate                                 | 4.16        | 0.44        | High           |
| 12. Training media enhanced understanding of fertilizer production                    | 4.16        | 0.50        | High           |
| 13. Materials and equipment were sufficient for participants                          | 4.19        | 0.46        | High           |
| 14. Audio-visual equipment was ready for use                                          | 4.41        | 0.49        | Highest        |
| 15. Overall satisfaction with the training of the farmer participants                 | 4.65        | 0.48        | Highest        |
| <b>Subtotal</b>                                                                       | <b>4.31</b> | <b>0.20</b> | <b>Highest</b> |
| <b>Overall mean</b>                                                                   | <b>4.32</b> | <b>0.13</b> | <b>Highest</b> |

## Discussion

These findings provided empirical evidence that participatory training grounded in adult learning and experiential learning, also the Participatory Action Research principles could effectively enhance farmers' knowledge, satisfaction, and adoption of sustainable fertilizer practices. The discussions were integrated the key findings to evaluate the roles of conditions, instructional quality, and participatory learning processes from the observed outcomes.

The farmer adoption of organic fertilizer done by rice straw fermentation showed gap between farmers' awareness and adoption in rice production. The farmer participants were possessed before getting the knowledge of organic fertilizer done by rice straw fermentation which the majority of participants were not applied into the rice fields. It may be due to the problem of organic fertilizer production process which lack of appropriated equipments and may concern on the slower nutrient release of produced organic fertilizer which a wrong techniques during fermentation process as the farmeres compared to chemical

fertilizers. (Pattanapant and Chaiprasert, 2019; Department of Rice, 2022). Similarly, international research had demonstrated that knowledge alone was insufficient to drive adoption unless it was supported by appropriate extension strategies and hands-on learning opportunities (Knowler and Bradshaw, 2007).

According to the strong demand for study visits, hands-on training, and demonstrations underscores the importance of participatory and experiential extension approaches. These findings aligned with participatory management and Participatory Action Research (PAR) principles, which emphasized on stakeholder involvement in problem identification, solution design, and implementation (Erwin, 1976; Pretty, 1995). By actively engaging farmers in practical activities, the training program addressed real constraints faced by the community and increased the relevance and feasibility of organic fertilizer production.

The high ratings for instructional video quality, particularly academic usefulness and content completeness, indicated that well-designed learning media could effectively support knowledge transfer among adult learners. This finding supported the adult learning theory, which emphasized relevance, self-directed learning, and the integration of learners' prior experience (Knowles, 1984), also this was consistent with recent studies highlighting the role of self-directed and participatory learning approaches in agricultural extension contexts (Balaji, 2025). In addition to extension approaches, instructional quality also played a critical role in enhancing learning outcomes. The availability of video-based materials allowed farmers to review content repeatedly, thereby reinforcing learning and supporting the sustained application of new practices (Zoundji *et al.*, 2024).

The significant increase in post-training knowledge scores, together with a very large effect size, provided strong empirical evidence of the effectiveness of the participatory training approach. The very large effect size might reflect the low baseline knowledge of participants combined with the intensive, hands-on nature of the training and the relatively small, well-defined participant group. This finding was consistent with the experiential learning theory, which emphasized on learning through direct experience and practice (Kolb, 1984). Similar improvements in farmers' technical knowledge have been reported in both Thai and international studies employing hands on and practice-oriented training methods (Soythong, 2018; FAO, 2017).

The consistently high levels of satisfaction with the training program on rice straw pellet organic fertilizer further support the effectiveness and acceptability of the program. A high level of satisfaction with training content, activities, and media suggested that the program successfully met farmers' expectations and addressed their practical needs. Satisfaction was a critical factor

influencing continued participation and the long-term adoption of agricultural innovations (Rogers, 2003). In this study, a high of satisfaction was associated with the continued use of rice straw pellet organic fertilizer and the dissemination of knowledge to other farmers, indicating the potential for broader community-level impacts.

In overall, the integrated findings from the main results demonstrated that the success of the training program could be attributed to the combination of participatory learning, adult learning principles, and experiential training within a Participatory Action Research (PAR) framework. This research findings are not only to encourage farmers' knowledge and skills but also to facilitate the behavioral change and the adoption of organic fertilizer done by rice straw fermentation practices. These outcomes are contributed to sustain the rice farming by promoting the efficient use of rice straw waste which targeted to reduce chemical fertilizer application which can be supported to the environmentally friendly practices. It is supported by the national and international sustainability goals (Department of Rice, 2022; FAO, 2021).

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### **Conflicts of interest**

The authors declare no conflict of interest.

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