ผลของการอบรมเชิงบรรยายต่อความรู้และความตระหนักเกี่ยวกับการควบคุมโดยชีววิธีด้วยไรโซแบคทีเรียที่ส่งเสริมการเจริญเติบโตของพืช ของเกษตรกรจังหวัดพิษณุโลก ประเทศไทย

Impact of a Lecture-based Intervention on Knowledge and Awareness of Plant Growth Promoting Rhizobacteria as a Biological Control Measure Among Farmers in Phitsanulok, Thailand

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Abstract: Misuse and overuse of pesticides have long been a serious problem in Thailand. Plant Growth Promoting Rhizobacteria (PGPR) has currently been a promising environmental-friendly alternative to synthetic pesticides in controlling plant diseases. The objectives of this study were to (1) investigate the effect of a lecture-based intervention on farmers' knowledge and awareness; and (2) examine the relationship between prior conditions and their knowledge and awareness of PGPR as a biological control measure. This one-group, pre-post, quasi-experimental study was conducted in Phitsanulok, Thailand. The intervention consisted of a one-day lecture/discussion and a field demonstration, with one-, three-, and six-month follow-ups. Thirty-two farmers participated in this study. The results indicated that the intervention significantly affected farmers' knowledge. In addition, the gain of knowledge was consistent in farmers of different age, gender, educational level, and frequency of pesticide use. However, the intervention could not create a significant difference on farmers' awareness, except a minor improvement in the awareness of pesticide harm. Changes of knowledge persisted to six months. Education was an important prior condition that determined the level of knowledge and awareness among participants. In conclusion, the lecture-based intervention had a significantly impact on farmers' knowledge of PGPR as a biological control measure.

Keywords: Diffusion of Innovations, intervention, Plant Growth Promoting Rhizobacteria, knowledge, awareness

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บทคัดย่อ: การใช้สารปราบศัตรูพืชอย่างไม่เหมาะสมเป็นปัญหาสำคัญสำหรับประเทศไทย เมื่อไม่นานมานี้ไรโซแบคทีเรียที่ส่งเสริมการเจริญเติบโตของพืช (พีจีพีอาร์) ได้รับการพิสูจน์แล้วว่า เป็นทางเลือกในการควบคุมโรคพืชที่เป็นมิตรต่อสิ่งแวดล้อมมากกว่าสารเคมี วัตถุประสงค์ของการวิจัยครั้งนี้เพื่อ (1) ศึกษาผลของโครงการอบรมที่มีต่อความรู้และความตระหนักของเกษตรกร และ (2) ศึกษาความสัมพันธ์ระหว่างปัจจัยพื้นฐานกับความรู้และความตระหนักของเกษตรกรเกี่ยวกับการจัดการและควบคุมศัตรูพืชด้วยพีจีพีอาร์ การวิจัยนี้เป็นแบบกึ่งทดลอง ตัวอย่างกลุ่มเดียว ทดสอบก่อนและหลัง ดำเนินการในจังหวัดพิษณุโลก การอบรมประกอบด้วยการบรรยายและอภิปรายร่วมกับการเยี่ยมชมแปลงสาธิต ติดตามผลที่ 1 3 และ 6 เดือนหลังการอบรม มีเกษตรกรเข้าร่วมในการวิจัยทั้งสิ้น 32 ราย ผลการวิจัยพบว่าการอบรมสามารถเพิ่มความรู้ของเกษตรกรได้อย่างมีนัยสำคัญ เกษตรกรที่มีอายุ เพศ ระดับการศึกษา และความถี่ในการใช้สารปราบศัตรูพืชมีการเพิ่มขึ้นของความรู้ใกล้เคียงกัน อย่างไรก็ตาม การอบรมไม่สามารถเพิ่มความตระหนักของเกษตรกรได้อย่างมีนัยสำคัญ ยกเว้นความตระหนักต่ออันตรายของสารปราบศัตรูพืช ความรู้ที่เพิ่มขึ้นของเกษตรกรมีความคงทนถึง 6 เดือนหลังการอบรม การศึกษาไม่ใช่ปัจจัยพื้นฐานที่ทำนายระดับความรู้และความตระหนักของเกษตรกร โดยสรุป การอบรมเชิงบรรยายสามารถเพิ่มความรู้ของเกษตรกรเกี่ยวกับการจัดการและควบคุมศัตรูพืชด้วยพีจีพีอาร์

คำสำคัญ: การแพร่กระจายของนวัตกรรม การอบรม แบคทีเรียหากินอิสระรอบรากพืชที่ส่งเสริมการเจริญเติบโตของพืชความรู้ ความตระหนัก

Introductin

The use of chemical pesticides for plant disease control is widespread in Thailand since most farmers believe that they are the only option for maintaining the quality and quantity of their produces. During 1999-2004, the total quantity of imported pesticides increased from 51,344 to 99,839 tons, causing the escalated values from 6,417.46 to 10,372.07 million Baht (Office of Agricultural Economics, 2005). Besides negative economic impacts to the country, continuous misuse and overuse of pesticides cause dramatic impacts on human health and the environment (Food and Drug Administration, 2004).

Phitsanulok is located in the lower-northern region of Thailand. The province has the area of 10,815 sq km. The main source of incomes of its people come from agriculture, especially rice and field crops. The majority of farmer in Phitsanulok was found to use pesticides aggressively and without proper protection (Kanato, 1998).

In recent years, microbial inoculant technology involving plant-beneficial microorganisms such as Plant Growth Promoting Rhizobacteria (PGPR) has drawn substantial attention from scientists around the world as a more environmentally-friendly method to regulate plant diseases compared to chemical agents (Kloepper *et al*., 1986; van Peer *et al*., 1991; Wei *et al*., 1992; Glick *et al*., 1994; Raupach *et al*., 1996; Zhang *et al*., 1996). This innovation is currently one of the promising tools for sustainable plant production. Greenhouse and field studies in Phitsanulok have found PGPR to be effective in plant disease control (Jetiyanon and Kloepper., 2002; Jetiyanon *et al*., 2003). The technology was ready to be transferred to farmers in the area. Unfortunately, numbers of initiatives from both governmental and non-governmental entities to promote the adoption and diffusion of more sustainable agricultural technologies among farmers have been so far disappointing. Experiences from a large number of projects indicated that the problem of such failure lie in the incompatibilities of the innovation introduced with the adopters (Laper *et al.*, 1999). Appropriate knowledge and awareness of the innovation must be established among the adopters prior to the introduction of innovation.

The objectives of this study were: (1) to examine the effect of intervention on farmers' knowledge and awareness of PGPR as a biological control method; and (2) to examine the relationship between prior conditions (i.e., age, gender, educational level, and frequency of pesticide use) and knowledge and awareness of PGPR as a biological control measure among farmers in Phitsanulok.

Materials and Methods

This one-group, pre-post, quasi-experimental study was conducted between October 2004 and May 2005, as parts of an on-going project which attempts to persuade vegetable growers to switch from heavy chemical use to the adoption of PGPR technique. The study protocol was approved by Naresuan University Institutional Review Board.

The Intervention

Public outreaches to announce the intervention were conducted by the research team one month prior to the scheduling date. All farmers who expressed their interest were invited to join a one-day lecture/discussion and a field demonstration at Naresuan University. Transportation was provided for those who had difficulty traveling to the location.

The one-day intervention consisted of two parts: (1) a lecture and group discussion by the researchers/innovators, and (2) a field demonstration. These activities were aimed at increasing knowledge and awareness of the innovation among participating farmers. The lecture/discussion was designed to include three types of knowledge about the innovation: awareness knowledge, how-to knowledge, and principles knowledge. Awareness knowledge was defined as information about the existence of an innovation. How-to knowledge was the information on how to use such innovation properly. Finally, principles knowledge was the information required to understand the functioning principles of the innovation. The lecture/discussion began with the principles knowledge including plant diseases and disease control, as well as general information on PGPR. The lecture/discussion then proceeded to the existence of the innovation (PGPR) and how it worked; the outcomes and advantages of PGPR in terms of plant growth promotion, disease resistance, and environmental friendliness. At the end, the how-to knowledge was introduced and field demonstration was carried out. All aspects of the lecture/discussion were made in lay terminology. During the lecture/discussion and field demonstration, farmers were given opportunities to discuss their ideas with the innovators and their peers.

The Measurements

Knowledge and awareness were examined by a brief questionnaire which was administered by a group of trained interviewers at pre-intervention, immediately after the intervention, and at one, three, and six months after the intervention. The instrument was pilot tested to assess its reliability and validity in a sample of farmers in Phitsanulok.

The revised questionnaire comprised of ten questions on knowledge:

1. When is the appropriate time for safely harvesting agricultural produce after chemical application?
2. Can some fungi, bacteria, and virus in the environment be the cause of diseases in plants?
3. Can plants be induced against diseases?
4. What is "biological control?"
5. Can some fungi, bacteria, and virus in the environment be beneficial to the plants?
6. Is there any measure besides chemical application to control plant diseases?
7. What is "PGPR?"
8. What is the benefit of PGPR to the plants?
9. What is <u>not</u> the benefit of PGPR to the plants?
10. How should PGPR be applied to the plants?

Ten questions assessing awareness of the farmers:

1. In general, pesticides do not harm the farmers who apply them.
2. There should be some other alternatives to pesticides.
3. Pesticides can be resided in the soil and environment after application.
4. Pesticides are highly reliable in controlling pest.
5. Pesticides are cost-effective.
6. Pesticide-contaminated vegetables can be consumed without any harm.
7. Pesticide residues can be degraded rapidly in the environment.
8. Currently, farmers already have a good measure for plant diseases control.
9. Any alternative method does not affect the current use of pesticides.
10. In general, farmers appreciate their use of pesticides for plant diseases control more than any other measures.

In addition, farmers' characteristics and prior conditions were explored.

Data Analysis

Changes in farmers' knowledge and awareness as a result of the intervention were analyzed by Wilcoxon Sign Ranks or paired t-tests. Independent samples t-tests were utilized to assess the differences in knowledge and awareness scores among farmers with dissimilar characteristics and prior conditions. The level of significance was set at 0.05.

Results

The Participants

Thirty-two farmers consented to participate in this study. The majority of them were female (23, 71.9%). More than half (21, 65.6%) had some primary school education. The rest (11, 34.4%) had at least some of secondary school background. The average age of the participants was 44.3$\pm$12.9 years old (range 23-70).

Impact of the Intervention on Knowledge and Awareness

At pre-intervention, the majority of participants (60-75%) accurately answered questions 1, 2, and 6, whereas approximately 30-40% had already comprehended questions 3, 4, and 5. Very few were able to answer questions 7, 8, 9, and 10, which were specific knowledge regarding PGPR technique. Immediately after the intervention, every question in the test was correctly identified by more than 75% of the farmers, except for questions 3 and 4, which were related to general knowledge about pathogens and biological control where approximately half of the farmers obtained correct answers. However, this was significantly higher compared to pre-intervention (50.0 versus 31.3% for question 3, and 53.1 versus 34.4% for question 4). Correspondingly, total knowledge scores increased significantly (P<0.001) after the intervention. This level of knowledge appeared to persist at follow-ups (Table 1).

Before the intervention, the majority of participants exhibited positive feelings about the use of pesticides (Table 2). For example, 34% agreed that "In general, pesticides do not harm the farmers who apply them." Even though most of the farmers (97%) believed that the residue of pesticides could

Table 1 **Participants' knowledge of PGPR as a biological control measure at pre-intervention, immediately after intervention, and one-, three-, and six-months follow-ups.**

Question	Number (percent) correctly answered				
	Pre-intervention (n=32)	Immediately after intervention (n=32)	One-month follow up (n=14)	Three-month follow up (n=10)	Six-month follow up (n=12)
1.	20 (62.5)	27 (84.4)* a	9 (64.3)	1 (10.0)* c	10 (83.3)
2.	23 (71.9)	24 (75.0)	13 (92.9)	9 (90.0)	11 (91.7)
3.	10 (31.3)	16 (50.0)* a	6 (42.9)	4 (40.0)	5 (41.7)
4.	11 (34.4)	17 (53.1)* a	2 (14.3)* c	3 (30.0)	4 (33.3)
5.	13 (40.6)	26 (81.3)** a	10 (71.4)	5 (50.0)	12 (100.0)* c
6.	24 (75.0)	28 (87.5)	12 (85.7)	7 (70.0)	10 (83.3)
7.	1 (3.1)	27 (84.4)** a	11 (78.6)	7 (70.0)	10 (83.3)
8.	5 (15.6)	27 (84.4)** a	13 (92.9)	9 (90.0)	11 (91.7)
9.	5 (15.6)	25 (78.1)** a	11 (78.6)	9 (90.0)	9 (75.0)
10.	4 (12.5)	30 (93.8)** a	14 (100.0)	9 (90.0)	10 (83.3)
Total score±SD	3.63±1.98	7.72±1.84** b	7.21±1.80	6.22±2.28	7.67±2.39

Note. Question 1. When is the appropriate time for safely harvesting agricultural produce after chemical application?; 2. Can some fungi, bacteria, and virus in the environment be the cause of diseases in plants?; 3. Can plants be induced against diseases?; 4. What is "biological control?"; 5. Can some fungi, bacteria, and virus in the environment be beneficial to the plants?; 6. Is there any measure besides chemical application to control plant diseases?; 7. What is "PGPR?"; 8. What is the benefit of PGPR to the plants?; 9. What is not the benefit of PGPR to the plants?; and 10. How should PGPR be applied to the plants?

[a]Wilcoxon Signed Ranks Test, compared with pre-intervention. [b]Paired Samples t Test, compared with pre-intervention. [c]Wilcoxon Signed Ranks Test, compared with immediately after intervention.

* P<0.05 ** P<0.001

Table 2 Participants' awareness of PGPR as a biological control measure at pre-intervention, immediately after intervention, and one-, three-, and six-months follow-ups.

Statement	Number (percent) agreed or strongly agreed				
	Pre-intervention (n=32)	Immediately after intervention (n=32)	One-month follow up (n=14)	Three-month follow up (n=10)	Six-month follow up (n=12)
1.	11 (34.4)	7 (21.9)	3 (21.4)	8 (80.0)	4 (33.3)
2.	27 (84.4)	25 (78.1)	12 (85.7)	8 (80.0)	12 (100.0)
3.	31 (96.9)	28 (87.6)	12 (85.7)	10 (100.0)	12 (100.0)
4.	14 (43.7)	16 (50.0)	7 (50.0)	5 (50.0)	7 (58.3)
5.	19 (59.4)	20 (62.6)	9 (64.3)	6 (60.0)	8 (66.7)
6.	8 (25.0)	8 (25.1)	6 (42.9)	7 (70.0)	5 (41.7)
7.	16 (50.0)	6 (18.7)* a	6 (42.9)	4 (40.0)	6 (50.0)
8.	24 (75.0)	21 (65.7)	9 (64.3)	4 (40.0)	8 (66.7)
9.	11 (34.4)	8 (25.0)	6 (42.9)	3 (30.0)	1 (16.7)
10.	22 (68.8)	16 (50.0)	10 (71.4)	5 (50.0)	6 (50.0)

Note. Statement 1. In general, pesticides do not harm the farmers who apply them.; 2. There should be some other alternatives to pesticides.; 3. Pesticides can be resided in the soil and environment after application.; 4. Pesticides are highly reliable in controlling pest.; 5. Pesticides are cost-effective.; 6. Pesticide-contaminated vegetables can be consumed without any harm.; 7. Pesticide residues can be degraded rapidly in the environment.; 8. Currently, farmers already have a good measure for plant diseases control.; 9. Any alternative method does not affect the current use of pesticides.; and 10. In general, farmers appreciate their use of pesticides for plant diseases control more than any other measures.

[a] Wilcoxon Signed Ranks Test, compared with pre-intervention

* P<0.01

reside in the environment, half (50%) believed that the environment would be able to cleanse itself rapidly. One-fourth of the farmers understood that the consumers would be safe ingesting these produces, and about half (44%) believed that pesticides were highly reliable. More than half of the farmers were convinced that their current pest-control methods were trustworthy (75%), and the use of pesticides was cost-effective (60%). Positively for the aforementioned reasons, only a few (34%) agreed with the idea of replacing their current methods with an alternative.

The intervention could not significantly alter their awareness, except for the item 7, "Pesticide residues can be degraded rapidly in the environment." That is, significantly fewer farmers agreed with this statement (18.7% at post-intervention versus 50% at pre-intervention, P<0.05). Approximately the same levels of awareness continued to at least six months

Awareness items were then grouped into three domains, namely (1) awareness of pesticide harm, (2) awareness of ineffectiveness to costs of pesticide use, and (3) awareness of alternatives to pesticide use (Table 3).

Table 3 Domains of awareness among participants at pre-intervention, immediately after intervention, and one-, three-, and six-months follow-ups[a].

Domain (item number)	Mean±SD score				
	Pre-intervention (n=32)	Immediately after intervention (n=32)	One-month follow up (n=14)	Three-month follow up (n=10)	Six-month follow up (n=12)
1. Awareness of pesticide harm (1, 3r[d], 6, 7)	11.93±1.94	12.07±1.87* b	11.43±2.28	11.20±2.90	11.42±1.78
2. Awareness of ineffectiveness to costs of pesticide use (4, 5)	4.87±1.41	4.48±1.40	4.79±1.81	4.30±1.70	2.50±0.67** c
3. Awareness of alternatives to pesticide use (2r[d], 8, 9, 10)	10.00±1.70	10.45±1.99	10.08±2.47	13.20±3.94	11.08±1.44

Note. [a]Higher scores indicated greater awareness, [b]Paired Samples t Test, compared with pre-intervention. [c]Paired Samples t Test, compared with immediately after intervention. [d]Reverted scale.

* P<0.05 **P <0.005

Higher scores indicated greater awareness. Before the intervention, the participants showed moderate awareness levels in all domains, meaning that they are indifferent of pesticide use. Immediately after the intervention, awareness of pesticide harm increased significantly (P<0.05). However, their awareness of the ineffectiveness to costs of and alternatives to pesticides remained the same after intervention. At one-, three- and six-month follow-ups, the same levels of awareness in all domains were reported. Interestingly, however, the farmers exhibited significantly lower awareness of ineffectiveness to costs of pesticides at six-month follow-up compared with post-intervention. This drastic drop of awareness had not been evident at all in one- or three-month follow-up visits.

Factors Affecting Knowledge and Awareness

Four prior conditions were hypothesized to affect the level of knowledge and awareness among farmers, i.e., age (under/over 40), gender (male/female), educational level (some primary/some secondary school), and frequency of chemical use (frequent/non-frequent users). To test these hypotheses, baseline knowledge and awareness scores of participants of different conditions were compared (Table 4).

Table 4 Basic knowledge and awareness among participants of different age, gender, educational level and frequency of pesticide use.

Hypothesized variable (valid n)	Mean±SD score			
	Prior knowledge	Prior awareness of pesticide harm	Prior awareness of ineffectiveness to costs of pesticide use	Prior awareness of alternatives to pesticide use
Age:				
≤ 40 (n=11)	4.36±1.80	10.00±1.73	5.27±1.56	11.09±1.58
> 40 (n=20)	3.05±1.85	9.75±1.71	4.70±1.34	9.40±1.54** a
Gender:				
Male (n=9)	3.55±1.94	8.89±1.45	4.55±1.59	9.89±1.83
Female (n=23)	3.65±2.03	10.17±1.64* a	5.00±1.35	10.04±1.69
Education:				
Primary school (n=21)	3.05±1.86	9.38±1.75	4.77±1.44	9.57±1.69
Secondary school (n=11)	4.73±1.80* a	10.64±1.21* a	5.09±1.38	10.82±1.47* a
Frequency of pesticide use:				
Frequent user (n=17)	3.41±1.97	9.88±1.61	4.71±1.49	10.24±1.82
Non-frequent user (n=11)	4.00±2.28	9.27±1.49	4.82±1.33	9.73±1.62

Note. [a]Independent samples t test.

* P<0.05 **P <0.001

Education: Educational level was a very important factor to distinguish prior knowledge and awareness levelsamong farmers. Farmers who received at least some secondary school education exhibited significantly greater knowledge and awareness of pesticide safety and alternatives to pesticide use than those with primary school education (P<0.05).

Age: At pre-intervention, awareness of alternative to pesticide use notably differed among farmers of dissimilar age groups (P<0.005). Younger farmers were more aware of other options than their older counterparts.

Gender: With regard to gender, female farmers demonstrated considerably higher level of awareness about harms of pesticides than males (P<0.05).

Frequency of Pesticide Use: Frequent users were defined as those who reported applying pesticides at least once a week. In this study, we found no statistical difference between knowledge and awareness among frequent and non-frequent users.

Discussion and Conclusion

Before discussing the results of this study, few limitations need to be addressed. First, the study was conducted on one location, i.e., Phitsanulok. The result may not be generalizable to farmers of different locations. Second, due to the participatory nature of this study, only a group of interested farmers volunteered to partake in our one-day, lecture-based intervention. This small number of participants was the main disadvantage of this study. In addition, loss to follow-up contributed to even smaller number of participants. Statistical analysis results must be interpreted with caution.

The inability of our intervention to shift participants' awareness was hypothesized to be due to the fact that knowledge is only one among many factors affecting the formation of awareness. As Ajzen (1988) mentioned, awareness or attitudes consist of the cognitive, affective and conative elements. The cognitive component of attitudes is formed by knowledge, direct experience and related information about the object. The affective component is shaped by the person's assessment (emotions or feeling) toward the object. Finally, the conative component is shaped by the individual's absolute and relative intention to practice. In this study, our intervention focused solely on providing information, hence targeting the cognitive part. The other elements need to be taken into consideration to achieve awareness formation. Previous studies had shown that hands-on experience and participatory activities were effective in changing farmers' perception and awareness (Wadsworth, 1990; Bacic *et al*., 2006). Likewise, regular visits by change agents were proved to be effective in changing farmers' awareness and intention to adopt new technologies (Williamson *et al*., 1988; Schuck *et al*., 2002). Only when awareness is formed, one can move to the next stage of adoption process, i.e., persuasion.

Farmers with more years in school were more knowledgeable of PGPR as a biological control measure than those with less schooling. We also found that female farmers were more concerned about pesticide safety than male farmers. Additionally, younger farmers were more aware of alternatives to pesticides than older ones. Our findings were consistent with previous studies (Black and Reeve, 1993; Morris *et al*., 2000; Reece and Sumberg, 2003). In addition, these results confirm the presupposition of Diffusion of Innovations Theory that prior conditions play an important role in the process of adoption (Rogers, 1983; Adesina and Zinnah, 1993; Adesina and Baidu-Forson, 1995). However, we did not find at pre-intervention any statistical difference between knowledge and awareness levels among farmers of different frequencies of pesticide use. This finding may indicate that some factors besides knowledge and awareness were critical in distinguishing farmers' pesticide use behavior. Exit interviews with 32 participating farmers on the intervention day revealed that, serious plant disease epidemic during that particular season was the main justification for them to use pesticide aggressively. We hypothesized, then, that lack of effective alternatives was the main factor in determining the use of pesticides among these farmers.

The last issue concerns the applicability of the theory itself. Since Diffusion of Innovations Theory was created in western culture environment (Rogers, 1983), there is a possibility that the theory may not be appropriately applied in Thai culture. Future studies should also address the issue about cultural implications and applications of the theory.

In conclusion, this study was the first of its kind to examine the results of a one-day, lecture based intervention on farmers' knowledge and awareness of PGPR as a biological control measure in the Thai context. The intervention exhibited a significantly positive impact on Phitsanulok farmers' knowledge of PGPR as a biological control measure. This change was robust, and persisted at least six months. However, the intervention was not enough to increase farmers' awareness of the issues, except a minor improvement in awareness of pesticide harm. Future studies concerning on awareness rising is highly warranted to move farmers along the adoption process.

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