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# Use of Biological Pest Control among Rice Farmers in Simorgh County of Mazandaran Province: Assessing Behavior Change for Promoting Adoption

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## ABSTRACT

**Continuous Biological Control (BC) of pests can reduce unnecessary pesticide applications in rice production, thus promoting occupational safety and health in farming. In this study, the Transtheoretical Model (TTM) of behavior change was examined for its applicability in explaining adoption and maintenance of BC use among 344 rice farmers of Simorgh County, Mazandaran Province in northern Iran, to better understand how farmers change their pest management behavior for incorporating BC. The stages of behavior change in BC use were assessed according to the TTM model, i.e. Pre-Contemplation (PC), Contemplation (C), Preparation (PR), Action (A), and Maintenance (M), in the management of rice stem borer [*Chilo suppressalis* (Walker)]. Almost three quarters (75.1%) of the farmers were in pre-action stages (43.1% in PC stage, 16.3% in C stage, and 15.7% in PR stage), 15.1% were changing their behavior (A stage), and while few farmers (9.8%) reported continuous use of BC agents for more than two cropping seasons (M stage). Farmers in the early stages of TTM model showed lower education levels, higher income, lower self-consumption of rice, higher grain yields, higher damage by rice stem borer, and lower knowledge levels about natural enemies than those who were in the later stages of change. Moreover, self-efficacy in BC use and perceived advantages of BC use increased through the stages of change, whereas the perceived disadvantages of BC use decreased. This is the first report supporting the appropriateness of the TTM in explaining farmers' behavior change in BC use, which provides novel evidence on farmers' adoption process of BC. Extension measures should focus on usual obstacles related to BC use, such as perceived advantages and disadvantages of BC as well as self-efficacy in BC use, targeting to match the stage of change with various intervention strategies.**

**Keywords:** Biological Control Adoption, Environmental health, Rice stem borer, Stage of change theory, Transtheoretical model.



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## INTRODUCTION

In Mazandaran Province of northern Iran, many people are employed in rice farming, which serves as a major source of income (Razzaghi-Borkhani *et al.*, 2013). Nearly 40% of the total cultivated land for rice production in the country is in this province (MAJ, 2015). Rice is grown under both traditional and mechanized systems in this region (Agha-Alikhani *et al.*, 2013). However, different pest threats inflict heavy damage to the crop (Ghiasi *et al.*, 2017). The Asiatic rice borer, *Chilo suppressalis* (Walker) (Lepidoptera: Crambidae), is one of the main pests affecting rice production in Mazandaran paddy fields (Noorhosseini *et*

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*al.*, 2010), causing about 15% annual yield losses (Asadpour, 2011).

The use of pesticides for managing pests in rice fields is common among farmers in Mazandaran Province to the extent that it is recognized as a necessary practice for the current rice production systems (Abdollahzadeh *et al.*, 2017b). Indeed, rice farmers frequently apply higher rates of pesticides than those recommended by experts and extension agents (Abdollahzadeh *et al.*, 2015), considering that farmers usually believe that "if little is good, a lot more will be better" (Aktar *et al.*, 2009). Therefore, almost 80% of the rice farmers use chemical methods for pest control (Mahdavi and Fahimi, 2001). Especially, the provinces located on the southern coast of the Caspian Sea in northern Iran (i.e., Mazandaran, Guilan, and Golestan) use about 60% of the total pesticides used in the country (Heidari *et al*. 2007). In total, farmers use about 26,000 tonnes of pesticides, including more than 140 different active ingredients each year (Veisi, 2012). Evidently, Iranian farmers have widely overused chemical pesticides (Karamidehkordi and Hashemi, 2010; Monfared *et al.*, 2015; Sharifzadeh *et al.*, 2018). However, benefits from pesticide use can be accompanied by direct and indirect dangers for both humans and the environment (Damalas, 2009). Hence, serious impacts on public health and agroecosystem sustainability have occurred by uncontrolled pesticide applications in several provinces of the country (Hashemi *et al.*, 2012).

To deal with the negative effects of pesticide application, the government of Iran decided to promote clean production strategies in paddy fields (Veisi, 2012). In the early 1990s, the Iranian Ministry of Agriculture Jahad (MAJ) launched Biological Control (BC) strategies with 3-5 releases of BC agents per cropping season to achieve adequate pest control (Veisi *et al.*, 2009). Biological control offers a low-cost, environmentally benign, and sustainable pest control strategy. Correct and consistent use of BC strategies was found effective in the prevention of stem borer outbreaks (Abdollahzadeh *et al.*, 2016a). Most BC strategies have dealt with natural enemies, especially *Trichogramma* spp. (Hymenoptera: Trichogrammatidae) for the control of rice stem borer (Abdollahzadeh *et al.*, 2016a). Implementation of governmental supportive programs in Iran has made BC strategies readily accessible to farmers by covering a part of BC costs and providing agents for implementation of BC, farmers' field schools, and extension training programs (Abdollahzadeh *et al.*, 2016b, 2018).

Despite these initiatives for promotion of BC, insufficient acceptance by farmers has been an obstacle to successful adoption, especially the use of *Trichogramma* spp. wasps for pest control (Abdollahzadeh *et al.*, 2015). According to the annual report of Mazandaran Agriculture Jahad Organization (MAJO, 2015), the use of BC strategies by rice farmers and fruit growers in the area occurred at a quite slow pace. In other words, due to poor knowledge about BC strategies and lack of knowledge about potential risks of pesticides to human health and the environment, many farmers do not persistently employ *Trichogramma* spp. for the control of rice stem borer (Abdollahzadeh *et al.*, 2015).

The main purpose of this research was to examine the applicability of the Trans-Theoretical Model (TTM) of behavior change in explaining adoption and maintenance of BC use among paddy farmers in Mazandaran Province, Iran. The applicability of the TTM model has been examined in crop protection related issues. Gaining new insights into the stages of BC use and associated factors influencing Iranian paddy farmers can shed some light on better understanding BC adoption and assist future targeted interventions by crop protection experts, extension agents, and policy administrators to satisfy the needs of the studied population.

For better understanding the change of farmers' behavior for continuous use of BC,





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in this study, we applied the Transtheoretical Model (TTM), also known as the Stage Of Change (SOC) model (Prochaska *et al.*, 2002), which considers regular BC use as a dynamic and multi-determined process. The model provides a useful framework for understanding how individuals intentionally change their behaviors, with or without professional intervention. The TTM defines change as a gradual, continuous, and dynamic process. It holds that individuals do not go directly from old behaviors to new behaviors (e.g., from not using to always using BC), but progress through a sequence of stages: Pre-Contemplation (PC), Contemplation (C), Preparation (PR), Action (A), and Maintenance (M) (Horn, 1976).

The TTM confirms that people differ in the level of readiness to adopt new behaviors, considering that change of a behavior, i.e. from using chemical control to using BC, is mediated by three core constructs: stages of change, self-efficacy, and decisional balance. Self-efficacy refers to the degree of confidence in one's ability to perform a specific behavior (Bandura, 1977), while decisional balance refers to an individual's perception of the importance of the pros (perceived advantages) vs. the cons (perceived disadvantages) of BC use (Prochaska *et al.*, 1992).

The model has been applied to a broad range of health behavior cases (Prochaska *et al.*, 1992; Prochaska *et al.*, 1994; Prochaska *et al.*, 2002). However, in the area of Integrated Ppest Management (IPM) adoption behavior and, specifically, the area of BC use adoption, the model has not received attention. In an earlier study, we found that farmers' acceptance of BC use as an alternative method to pest control in a paddy field setting in Iran could be accounted for stages of change and related TTM constructs, such as self-efficacy (Abdollahzadeh *et al.*, 2017a).

The purpose of this further study was to identify an extended range of factors associated with farmers' stages of change in the acceptance of BC use. We were particularly concerned to identify factors that could be used for the development of interventions for promoting BC adoption and other IPM measures use in paddy field of Iran.

## MATERIALS AND METHODS

### Sample and Sampling Procedure

A cross-sectional study was conducted in Simorgh County of Mazandaran Province, between April and June 2017. Mazandaran Province is located along the southern coast of the Caspian Sea and in the adjacent Central Alborz Mountain Range (Figure 1). The province enjoys a moderate, subtropical climate. Rainfall is bimodal and less than 800 mm annually in most parts of the area (Sharifzadeh *et al.*, 2019). The dominant farming system of the area is characterized by small-scale rice cultivation, which plays a key role in the livelihood of farmers. Other sources of the economy include, but are not limited to, paper, wood, fabrics and construction materials (Bijani *et al.*, 2019). The area was selected purposively because of farmers' experience in BC activities and of a large number of rice farmers who already received technical and financial assistance for their BC practices.

The main crops grown in the region are rice, citrus, wheat, soybean, rapeseed, kiwi, vegetable, strawberry, maize and clover. The region has a total area of 108 $km^2$. Rice farmers in Simorgh County comprised the sample for this study (N= 2,305). A multi-stage cluster sampling procedure was used for sampling. Administratively, Simorgh County was reduced to two districts, four sub-districts, and 30 villages as determined by the Ministry of Interior. We selected four villages in each sub-district. An initial list of rice farmers from those sixteen villages was then prepared and a random sample of farmers drawn. The number of farmers sampled from each village was proportional to the number of farmers in the village. Our questionnaires were distributed by local extension personnel (responsible for regular





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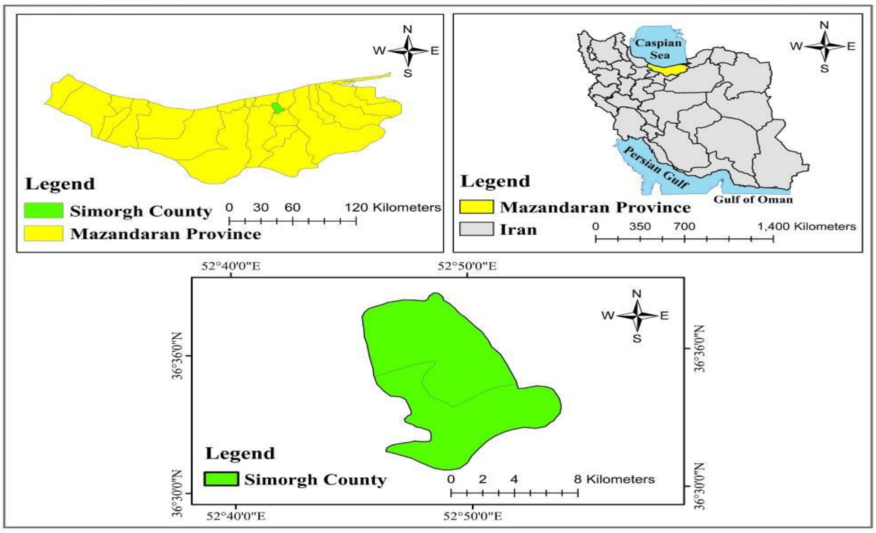


**Figure 1.** Location map of study area.

visiting fields in the study area), who received a survey pack i.e. questionnaires, instructions, promotional material, and training on introducing and disseminating the questionnaires to the farmers. Of the 360 questionnaires that were distributed, 344 were completed and returned by the farmers. Of these, twelve were less than 50% completed and were discarded, thus 332 questionnaires were considered for analysis. The number for the survey sample was calculated using the table of Krejcie and Morgan (1970).

## Data Collection and Measures

We designed the survey based on our prior works in BC adoption (Abdollahzadeh *et al.*, 2015; Abdollahzadeh *et al.*, 2017a; Sharifzadeh *et al.*, 2017; Abdollahzadeh *et al.*, 2018), a comprehensive review of IPM adoption literature, earlier work based on TTM of behavior change (Prochaska *et al.*, 1992; Prochaska *et al.*, 1994; Prochaska *et al.*, 2002), and exploring perspectives of key stakeholders of the agricultural sector (e.g., informants farmers, extension personnel, and providers of BC agents) on BC use in the province. A structured questionnaire was designed consisting of four main parts related to: (1) Farmers' characteristics, (2) Farms characteristics, (3) Perception of harmful effects of pesticides (related to cartap, fipronil, diazinon, fenitrothion, and thiodicarb commonly used in rice production), (4) Items assessing the three main constructs of TTM, i.e. stages of change for the use BC in rice stem borer management, decisional balance i.e. perceived advantages and disadvantages of BC, and self-efficacy in BC use. Ten items (five advantages and five disadvantages) were employed as measures for the perceived advantages and disadvantages of using BC. The items for measuring perceived advantages (pros) of using BC covered protection from hazards of pesticide use, customers' positive reaction to rice cultivation with BC use, maintenance of beneficial insects in field, reduced contamination of the farm environment, and less financial cost. Items for measuring perceived disadvantages (cons) of using BC covered incompatibility of BC to local warm and humid climate, unavailability of BC agents, poor technical skill of farmers, inadequate support and extension services, and low effectiveness of available *Trichogramma* spp. wasps for the control of rice stem borer. Four items for self-efficacy were written in such a way to assess farmers' level of ability and skill in dealing with *Trichogramma* spp. wasps for the control of rice stem borer under various circumstances in the field. Farmers were asked to rate how confident they would





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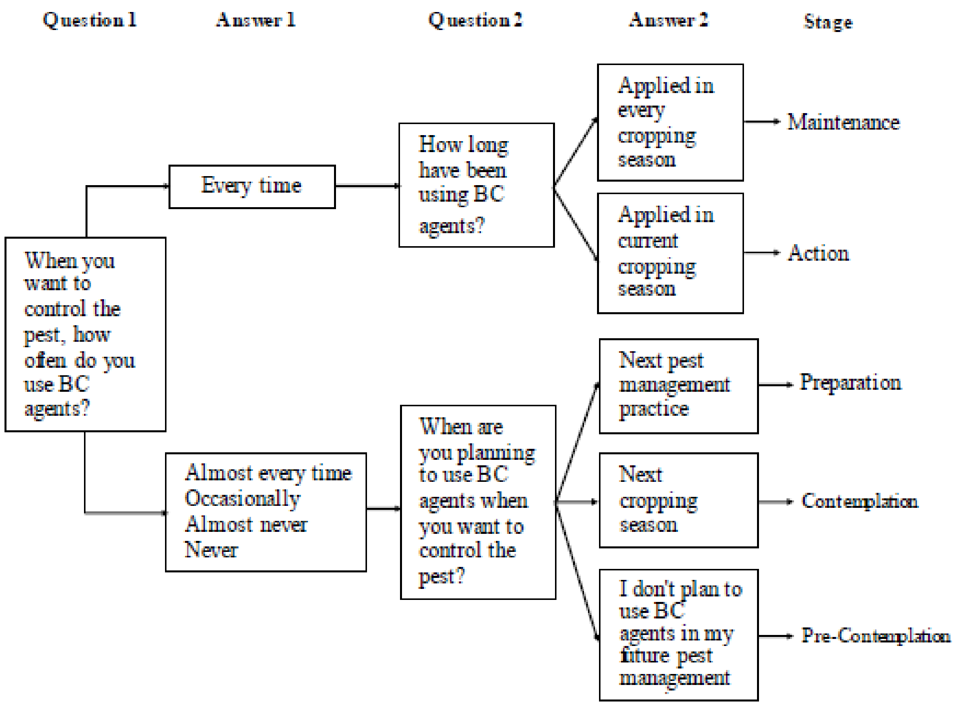


**Figure 2.** Classification framework of paddy farmers based on frequency and duration of *Trichogramma* spp. use and intention to use in future pest management practices.

be in using *Trichogramma* spp. wasps in a variety of situations (e.g. in an outbreak of rice stem borer; using *Trichogramma* spp. wasps in part of the farm, specifying the frequency of release of *Trichogramma* spp. wasps per cropping year, and specifying the number of *Trichogramma* spp. wasps in each time of release. High scores in the above items indicate high levels of farmers' confidence on the use of BC agents.

Seven items were used to measure perceptions of harmful effects of pesticides among farmers. These items included pesticides harmful effects on human health, death of livestock/poultry, damage to the environment, soil contamination and reduced fertility, production of toxic waste products, contamination of major water bodies, and destruction of natural enemies of pests. Each item was scored on a 5-point Likert-type scale (from 1= strongly agree to 5= Strongly disagree). The Cronbach's coefficient of all scales varied from 0.72 to 0.84, which showed good internal consistency. Measures for the perceptions of harmful effects of pesticides were derived from Abdollahzadeh *et al.* (2015a) and Rahman (2003b), whereas items related to perceived self-efficacy in BC use was adopted from Sharifzadeh *et al.* (2017). The scales gathered information relating to perceived advantages (pros) and disadvantages (cons) of BC use as well as stages of change towards BC use developed and initially pilot-tested in this study.

To measure the stage of change towards BC use as defined by the TTM i.e. using *Trichogramma* spp. for the management of rice stem borer in paddy fields, we developed a five-item algorithm to explore BC use among farmers involved in the management of rice stem borer. Farmers were classified into one of the five TTM stages, based on questions about frequency and duration of *Trichogramma* spp. use and intention to use *Trichogramma* spp. every time they wanted to control the rice stem borer in the future pest management practice (Figure 2). Farmers were first asked how often they used *Trichogramma* spp. for the control of rice stem borer during a cropping season.




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Farmers who reported persistent use of BC agents (i.e., every time) for more than two cropping seasons (and they had discarded using chemicals to control rice stem borer in their farms) were grouped into the Maintenance stage (M), whereas those using BC agents every time, but only for one cropping season or less were classified into the Action stage (A). Those who were not using BC agents every time, but intended to do so within the next pest management practice, were classified into the Preparation stage (PR), and those who intended to use BC agents within the next cropping season were classified into the Contemplation stage (C). Those who neither used BC agents nor intended to use them within the next cropping season were classified into the Pre-Contemplation stage (PC). Each farmer was asked to rate how important each statement is to the decision of using BC or not. A 5-point Likert-type response option was used, ranging from 1= Not important to 5= Extremely important. We pilot-tested the survey questionnaire among 30 farmers and revised it based on feedback about content and format as well as on input from additional extension personnel at the county agriculture office.

### Data Analysis

The Predictive Analytics Software (PASW) ver. 20.0 (formerly SPSS statistics) was employed to analyze data of the survey. To calculate differences between stages of change, we used an ANOVA-F test with a Tukey post-hoc comparison of stages. The chi-square test was used for group comparisons with respect to categorical variables. All P values were two-sided and considered statistically significant at P< 0.05.

## RESULTS

More than two third (75.1%) of all farmers were in pre-action stages (43.1% PC, 16.3% C, and 15.7% PR) (Table 1), 15.1% were changing their behavior (A stage), while few farmers (9.8%) reported persistence use of BC agents (every time) for more than two cropping seasons (M stage).

Farmers in PC, C, and PR stages had significantly lower (P< 0.01) education levels than those in the A and M stages (Table 2). Annual farm income was higher (P< 0.01) in the PC and C stages than in the PR, A, and M stages (Table 2). Rice self-consumption was lower (P< 0.01) in the pre-action stages (PC, C, and PR) than in the action stages (A and M) (Table 2). Farmers in the M and A stages showed higher levels of rice self-consumption, probably because they tended to pay more attention to the health status of rice produced for the consumers.

Higher rice grain yield (P< 0.01) for farmers in the PC and C stages than in the A and M stages was recorded (Table 3). Also, rice damage by stem borer was higher (P< 0.01) in the PC, C, and PR stages than in the A and M stages (Table 3). In fact, by increasing the level of product losses by stem borer, farmers' dependence on the use of pesticides increased, while by lowering yield losses by stem borer, farmers' loyalty to the BC was amplified.

**Table 1.** Stage of change in the use of *Trichogramma* spp. for the management of rice stem borer.

| Variable | Frequency | Percentage |
|---|---|---|
| Pre-Contemplation (PC) | 143 | 43.1 |
| Contemplation (C) | 54 | 16.3 |
| Preparation (PR) | 52 | 15.7 |
| Action (A) | 50 | 15.1 |
| Maintenance (M) | 33 | 9.9 |
| Total | 332 | 100.0 |





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**Table 2.** Farmers' characteristics across the stages of change.[a]

| Independent variable | | PC | C | PR | A | M | F-test |
|---|---|---|---|---|---|---|---|
| Age (years) | Mean | 42.9 | 39.6 | 43.7 | 43.2 | 39.8 | 1.09 ns |
| | SD | 13.6 | 12.8 | 14.4 | 14.3 | 12.5 | |
| Rice cultivation experience (Years) | Mean | 24.5 | 25.2 | 23.4 | 23.2 | 21.2 | 0.97 ns |
| | SD | 10.6 | 9.7 | 9.4 | 10.3 | 12.9 | |
| Education level (Years) | Mean | 4.3b | 4.6b | 4.6b | 8.6a | 9.2a | 12.08 ** |
| | SD | 4.5 | 5.2 | 6.1 | 5.2 | 5.2 | |
| Family size (No individuals) | Mean | 3.5 | 2.8 | 3.5 | 3.0 | 3.7 | 1.79 ns |
| | SD | 2.1 | 2.1 | 2.1 | 1.9 | 2.6 | |
| Share of family labor force in rice farming (%) | Mean | 24.2 | 23.1 | 26.3 | 29.5 | 30.8 | 1.62 ns |
| | SD | 18.8 | 20.2 | 18.1 | 16.9 | 16.2 | |
| Annual farm income (US $) | Mean | 8969.8a | 7288.4a | 5265.6b | 4304.0b | 4199.5b | |
| | SD | 8978.7 | 5405.8 | 2746.7 | 2803.6 | 3023.8 | 7.77 ** |
| Share of off-farm income (% Of total income) | Mean | 10.3 | 12.8 | 11.7 | 9.7 | 9.2 | 0.54 ns |
| | SD | 14.0 | 14.9 | 14.0 | 13.2 | 13.6 | |
| Self-consuming (kg $ha^{-1}$) | Mean | 11.6b | 10.1b | 12.6b | 21.1a | 22.2a | 8.34 ** |
| | SD | 13.0 | 13.9 | 13.2 | 14.8 | 16.7 | |

[a] PC: Pre-Contemplation; C: Contemplation; PR: Preparation; A: Action; M: Maintenance; SD: Standard Deviation; ns: Not significant, ** Significant at P< 0.01. (a-b) Different letters within each variable indicate statistically significant differences (Tukey test).

**Table 3.** Farm management characteristics across the stages of change.[a]

| Independent variable | | PC | C | PR | A | M | F-test |
|---|---|---|---|---|---|---|---|
| Rice crop area (ha) | Mean | 11.6 | 10.1 | 12.6 | 21.1 | 22.2 | 1.21 ns |
| | SD | 13.0 | 13.9 | 13.2 | 14.8 | 16.7 | |
| Rice grain yield (kg/ha) | Mean | 3.9a | 4.0a | 3.8a | 3.3b | 3.3b | 5.99 ** |
| | SD | 0.9 | 1.1 | 1.0 | 1.2 | 1.0 | |
| Extension contacts (number per month) | Mean | 0.7 | 1.1 | 0.7 | 1.1 | 0.7 | 2.06 ns |
| | SD | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | |
| Rice damaged by stem borer (% of total production) | Mean | 13.4a | 12.7a | 10.5a | 6.5b | 5.7b | 13.85 ** |
| | SD | 7.9 | 8.1 | 7.9 | 5.6 | 3.9 | |

[a] PC: Pre-Contemplation; C: Contemplation; PR: Preparation; A: Action; M: Maintenance; SD: Standard Deviation; ns: Not significant, ** Significant at P< 0.01. (a-b) Different letters within each variable indicate statistically significant differences (Tukey test).





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Only 6.3% of the farmers in the PC stage reported that they had full knowledge about natural enemies of *C. suppressalis*, whereas a higher proportion (24.2%) claimed the same level of knowledge in the M stage (Table 4). With reference to technical training in BC use, 11.9% of the farmers in the PC stage had technical training on BC use, while 51.5% of the farmers in the M stage mentioned they had this type of training. When asked about trust in providers of BC agents, particularly in terms of timely provision of *Trichogramma* spp. wasps when an outbreak of rice stem borer occurred, about 67% of the farmers in the PC stage and 72% in the C stage did not trust providers of BC agents. On the contrary, about 62% and 63% of the farmers in the A and M stages stated they trusted providers of BC agents.

Scores of perceived self-efficacy in BC use differed significantly between the five stages of change (F= 13.19, P< 0.01) (Table 5). Self-efficacy in BC use was higher in the action stages (A and M) than in the pre-action stages (PC, C, and PR). Thus, farmers in the A and M stages had a higher ability and skill in dealing with *Trichogramma* spp. use for the control of rice stem borer under various circumstances in the field than farmers who did not consider taking action in BC use. The perceived advantages of BC use increased significantly through the stages of change (F= 17.01, P< 0.01). Post hoc comparisons revealed higher advantage scores for farmers in the M stage than in the PC and C stages (Table 5). For the perceived disadvantages of BC use, scores decreased significantly through the stages of change (F= 42.24, P< 0.01). Post hoc comparisons confirmed that the perceived disadvantages of BC use were higher in the PC and C than

**Table 4.** Farmers' recognition of BC and pesticide-related illness across the stages of change.[a]

| Independent variable | PC | C | PR | A | M | Chi square |
|---|---|---|---|---|---|---|
| Experience of pesticide-related illness | | | | | | |
| No | 63.6 | 61.1 | 65.4 | 54.0 | 42.4 | 6.6 ns |
| Yes | 32.2 | 35.2 | 32.7 | 40 | 54.5 | |
| Missing | 4.2 | 3.7 | 1.9 | 6.0 | 3.1 | |
| Knowledge about natural enemy of pest | | | | | | |
| No knowledge | 54.5 | 50.0 | 53.8 | 36.0 | 39.4 | 31.19 ** |
| Little | 25.2 | 27.8 | 19.2 | 18.0 | 12.1 | |
| Moderate | 10.5 | 18.5 | 19.2 | 28.0 | 21.2 | |
| Very good | 6.3 | 1.9 | 7.8 | 18.0 | 24.2 | |
| Missing | 3.5 | 1.8 | 0 | 0 | 3.1 | |
| Technical training on BC use | | | | | | |
| No | 83.9 | 77.8 | 75.0 | 46.0 | 39.4 | 46.38 ** |
| Yes | 11.9 | 18.5 | 25.0 | 50.0 | 51.5 | |
| Missing | 4.2 | 3.7 | 0 | 4 | 9.1 | |
| Trust in BC agent providers | | | | | | |
| No | 67.1 | 72.2 | 40.4 | 38.0 | 36.4 | 31.67 ** |
| Yes | 30.9 | 27.8 | 59.6 | 62.0 | 63.6 | |
| Missing | 2.0 | 0.0 | 0.0 | 0.0 | 0.0 | |

[a] PC: Pre-Contemplation; C: Contemplation; PR: Preparation; A: Action; M: Maintenance; SD: Standard Deviation; ns: Not significant, ** Significant at P< 0.01.





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**Table 5.** Farmers' perceived harmful effects of pesticides, perceived self-efficacy, and perceived advantages and disadvantages of BC use across the stages of change.

| Independent variable | | PC | C | PR | A | M | F-test |
|---|---|---|---|---|---|---|---|
| Perceived harmful effects of pesticides | Mean<br>SD | 3.3<br>0.7 | 3.4<br>0.8 | 3.4<br>0.5 | 3.5<br>0.8 | 3.6<br>0.9 | 1.13 ns |
| Perceived self-efficacy in BC use | Mean<br>SD | 2.7b<br>0.7 | 2.7b<br>0.8 | 3.0b<br>0.7 | 3.4a<br>0.8 | 3.6a<br>1.1 | 13.19 ** |
| Perceived advantages of BC use | Mean<br>SD | 2.7b<br>1.3 | 2.8b<br>1.3 | 3.1a<br>1.3 | 4.0a<br>0.9 | 4.3a<br>0.6 | 19.40 ** |
| Perceived disadvantages of BC use | Mean<br>SD | 3.9a<br>0.7 | 3.8a<br>0.7 | 3.5a<br>1.0 | 2.4b<br>1.2 | 2.1b<br>1.2 | 46.15 ** |

[a] PC: Pre-Contemplation; C: Contemplation; PR: Preparation; A: Action; M: Maintenance; SD: Standard Deviation; ns: Not significant, ** Significant at P< 0.01. All means on a scale from 1 to 5. (a-b**)** Different letters within each variable indicate statistically significant differences (Tukey test).

in the A and M stages (Table 5).

To aid comparisons with advantages and disadvantages in other behavior areas, the average scores through the stages of change are depicted in Figure 3, which shows the typical crossover between advantages and disadvantages between the PR and A stages. Farmers in the PC (t= -9.56, df= 142, P< 0.01) and C (t= -4.67, df= 53, P< 0.01) stages weighed the disadvantages of BC use significantly higher than the advantages. This was reversed in the A (t= 7.15, df= 49, P< 0.01) and M (t= 8.86, df= 32, P< 0.01) stages, where the advantages were perceived as more important than the disadvantages. The difference between advantages and disadvantages for the PR stage was not significant.

## DISCUSSION

This study explored the status of BC use among rice farmers in Mazandaran Province based on stages of behavior change of the TTM. The TTM is a framework for

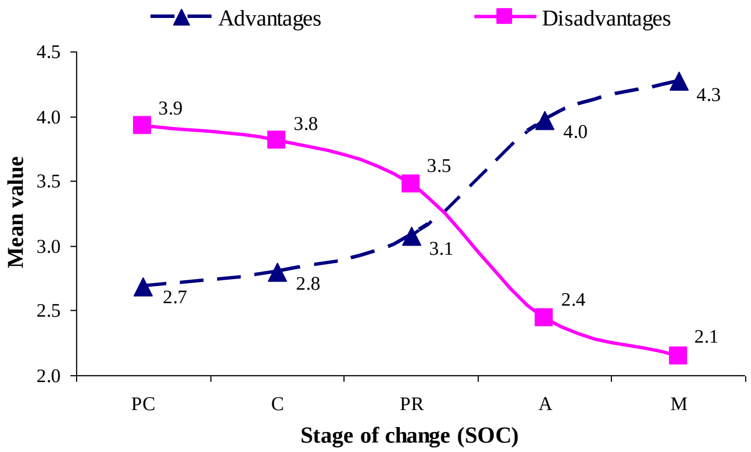


**Figure 3.** Means for perceived advantages and disadvantages of BC use (on a scale from 1 to 5) across the stages of change (PC: Pre-Contemplation; C: Contemplation; PR: Preparation; A: Action; M: Maintenance).





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understanding intentional behavioral change and has been used in several studies, particularly in the area of health-related behavior. However, the use of the TTM for explaining farmers’ behaviors towards BC use has not been reported in the literature. The results imply that the stages of change for maintaining a BC practice in the field can be characterized by differences in the perceived advantages and disadvantages of this behavior. In this context, the study could assist the selection of appropriate measures relative to the TTM stages of change in farmers dealing with control of *C. suppressalis* in rice, targeting to match the stage of change of farmers' behavior with various intervention strategies. Moreover, key concepts of the TTM could help extension agents recognize that farmers’ behavior pass through multiple stages with different readiness of farmers for behavior change. Therefore, the study provides a better understanding of farmers’ intention to change concerning BC use, which could be useful particularly for extension agents in future projects and campaigns. Subsequently, the extension agents could develop various strategies based on each specific stage of change to help farmers move forward in the adoption and maintenance of BC in their pest control practices.

Farmers who were in the later stages of change for BC use (A and M) had more education than those in the early stages (PC, C, and PR). As argued by Khan and Damalas (2015), higher levels of education are usually associated with less encouragement for pesticide use and thus education can be a basic determinant of environmentally sound behavior in pest control. Also, Khan *et al.* (2015) found that high levels of education were linked with decreased tendency of pesticide overuse. As the educated farmers are highly aware of the harmful effects of pesticides on the environment (Talukder *et al.,* 2017) and human health (Abdollahzadeh *et al.,* 2015), they are more concerned about the negative effects and thus more reluctant to use pesticides in current pest control practices (Rahman, 2003a). Accordingly, the educated farmers were in the later stages of change for BC use and tended to employ *Trichogramma* spp. for rice stem borer management. The results further revealed that the annual farm income of the studied farmers was higher in the earlier stages (PC) than in the later stages (M, A, and PR). A possible explanation for this trend might be the fact that farmers with high annual income always try to maintain or enhance earnings by applying more inputs, particularly chemical pesticides, since they strongly believe that the application of high rates of pesticides is more effective and could reduce yield losses (Abdollahzadeh *et al.,* 2015). On the other hand, since the use of BC strategies might decrease farmers’ crops yield and income in the short run, those who had high annual income tended not to use BC strategies and preferred to use pesticides and earn high income instead. In addition, caution should be considered in interpreting this result because the success of biological control in maintaining yield and reducing pest problem is highly dependent on the behavior of neighboring farmers in using this method.

Moreover, farmers in the action stages (A and M) had a higher level of rice self-consumption compared with farmers in the pre-action stages (PC, C, and PR). Since consumption of food products containing pesticide residues is hazardous and can endanger consumers’ health, farmers with a high level of rice self-consumption show greater willingness to use BC strategies and produce safe products. This view is supported by Rosenstock (1974), who applied the Health Belief Model (HBM). In other words, when farmers perceive that they are seriously exposed to pesticide-related risks and these risks have adverse effects on their lives, they are more likely to be motivated to use BC strategies.

Farmers in the early stages of change (PC and C) to use BC strategies had higher rice grain yields compared with those in later stages (A and M). Given that farmers considered the use of pesticides for increasing yields, those who had high rice grain yields recognized the use of pesticides as necessary inputs to maintain or increase their rice yields. Hence, chemical pest control with heavy use of pesticides was a rule for most farmers in Mazandaran Province, as they believed that non-use of pesticides could decrease yields (Abdollahzadeh *et al.*, 2015). The amount of rice damaged by stem borer was higher in the pre-action stages (PC, C, and PR) compared with action stages (A and M). Since farmers believed that heavy use of pesticides was more effective for eradicating pests, their dependency on pesticide use was enhanced with increasing amount of rice losses caused by stem borer. On the other hand, due to the effectiveness of BC strategies in the prevention of stem borer outbreaks (Abdollahzadeh *et al.*, 2016a), farmers who were in later stages of change to use BC experienced a lower amount of rice damage by stem borers.

Farmers in the later stages of change (A and M) had more knowledge about natural pest enemies compared to those in the early stages (PC, C, and PR). Given that BC strategies are relatively more complex than conventional methods of pest control, such as the use of pesticides, farmers who desire to use BC should have more information and knowledge about it. Accordingly, as farmers move towards later stages of change (action stages), they are more likely to have high knowledge of BC, particularly about natural enemies of pests. Farmers in the later stages of change (A and M) received more technical training on BC use compared with those in the early stages of change. As mentioned above, the use of BC strategies, like employing *Trichogramma* spp. for the management of rice stem borer, requires great familiarity with and adequate knowledge about those strategies. In this regard, it seems that one of the best methods for increasing familiarity with and knowledge about those strategies is to participate in the related training courses. Therefore, farmers who tend to use BC would become more sensitive and try to get more prepared for using BC strategies by receiving technical training on their application. By moving towards the later stages of change concerning BC use, farmers' levels of trust in providers of BC agents increased. This could be attributed to the fact that farmers who were in the action stages had more interactions with providers of BC agents to get the necessary information. Moreover, these farmers practically received the support of providers of BC agents and, consequently, got more confident in their abilities and commitments to help themselves when facing stem borer outbreaks.

Farmers in the later stages of change (A and M) exhibited higher levels of self-efficacy in using BC strategies compared with those in the earlier stages (PC, C, and PR). This finding is in agreement with the results of Sinelnikov and Wells (2017), who found self-efficacy as a central determinant of farmers' motivations for moving from preparation towards action. In fact, there is a linear enhancement of pre-contemplation towards maintenance in self-efficacy. This view was also supported by Velicer *et al.* (1990), who argued that self-efficacy increases through the stages of change and is an important predictor of stage, especially at the A and M stages. A possible explanation for this trend might be the fact that farmers who use BC gradually gain more experience and knowledge on the use of *Trichogramma* spp. for the management of rice stem borer and, consequently, feel more confident in their abilities and skills for using BC, namely, their self-efficacy in BC use means increases. On the other hand, Byrd-Bredbenner *et al.* (2007) asserted that perceived self-efficacy affects the degree of extended effort and persistence in a particular behavior. In fact, when self-efficacy increases, farmers gain more motivation (Brown *et al.*, 2000) and show better performance (Rezaei *et al*., 2018). In this respect, Orji *et al.* (2012) argued that the tendency of performing a particular behavior can be enhanced by increasing the feeling of confidence about this behavior, which then reduces the difficulty perceived for its performance. In total, increasing farmers' levels of self-efficacy in BC encourages the use of BC.

The decisional balance components of the TTM seem to be well supported by the results of this study. Farmers appeared to be able to consider both the perceived advantages (pros) and perceived disadvantages (cons) of using *Trichogramma* spp. for the management of rice stem borer. Farmers who were in the later stages of change concerning BC use felt that the advantages of such change outweigh the disadvantages. Conversely, those who were in the early stages of change concerning BC use considered only the negative aspects of BC. This attitude might be explained by the fact that farmers who use BC strategies in practice obviously understand the advantages of those strategies and thus form a more favorable attitude towards them, since the belief in BC efficacy (also known as the perceived benefits of BC) is significantly associated with a positive attitude towards it (Abdollahzadeh *et al.,* 2018). Conversely, farmers who are in the early stages of change and do not use BC cannot have a proper understanding of its strategies, so, they prefer to use pesticides for the control of rice stem borer, concentrating only on BC disadvantages. In line with this finding, Mohammadi Zeidi *et al.* (2011) argued that the advantages and disadvantages are relevant to the understanding and prediction of transitions between the stages of change. A change of behavior in the PC stage can result in outweighing disadvantages over advantages, while a change of behavior in the A and M stages follow an opposite trend. Similarly, Prochaska *et al.* (1994) found that the advantages for individuals at the A and M stages outweigh the disadvantages, whereas the opposite holds true for pre-contemplators (early stages). However, the rate of BC use among rice farmers would seemingly increase if advantages were clarified and highlighted. Therefore, providing farmers with correct and readily available information about BC is necessary. In this regard, providing rice farmers with large-scale training, particularly through mass media like radio and television, and encouraging them to participate in extension courses related to BC will be some effective interventions that should be emphasized by the relevant policy-makers and planners.

The present research has a number of strengths including examining for the first time the TTM of behavior change in the context of BC adoption through assessing driving and inhibiting factors to the use of BC in rice fields of Mazandaran Province. As evident in a set of recent publications in the biocontrol literature, a social science perspective has largely been missing in the assessment of advantages and disadvantages pertaining to BC diffusion in the world's smallholder farming systems. The study identifies a number of factors that likely hamper or drive BC use and describes its potential value to further promote IPM in local farming systems. On the other hand, there are also a number of limitations that should be kept in mind. First, data reflect self-reported action of farmers, which might imply some response bias often occurring when individuals offer self-assessed measures. However, the homogeneous population (rice farmers) and the sample size of the study (332 participants) kept this potential bias to a negligible level. Also, the process of behavior change was assessed with single items (dichotomizing behavior measure). This limitation did not allow assessment of causal inferences and potential variation in the assessed variables over time. Actually, the processes of behavior change are important constructs of the TTM, which have not been used yet and must be assessed in future studies. Hence, future research could focus on the process of change through studying farmers' status concerning BC use in different time periods. Another limitation of the study comes from the measures used in this work. However, previous research showed that the use of the single-item measure seemed quite reasonable when assessing stage of change (Cook and Perri, 2004). In this context, the current study allows talking about behavior change and stages of farmers' change behavior in the BC use for pest management practice. This study can be considered as a first step towards developing the necessary instruments for TTM-based interventions in the context of BC diffusion efforts. Therefore, further validation of the newly developed scales with external criteria, e.g. behavioral observation, is necessary. To this end, we have developed the necessary methodology and a study for validating self-report constructs with behavioral observation methods is on the way. Finally, we found that 9.8% of the farmers persistently used BC (every time), while the remaining (90.2%) did not use BC continuously. Caution should be exercised in generalizing the results to other farmer populations in comparable settings due to possible over-reporting or under-reporting of BC use.

## CONCLUSIONS

Biological Control use behavior change among rice farmers in Mazandaran Province can be reasonably well conceptualized within the TTM framework. Overall, our results are congruent with those of TTM applications in other behavior areas. The relationship between this model and the perceived self-efficacy in BC use and perceived advantages and disadvantages of BC use, is worthy of further investigation as interventions that incorporate strategies to promote the BC effectiveness also may have the potential to influence behavior change. Most farmers were found in pre-action stages, while few farmers reported persistent use of BC agents. Based on the findings of this study, key concepts of the TTM could help extension agents recognize that farmers' behavior pass through multiple stages with different readiness of farmers for behavior change. The extension agents could develop various strategies based on each specific stage of change to help farmers move forward in the adoption and maintenance of BC in their pest management practices.

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## استفاده از مبارزه بیولوژیکی آفات در بین برنجکاران شهرستان سیمرغ استان مازندران: ارزیابی تغییر رفتار برای ارتقاء پذیرش

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## چکیده

استفاده مداوم از مبارزه بیولوژیکی (BC) آفات می‌تواند استفاده غیرضروری از آفت‌کش‌ها در تولید برنج را کاهش داده و در نتیجه ایمنی و سلامتی شغلی در کشاورزی را ارتقا بخشد. در این مطالعه، کاربرد مدل فرانظریه‌ای (TTM) تغییر رفتار در تبیین پذیرش و حفظ استفاده از مبارزه بیولوژیک در بین ۳۴۴ نفر از کشاورزان برنجکار شهرستان سیمرغ، استان مازندران در شمال ایران، برای درک بهتر

اینکه چگونه کشاورزان رفتار مدیریت آفت را برای کاربرد مبارزه بیولوژیک تغییر می‌دهند، مورد بررسی قرار گرفت. مراحل تغییر رفتار در استفاده از مبارزه بیولوژیک طبق TTM [یعنی پیش‌اندیشه (PC) ، اندیشه (C) ، آمادگی (PR) ، عمل (A) و نگهداری (M)] در مدیریت آفت ساقه‌خوار برنج [*Chilo suppressalis* (Walker)] ارزیابی شد. تقریباً سه چهارم کشاورزان (۷۵/۱ درصد) در مراحل قبل از عمل (۴۳/۱ درصد در مرحله پیش‌اندیشه، ۱۶/۳ درصد در مرحله اندیشه و ۱۵/۷ درصد در مرحله آمادگی) بودند، ۱۵/۱ درصد در حال تغییر رفتار خود بودند (در مرحله عمل)، در حالی که معدودی از کشاورزان (۹/۹ درصد) بیان کدرند که در حال استفاده مداوم از مبارزه بیولوژیک برای بیش از دو فصل زراعی (مرحله نگه‌داری) هستند. کشاورزان مراحل اولیه TTM در مقایسه با کشاورزان مراحل بعدی تغییر، دارای میزان تحصیلات پایین‌تر، درآمد بالاتر، خود مصرفی کمتر برنج، عملکرد بالاتر، زیان بیشتر از آفت ساقه‌خوار برنج، سطح دانش پایین‌تر نسبت به دشمنان طبیعی آفات بودند. علاوه بر این، خودکارآمدی در کاربرد مبارزه بیولوژیک و مزایای درک شده از کاربرد آن از طریق مراحل تغییر افزایش یافته، در حالی که معایب درک شده از کاربرد مبارزه بیولوژیک کاهش یافته است. این نخستین گزارشی است که مناسب بودن TTM در توضیح تغییر رفتار کشاورزان در کاربرد مبارزه بیولوژیک، که شواهد جدیدی در مورد روند پذیرش آن را ارائه می‌دهد، پشتیبانی می-کند. اقدامات ترویجی باید بر روی موانع مرسوم مربوط به کاربرد مبارزه بیولوژیک، از جمله مزایا و معایب درک شده از کاربرد مبارزه بیولوژیک و همچنین خودکارآمدی در استفاده مبارزه بیولوژیک با هدف هماهنگی با مراحل تغییر با ارائه راهبردهای مداخله‌گری متنوع، متمرکز شود.





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