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Chem. Biol. Technol. Agric. (2020) 7:7
https://doi.org/10.1186/s40538-019-0174-z

Chemical and Biological Technologies in Agriculture

RESEARCH

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Adoption of pro-environmental behaviors among farmers: application of Value–Belief–Norm theory

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Abstract

Background: The clean and pro-environmental technologies are one of the crucial instruments to produce healthy food without any chemicals. Recycling the agricultural residues by composting them is a clean and pro-environmental technology. Local rich compost as a clean and pro-environmental technology is the factor which strengthens agricultural soils in terms of organic materials and healthier crops production. The current study aims to analyze farmers' pro-environmental behaviors concerning the adoption of clean technology of local rich compost in Fars province, the south of Iran, in order to protect soil and produce healthy crops.

Methodology: The statistical society of the study includes the farmers who produce and adopt the technology of local rich compost in this province. The sample included 130 framers from 30 villages of Fars counties. The study was conducted by multi-stage random sampling and the data were gathered through a survey using questionnaires.

Results: Given the results, the most pro-environmental behaviors among the farmers are the environmental activism behavior. Therefore, among the pro-environmental behaviors, they intend to attend extension classes and join the farmers' groups more. The average of chemical fertilizers consumption decreased significantly after adoption of the local rich compost.

Conclusion: Based on the study model, "perceived behavioral control", "social and moral norms", as well as "extension education" had a significant effect on the farmers' intent to continue to produce the clean and pro-environmental technologies. The current study presents some recommendations for adoption of the clean and pro-environmental technologies.

Keywords: Clean technology, Value–Belief–Norm theory, Local rich compost, Pro-environmental behavior, Residue management, Iran

Background

Today, the current agricultural system is technology-based, emphasizing the high efficiency types, as well as the amount of herbicides, pesticides and chemical fertilizers being used. The goals are to produce crops for human consumption. Alongside increasing the crops and solving the food shortage, new problems have been created in agricultural ecosystems in a large number of developed and developing countries. The most important problems include the water sources being contaminated, affecting the soil health, and decreasing the absorbable amount of micronutrients such as zinc, copper and iron leading to loss of biological balance of the ecosystems, and consequently pest resistance against the chemicals and rise in new pests, as well as declining the quality of crops [9, 19]. The pests and nitrates separated from chemical fertilizers are observed in groundwater in most agricultural areas. In addition, soil erosion is a worrying issue in agricultural areas. The pesticide-resistant pests continue to grow and

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pest control has remained unresolved. A large number of studies demonstrate that pesticides affect organisms such as livestock and especially human directly [17]. The examples of adverse effects of chemicals consumption include extreme loss of biologic diversity, a large number of plants and animals being exposed to extinction, accumulating dangerous materials in the environment and health problems for humans.

Recycling the agricultural residues in the form of producing compost is one of the most suitable options among the clean and pro-environmental technologies for managing the agricultural residues. The composting technology is a biological process, in which organic and biodegradable residues are turned into useful organic substances for plants under aerobic or non-aerobic conditions. Farmers have used a type of composting process simply and traditionally for centuries. They accumulated plant residues and animal wastes or kept them in a pit to be degraded as an effect of natural activities of microorganisms and finally, used this product in agricultural activities. The time required for these processes was usually longer than 6 months, with no special control except coating the accumulation with a thin layer of soil or mixing it one or two times [22]. The local rich compost as a clean and pro-environmental technology is the factor which enriches agricultural soils by organic substances and results in healthier crops. In addition, it helps to protect the environment and reduce the environmental pollution caused by agricultural residues. In local rich compost technology, the crop is prepared through using the animal fertilizers, plant residues, fruit wastes and remnants of animal corpses, and can be utilized after 18 days [22]. Therefore, perceiving the factors affecting the activities of farmers who use the local rich compost technology and the effects of this technology on their pro-environmental behaviors, especially related to agricultural residues management are highly critical.

Consumption of the chemical fertilizers in Iran has increased from 2.5 to 3.5 tons over the last 10 years [8]. About 4.1 million tons of chemical fertilizers and pesticides were distributed among farmers during 2004–2005 [26]. Calculations and statistics presented by Forests, Range and Watershed Management Organization and Environment Department are highly disappointing. In terms of soil erosion and destruction of fertile grounds and natural resources, Iran is in second place with 33 tons/ha after Australia, mainly due to excessive consumption of chemical fertilizers and pesticides [7]. 20% of natural soil erosion and 8% of soil washing on the global scale occur in Iran, if loss of soil is considered to be 2–2.5 billion tons per year. Given Iran's 1.1% share of the land of the world, this figure is highly significant. In addition, 15% of the agricultural lands of Iran are salty, sodic and marshy due to excessive irrigation. The situation is so worrying that more than half of the area of Iran (88 million hectare) was described as having critical conditions in terms of soil erosion in the soil and watershed protection bill [8]. Further, one of the main problems related to export of crops in Iran is their poor quality in terms of shelf life and nutritional value due to the excessive use of chemicals. Unfortunately, the amount of chemicals in crops is neither scientific nor principled in Iran, while the amount of these materials is quite low in other developed countries and in many cases, the tendency to produce food without using chemical inputs is increasing [17].

In Iran, the whole area under cultivation of crops produced without using pesticides and chemical fertilizers is about 239,462 ha, which includes 113,659 for farming crops and 125,802 ha for orchard crops. In Iran, the area under cultivation of farming and garden crops, produced without using pesticides and fertilizers, is 1 and 7.2% of the whole area under cultivation, respectively [21]. Therefore, in 2010, World Health Organization declared Iran 93rd in the health rank. The main reason for this ranking is the failure to respect the principles of efficient consumption of chemical fertilizers and pesticides, which results in some compounds of these materials remaining in the crops [17]. In addition, the amount of organic substances in agriculture soils of Fars province was decreased in order to improve the effectiveness of microbial fertilizers (biological), and the amount of organic substances of the soil should be increased at a desired level [22]. The excessive consumption of chemicals, which affects human health, agricultural soils and environment should be avoided, and clean technologies should be given special attention.

The considerable volume of plant residues has motivated the major policy-makers to develop the strategic plan of plant residue management for Development Plan policies in Iran. Developing such a plan, in addition to using the residues properly in order to produce added value, prevents the inappropriate disposal leading to environmental pollution, an increase in the efficiency of alternate industries, and the creation of employment [22]. The major policy in Iran is to produce healthy food and minimize the environmental pollution caused by chemicals. The current study aims to analyze farmers' pro-environmental behaviors in adoption of the local rich compost technology for soil protection and healthy food production in Fars province, the south of Iran. To this aim, the study seeks to identify farmers' pro-environmental behaviors in adoption of the local rich compost technology, as well as the factors affecting farmers' behavior in adoption of this technology and some of its consequences.

Review of literature

Some researchers categorized the most crucial variables affecting the farmers' attitudes and pro-environmental behaviors into individual, social and economic factors [8, 31]. The most important individual and professional characteristics include age, educational level, household size, agricultural experiences and farming being the people's full-time job, and the most important influential economic features are such as area under cultivation, yield level, income level, land property type, production tools and bank facilities. Afshari et al. [1] demonstrated that knowledge of sustainable agriculture, possibility of sustainable agriculture methods, moral and social norms in performing the sustainable activities, awareness of environmental consequences, level of education and land area influence farmers' behaviors related to sustainable agriculture directly. In addition, environmental affections and social norms affect farmers' behaviors related to sustainable agriculture. Nemat Pour and Rezaei-Moghaddam [22] suggested that rural women have a highly desirable attitude toward vermicomposting. Further, they argued that attitude toward vermicomposting and motivation to do this process affects the consequences of this technology significantly. Illukpitiya and Gopalakrishnan [13] concluded that farmers' awareness and attitude toward other people's needs in the form of social norms are shaped in a background of individual, economic, institutional and natural (physical situation of land) factors. These factors lead to behavioral tendencies. In addition, these tendencies might be indicated in the form of a real behavior, depending on farmer's adequate income, knowledge of needed technologies and essential inputs. In the present study, the necessity of using behavioral theories to identify the factors controlling the behavior and the importance of attitude toward managing the plants residues are considered.

For better understanding the farmers' pro-environmental behaviors, the present study was conducted based on Value–Belief–Norm (VBN) theory. Based on this theory, pro-environmental behavior originates from the individual norms such as the feeling of moral obligation to act pro-environmentally. These beliefs, that environmental conditions threaten individual values (awareness of consequences) and people can reduce these threats (responsibility), activate the individual norms [25]. Based on VBN theory, awareness of consequences and responsibility depend on the general beliefs in human–environment relationship and to some extent the relatively fixed value orientations. Stern et al. [28] claimed that individual norms may influence all types of behavior and environmental intentions. They determined the types of behavior as follows: environmental activism such as active participation in environmental organizations and associations, inactive behaviors in public spheres such as playing the role of pro-environmental citizen or accepting general policies, environmentalism in a particular sphere such as shopping, use and disposal of personal products and a family which has environmental effects, and organizational activities such as designing and planning the environmentally safe products.

Research method

This study was conducted using survey research in Fars province, the south of Iran (Fig. 1). To this aim, the counties in Fars, in which the local rich compost technology is used, were selected as the study area. The statistical population included 250 farmers of 30 counties. The study used multi-stage random sampling. 10 counties were randomly selected among 30 counties. Then, 3 villages were selected from each county. Finally, 150 farmers were chosen using Krejcie and Morgan [16] table. The data were collected by questionnaire. The questionnaire included open and closed question and used Likert scale. The reliability of the questionnaire was calculated through a pilot study completing 30 questionnaires out of the main sample (Table 1). Table 2 indicates the definition of the main variables.

Research hypothesis

1. There is a relationship between individual, professional, agricultural, economic and social characteristics of farmers and their pro-environmental behavior.
2. There is a relationship between individual, professional, agricultural, economic and social characteristics of farmers and continue to produce clean technology.
3. The variables of social norms, moral norms, awareness of environmental consequences, environmental affections, perceived behavioral control of clean technology, environmental responsibility and other characteristics of individual, professional, agricultural, economic and social are the predictive factors of environmental attitude, pro-environmental behavior as well as continue to produce clean technology between farmers.

Data analysis methods

Collected data were analyzed using statistical and inferential statistics in order to test mentioned hypothesis.

Besides computing the parameters of descriptive statistics, some other tests including paired *t* test (comparing the conditions of before and after using local compost), Pearson correlation coefficient (determining the relationship between main variables) as well as path analysis (influencing factors of adoption and continue clean technology use) have been done in the study.

Structural equation modeling (SEM) is a powerful statistical approach to model testing. Indeed, SEM comprises a merging of two approaches to model testing: multiple regression analysis and factor analysis. Regression analysis is concerned with relationships (often assumed to be causal) between predictor variables and a criterion variable [18]. SEM can also be used to test hypothesized structural relationships between observed variables, as in traditional path analysis. This modeling is most often accomplished for testing linear models; it is possible to use the method to test interactive models. Similarly to the method for testing interactions using moderated regression analysis, the interaction between the latent variables is represented by the products of their respective observed indicators and the resultant interaction latent variable is modeled alongside the main effect latent variables [14]. The main aim of researchers in selecting SEM for data analysis is to calculate the direct and indirect effects of the research variables on dependent factor, because it is important to determine the indirect effects of each independent variable through the mediators in addition to their direct effect as well. In other words, direct effect of one variable (A) on another one (B) means the changes in variance of variable (B) directly caused by (A). Indirect effect of variable (A) on (B) referred to variance change of (B) started from (A) and through the other variables placed in the middle of the model named as mediators. Beta coefficient refers to regression matrix that relates the endogenous latent variables (etas) to one another. Path coefficient is like a combination of correlation coefficient and regression coefficient. Correlations between variables in the framework of equation system are separated in different effects by path analysis as follows [3]: *direct effects* of a variable on dependent variable, *indirect effects* of a variable on dependent variable through other factors, *spurious effects* caused by the correlation of external variables and *unanalyzed effects* which depends on the analysis way of model.

There are some parameters as global fit assessment of the goodness of model as follows [18]:

- *Degrees of freedom (df)* are the difference between the total number of observed variances/covariances in the data and the number of parameters to be estimated by the model.
- *Root mean square error of approximate (RMSEA)* means how well the model approximates the data. Conventionally, values < 0.05 indicates close fit; < 0.08 a reasonable fit and > 0.01 indicates poor fit.
- *Goodness of Fit Index (GFI)* means absolute measure of fit (analogous to R^2 in regression analysis. Sample size could have effects of the amount of GFI.
- *Comparative Fit Index (CFI)* refers to incremental measure of fit, conventionally, values > 0.95 indicate reasonable fit.

Results and discussion

Demographic information

The frequency distribution of farmers' age is shown in Table 3. The mean of age equaled 46.19 years which the oldest respondent was 81 and the youngest was 26.

Due to the farmers' educational level, the findings showed that the educational mean of the respondents was about 9 years. There were some illiterate farmers, and on the other side a few of them had academic education (Table 4).

According to Table 5, the mean of farmers' use of local rich compost equaled 12 tons/ha which the highest use was 60 tons/ha and the lowest amount was just 0.5 tons/ha.

Agricultural consequences of adoption of the clean technology

Comparing wheat crop yield

Based on the result of paired *t* test in Table 6, there is a significant difference between the mean of wheat crop

Fig. 1 Geographical location of the studied area

Table 1 Alpha Cronbach values of research variables

Variables	No. of items	Alpha Cronbach values
Pro-environmental behavior (adoption)	12	0.79
Social norms	5	0.79
Attitude toward the environment	8	0.72
Continue to produce clean technology	4	0.81
Environmental affections	7	0.88
Moral norms	6	0.83
Environmental responsibility for soil management	6	0.75
Awareness of environmental consequences	6	0.65
Perceived behavioral control of clean technology	5	0.89

yield before and after adoption of the clean technology of the local rich compost ($P = 0.001$). After adopting the local rich compost, wheat crop performance increased per unit area and the difference between before and after using the local rich compost is 1.56 tons/ha. Thus, wheat crop yield increased from 4.14 to 5.70 tons/ha on average after using this clean technology.

Comparing the cost and consumption of fertilizer

The results of paired *t* test demonstrated that there is a significant difference between the mean of fertilizer consumption (phosphate, nitrogen and potassium) before and after adoption of the local rich compost ($P = 0.001$). Therefore, the mean of fertilizer consumption after adoption of the local rich compost decreased by 188.44 kg/ha for wheat (the means of fertilizer consumption before and after using the local rich compost are 460.75 and 272.31 kg, respectively). Given the high consumption of chemical fertilizer in Fars province, the consumption of chemical fertilizers is decreased by increasing the use of clean technology, especially the local rich compost, which is very critical for the move toward producing healthy crops. There is no significant difference between fertilizer costs per hectare before and after using the local rich compost. It might be due to adding the costs of producing the local rich composts to the total costs of different fertilizers' use although a decrease occurred in consuming the chemical fertilizer.

Comparing the seed consumption

As shown in Table 6, there is a significant difference between the seed consumption before and after adoption of the local rich compost ($P = 0.05$). The seed consumption after adopting the local rich compost decreased by 55.52 kg/ha for wheat on average (the means of seed consumption before and after using the local rich compost are 313.86 and 258.34, respectively).

Comparing the water consumption As shown in Table 6, there is a significant difference between the mean of water consumption before and after using the local rich compost ($P = 0.001$). The mean of water consumption decreased by 2687.13 m^3 after adoption of the local rich compost. (The mean of water consumption before and after using the local rich compost is 13312.50 and 10,625.37 m^3, respectively.) Given the drought during the last years and water shortage, the use of the clean

Table 2 Definition of the research variables

Variables	Definitions
Social norms	Farmers' perception of social pressures and expectations to perform pro-environmental behaviors related to healthy crop production
Environmental affections	Negative or positive feeling towards the environment and empathy with nature, as well as creating emotional relationship with nature and the environment
Moral norms	Farmers' self-expectation of performing pro-environmental activities in a special situation (non-use of chemicals) as a feeling of moral obligation
Environmental responsibility for soil management	Attributing pro-environmental behavior to protect and strengthen soil to him/herself
Awareness of environmental consequences	People's awareness level of adverse effects of their activities (using chemicals in agriculture) on themselves and the others
Perceived behavioral control of clean technology	People's perception of their control level on needed resources of pro-environmental behaviors and avoiding non-environmental behaviors to produce healthy crop
Attitude toward the environment	A complicated and multidimensional concept including negative and positive senses on the environment and a mental state which affects people's selections related to the environment
Pro-environmental behavior (Adoption)	It refers to farmers' decisions in order to accept and utilize modern and clean technologies in their agricultural lands in accordance with environmental protection
Continue to produce clean technology	It means that the adopters continue the process of compost production as a clean technology in their future croplands

Refs. [2, 4, 5, 10, 12, 17, 24, 29, 32]

technologies such as local rich compost results in saving water, along with soil fertility.

The behaviors related to clean technology

In this study, the behaviors, based on VBN theory, were classified as environmental activism behaviors, inactive behavior in public sphere, environmentalism in a special sphere and organizational behavior. These items indicate farmers' pro-environmental behavior. According to Table 7, the most pro-environmental behavior showed by the farmers is the environmental activism behaviors with mean of 4.08, which are defined as participating in organizations and associations, and focus on contributing to social movements. These behaviors include attending the extension classes of composting technology (3.85) and supporting the organizations which are developed using this technology (4.3). In addition, the results demonstrated that the inactive behaviors in public sphere are in the second place with the mean of 3.71. These behaviors are defined as supporting or accepting general policies and environmental laws, which include accepting the rules of bank facilities (3.11) and supporting the promotion policies of composting technology (4.28). The results indicated that the farmers have mostly inactive behaviors in producing and using the local rich compost, and only support these types of behaviors. It means that, in spite of accepting the pro-environmental behaviors by the farmers, they actually perform these behaviors less. Based on the results, organizational activities (farmers' planning to produce healthy crop) and environmentalism in producing and using the compost are placed in the following ranks with mean of 3.48 and 3.33, respectively.

The relationship between variables with pro-environmental behaviors and continue to produce clean technology

In this part, the relationship between the variables with pro-environmental behaviors was investigated in order to test hypothesis 1. Based on Table 8, there is a significant relationship between social norms related to use of local rich composts and the farmers' pro-environmental behaviors (hypothesis 1) ($r=0.71$, $P=0.0001$). In other words, the farmers who have stronger social norms related to use local rich compost and embrace the ideas of specialists in this technology use pro-environmental methods and compost more for increasing soil organic substances and producing healthy crops. In addition, they have stronger pro-environmental behaviors. The findings are consistent with the results of some other studies in terms of important role of social norms on environmental behaviors [24].

Perceived behavioral control of clean technology (access to resources for producing and using the local rich compost) has a significant relationship with the farmers' pro-environmental behaviors (hypothesis 1) ($r=0.46$, $P=0.0001$). The farmers who have more access to resources and facilities for compost productions, utilize it more for protecting the environment and have a stronger pro-environmental behavior. The researchers of Planned Behavior theory claimed that perceived behavioral control plays an important role in the outbreak of behaviors [5]. In addition, there is a significant relationship between the farmers' environmental affections and their pro-environmental behaviors due to hypothesis

Table 3 Frequency distribution of farmers in terms of their age

Age (year)	Frequency	Percent	Cumulative percentage
Less than 36	33	22	22
36–46	46	30.7	52.7
46–56	42	28	80.7
56–66	20	13.3	94
66–76	8	5.3	99.33
More than 76	1	0.7	100
Total	150	100	100

Mean: 46.19, SD: 11.94, Min: 26, Max: 81

Table 4 Frequency distribution of farmers in terms of educational level

Educational level (year)	Frequency	Percent	Cumulative percentage
Less than 3	4	2.7	2.7
3–6	45	30	32.7
6–9	24	16	48.7
9–12	45	30	78.7
12–15	8	5.3	84
More than 15	24	16	100
Total	149	100	100

Mean: 9.83, SD: 4.40, Min: 0, Max: 18

Table 5 Frequency distribution of local rich compost use

Use (ton/ha)	Frequency	Percent
Less than 10.5	110	73.4
10.5–20.5	21	14
20.5–30.5	12	8
30.5–40.5	3	2
40.5–50.5	2	1.3
More than 50.5	2	1.3
Total	150	100

Mean: 11.71, SD: 12.67, Min: 0.5, Max: 60, Mean: 11.71, SD: 12.67, Min: 0.5, Max: 60

Table 6 The results of paired *t* test for comparing the research variables for one hectare of wheat before and after using the local rich compost

Properties	Before the compost consumption		After the compost consumption		*t*	Sig. level
	Mean	Standard deviation	Mean	Standard deviation		
Yield (ton/ha)	4.14	1.49	5.7	2.18	10.09	0.001
Fertilizer costs (million Rial)	4.15	4.61	3.23	4.39	1.19	0.25
Fertilizers consumption (kg/ha)	460.75	326.84	272.31	179.4	5.2	0.001
Water (m^3/ha)	13,312.5	4725.23	10,625.37	5351.77	3.98	0.001
Seed consumption (kg/ha)	313.86	115.45	258.34	99.99	5.89	0.036

1 ($r=0.449$, $P=0.0001$). Thus, the farmers who have a strong emotional relationship with protecting soil and decreasing its chemicals display a stronger pro-environmental behavior. It is consistent with many studies [4, 20, 29, 30]. According to Table 8, there is a significant relationship between moral norms for using this technology and adoption of pro-environmental activities by farmers (hypothesis 1) ($r=0.66$, $P=0.0001$). In fact, the farmers who have sounder moral obligations toward using this technology and methods of increasing soil organic substances have stronger pro-environmental behaviors. Furthermore, the farmers' responsibility and their pro-environmental behaviors have a significant relationship with each other according to hypothesis 1 ($r=0.58$, $P=0.0001$). Therefore, adoption of the local rich compost is increased by enhancing the farmers' responsibility for using pro-environmental technologies to increase soil organic substances and produce healthy crop. Different studies have emphasized on the role of norms and social variables especially behavior responsibility on adoption of environmental technologies [24, 25].

The results of Table 8 showed that the farmers' awareness of consequences has a significant relationship with their pro-environmental behavior as it is mentioned in hypothesis 1 ($r=0.52$, $P=0.0001$). In other words, the farmers who are more aware of environmental consequences of producing and using the compost actually utilize this technology more. In addition, there is a significant relationship between the extension education in field of local rich compost by the farmers and their pro-environmental behaviors (hypothesis 1) ($r=0.52$, $P=0.0001$). Therefore, the farmers who have received more training in this clean technology and its benefits for soil and environment utilize these types of training more and have stronger pro-environmental behaviors. Moreover, there is a significant relationship between the farmers' environmental attitude and their pro-environmental behaviors ($r=0.42$, $P=0.0001$). This finding is in line with other studies regarding the effect of extension education on adoption of environmental technologies [22].

The correlation coefficients of research variables with continue to produce clean technology among farmers are shown in Table 8. It is done in order to test hypothesis 2 of the study. According to the results of Table 8, social norms has a significant relationship with the continuous production of compost (hypothesis 2) ($r=0.60$, $P=0.0001$). In fact, the farmers who have stronger social norms toward producing and using the clean technologies, and embrace the specialists' ideas tend to produce and use the compost continuously for improving soil organic substances and producing healthy crop. It is consistent with the results of many similar studies [28, 31]. In addition, there is a significant relationship between perceived behavioral control of clean technology and producing this technology continuously due to hypothesis 2 ($r=0.299$, $P=0.0008$). Thus, the farmers who have more access to resources and facilities for using the clean technologies use those resources and facilities to produce and use the local rich compost.

Besides, the farmers' environmental affections have a significant relationship with continue to produce clean technology (hypothesis 2) ($r=0.50$, $P=0.0001$). It means that the farmers who have a stronger emotional relationship with the environment, tend to produce compost continuously. Furthermore, there is a significant relationship between farmers' moral norms and continue to produce the compost according to hypothesis 2 ($r=0.729$, $P=0.0001$). Thus, the farmers with stronger moral norms related to use the clean technologies will produce these technologies more. Also, there is a significant relationship between environmental responsibility and the farmers producing the compost continuously (hypothesis 2) ($r=0.44$, $P=0.0001$). Given the result, farmers continue to produce clean technologies more if they are more responsible for their behavior related to the environment.

Based on Table 8, awareness of environmental consequences and continue to produce clean technology have a significant relationship with each other as it is mentioned in hypothesis 2 ($r=0.67$, $P=0.0001$). It means that the farmers who are more aware of

Table 7 The items of environmental behaviors of farmers in terms of local rich compost production

Environmental behavior	Mean	SD	Items	Mean	SD
			Attending in extension classes about compost	3.85	1
Environmental activism	4.08	0.82	Supporting the organizations in promoting compost use	4.3	0.92
			Accepting the rules regarding bank facilities granting	3.11	1.39
Passive behaviors in public domain	3.71	0.95	Supporting the encouraging policies about compost production	4.28	0.97
			Green fertilizers use in the farm	3.52	1.15
Environmentalism in special domain	3.33	0.61	Compost use for soil fertility	3.69	1.07
			Crop residue burning	1.87	1.21
			Chemical fertilizers and pesticides use recommended	3.84	1.07
			Crop residue to compost transformation and using in the farm	3.73	1.16
			Keeping wastes for transforming to compost	3.81	1.19
Organizational activities	3.48	0.64	Purchasing agricultural wastes from farmers to changing to the compost	2.68	1.21
			Rich compost use beside chemical fertilizers	3.97	1.02
Total environmental behavior	3.65	0.64			

Mean range: 1–5

Table 8 Results of Pearson correlation coefficient of research variables with farmers' pro-environmental behaviors and continue to produce clean technology

Variables	Pro-environmental behavior (adoption)		Continue to produce clean technology	
	r	*P*-value	*r*	*P*-value
Agricultural background	0.071	0.4	0.093	0.27
Social norms	0.714	0.0001	0.605	0.0001
Perceived behavioral control of clean technology	0.468	0.0001	0.299	0.0001
Environmental affections	0.449	0.0001	0.501	0.0001
Moral norms	0.665	0.0001	0.729	0.0001
Environmental responsibility	0.581	0.0001	0.44	0.0001
Awareness of consequences	0.52	0.0001	0.672	0.0001
Awareness of needs	0.33	0.079	0.179	0.031
Access to extension education	0.52	0.0001	0.31	0.0001
Attitude toward environment	0.425	0.0001	0.613	0.0001
Pro-environmental behavior (adoption)	–	–	0.603	0.0001

technology's consequences tend to produce it more continuously. In addition, there is a significant relationship between awareness of needs and continuously production of the compost (hypothesis 2) ($r=0.179$, $P=0.03$). Thus, the farmers who are more aware of soil needs for organic substances and disadvantages of chemical fertilizers will produce and use clean technologies, especially local rich compost, more. Further, the farmers' enjoyment of extension education in the field of the clean technologies, especially local rich compost has a significant relationship with producing the compost continuously due to hypothesis 2 ($r=0.31$, $P=0.0001$). Therefore, the farmers who have received more education in the field of the clean technologies and their advantages for soil and the environment actually produce and utilize these educations more. These findings are congruent with the results of previous studies [22].

There is a significant relationship between environmental attitude and production of compost continuously (hypothesis 2) ($r=0.61$, $P=0.0001$). It means that the farmers with higher attitude toward using the clean technologies and increasing soil organic substances tend to produce them more. In addition, there is a significant and direct relationship between pro-environmental behaviors and production of clean technology, continuously (hypothesis 2) ($r=0.60$, $P=0.0001$). Therefore, the farmers who have stronger pro-environmental behavior related to producing and using compost and increase soil organic substances will continuously produce it more.

Analyzing the causal model of the study in adoption of the clean technology

The most effective variables were selected to reach a structural model for farmers' pro-environmental behaviors and continue to produce the clean technologies in order to test hypothesis 3 of the study. Therefore, the variables used in the model include continue to produce clean technology, pro-environmental behavior, attitude toward environment, moral norms, awareness of consequences, awareness of needs, environmental affections, environmental responsibility, perceived behavioral control, social norms, agricultural experiences and extent of using the extension educations. The results of the causal model of the factors influencing the farmers' pro-environmental behaviors and continue to produce the clean technology are presented in Fig. 2.

In Fig. 2, there are nine factors as independent variables at the left side of the model and there are two factors as mediator variables in the middle of the model. The main aim of the study was to calculate the direct and indirect effects of the research variables on dependent factor of continue to produce clean technology, because it is important to determine the indirect effects of each independent variable through the mediators in addition to their direct effect as well. The following condition should be established for fitting data-model: CFI and NFI, the ratio of Chi-square to degree of freedom and RMSEA should be lower than 5, more than 95% and lower than 0.06, respectively [6, 11, 23]. As shown in Fig. 2, the values of the fitting indices demonstrate the appropriate compatibility of data-model.

The causal effects of the variables on attitude toward environment

As illustrated in Table 9 and Fig. 2, separating the causal effects of the variables on the farmers' environmental attitude demonstrates that environmental affections have a direct, positive and significant effect on the farmers' environmental attitude (hypothesis 3) ($\beta = 0.284$, $P < 0.01$). In other words, the exogenous variable of environmental affections is a significant predictor for the endogenous variable of the farmers' environmental attitude. The farmers who have more environmental affections and are closer to nature have a more positive attitude toward the environmental protection, which makes them more receptive to the local rich compost technology. The effect of the farmers' environmental affections to improve their behaviors and attitude has been emphasized in a large number of studies [25, 29].

Need awareness has a positive and significant effect on the farmers' attitude toward environment ($\beta = 0.31$, $P < 0.01$), which means that the farmers' attitude toward adoption of the clean technologies is enhanced by increasing their awareness of soil environmental needs for organic substances. In addition, moral norms have a positive and significant effect on the farmers' environmental attitude ($\beta = 0.336$, $P < 0.01$). Therefore, the farmers' moral norms such as attention to other factors besides increasing finance resources for performing agricultural activities compels them to have a positive attitude toward the environment and adoption of clean technologies. The theories of Logic Selection and Planned Behavior emphasizes that the norms play an essential role in people's attitude [24].

The causal effect of the variables on adoption of the clean technology

Social norms have a positive, direct and significant effect on the farmers' pro-environmental behavior (hypothesis 3) ($\beta = 0.32$, $P < 0.01$), which means that other farmers and prestigious people's encouragement or opposition is the most effective factor in adopting the clean technologies by farmers. For instance, if other farmers use local rich compost in their farm, it could encourage other farmers to do the same. The second factor influencing the farmers' pro-environmental behavior is their moral norms. This variable has a positive and significant effect on the farmers' behavior ($\beta = 0.266$, $P < 0.01$). Therefore, the farmers with stronger moral obligations on clean technologies accept them more. This is consistent with many similar studies in this area [31, 33].

The positive and significant effect of perceived behavioral control on the farmers' environmental behavior ($\beta = 0.264$, $P < 0.01$) demonstrates that the most important factor preventing the farmers from performing pro-environmental behaviors is their feeling of financial inability to produce and use the local rich compost. Thus, the external factors considerably affect the farmers' behaviors. Therefore, wealthy farmers may have more control on these factors and show more pro-environmental behaviors, especially in adoption of clean technologies since most pro-environmental behaviors are expensive. In addition, Klockner and Blobaum [15] reported that a perceived behavioral control is one of the main predictors of pro-environmental behaviors.

The responsibility of environmental behaviors is the fourth variable which influences the farmers' environmental behavior significantly ($\beta = 0.20$, $P < 0.01$). Therefore, the farmers' adoption of environmental behaviors such as using compost more, if they are responsible toward nature and environment and believe that protecting the environment depends on their behavior. Responsibility of behaviors is considered as key factors of environmental technologies adoption due to the study of Rezaei-Moghaddam and Fatemi [25].

The farmers' enjoyment level of extension education in the field of clean technologies is the last variable influencing their pro-environmental behaviors. How often the farmers' use these educations has a positive and significant effect on their pro-environmental behaviors ($\beta = 0.187$, $P < 0.01$). Thus, the farmers who enjoy these educations accept clean technologies more (Table 10). Education, especially extension type, plays an important role in adoption of the clean technologies [27].

The causal effects of the variable on continuing to produce the clean technologies

Table 11 shows that moral norms have a positive and significant effect on continuing to produce the clean technologies (hypothesis 3) ($\beta = 0.44$, $P < 0.01$). Believing in the moral norms enhances producing the clean technologies. Moral norms, by influencing the farmers' pro-environmental behaviors and attitude, have an indirect and weak effect on producing the compost continuously ($\beta = 0.038$). Thus, the importance and effectiveness of moral principles should be highlighted in shaping the pro-environmental behavior and producing the clean technologies. Awareness of environmental consequences has a positive

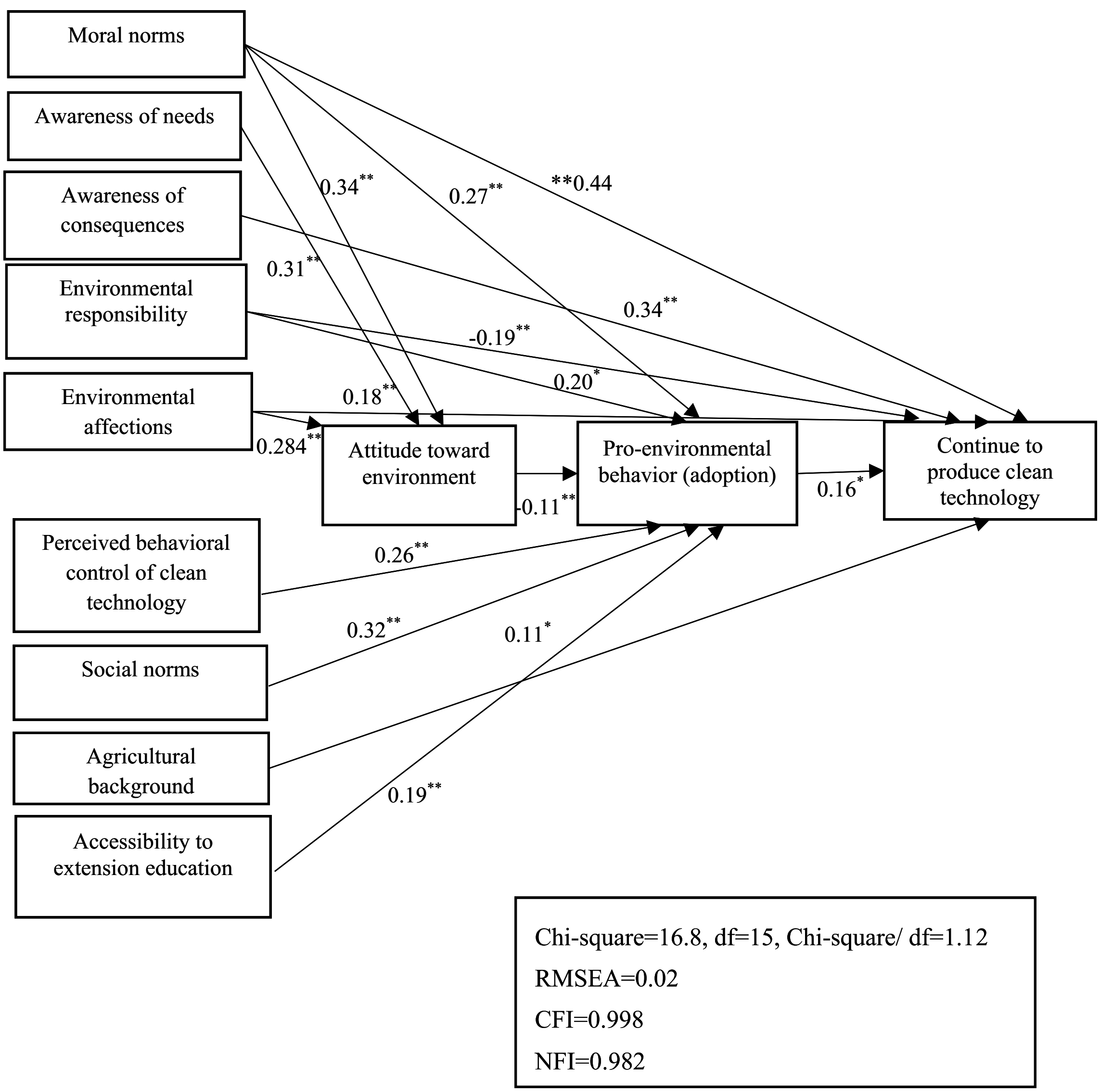

Fig. 2 The model of the farmers' pro-environmental behavior related to continuously producing of local rich compost

and significant effect on the farmers' continuous production of clean technologies ($\beta = 0.336$, $P < 0.01$). Therefore, the farmers' awareness of environmental consequences related to clean technologies such as local rich compost leads to their intention of continuously producing the clean technologies. Responsibility of pro-environmental behaviors related to the clean technologies has a negative and significant effect on continuous production of clean technologies ($\beta = -0.185$, $P < 0.004$). This variable with a direct effect on the farmers' pro-environmental behavior has a positive, indirect and significant effect on continuous production of clean technologies ($\beta = 0.033$). One of the main reasons is that extension educations of the local rich compost could only modify the farmers' behaviors related to technical issues of producing and using the compost, and do not play an important role in improving their environmental responsibility.

Environmental affections as the fourth variable have a positive, direct and significant effect on the farmers' continuous production of the clean technology ($\beta = 0.179$, $P < 0.01$). Thus, continue to produce the clean technology is enhanced by improving their environmental affections. Based on the results of the previous studies, environmental affections affect pro-environmental behavior considerably [25, 29].

The farmers' pro-environmental behavior is regarded as another variable which has a positive, direct and significant effect on continue to produce the clean technologies ($\beta = 0.165$, $P < 0.02$). The farmers' continuously producing and using the local rich compost are increased by enhancing their pro-environmental behaviors. The farmers' experiences are considered as the last variable which has a positive, direct and significant effect on continue to produce the clean technologies ($\beta = 0.106$, $P < 0.02$). Based on the result, the farmers who have more experiences tend to use and produce the local rich compost continuously.

Conclusion

The knowledge of each society enables it to supply its needs without harming the ecosystem cycles. In biofarming, feeding the plants and trees does not destroy the balance of soil elements and the final crop is without poisonous and chemical residues. In addition, the residues out of farm and biologic control are used and the consequences of using such type of agriculture are food security, economizing the crops production, and increasing the healthy crops.

Table 9 The direct, indirect and total standardized effects of research variables on farmers' attitude toward environment

Variables	Direct effect	Indirect effect	Total effect	Sig. level
Environmental affections	0.284	–	0.284	0.0001
Awareness of needs	0.310	–	0.310	0.0001
Moral norms	0.336	–	0.336	0.0001

During the last years, many concerns related to the consequences of some agricultural activities in the environment and society have been reported in the world. After humans' war with nature and the industrial revolution, serious blows have been imposed to nature by emerging synthetic chemicals, pesticides and chemical fertilizers. Destructing the soil due to the use of chemicals is considered as a serious threat which has attracted a lot of attention from international societies. In addition, the destruction causes the quality and fertility of soil to decrease, and threatens soil sustainability, environment quality and healthy crops production, which influence economic and social development negatively. Today, a significant number of politicians and economists in the world, in addition to accepting these threats, try to present appropriate solutions. Therefore, farmers hope for the sustainable agriculture which could supply adequate and healthy food, and protect the environment. To this aim, the clean and environmental technologies are considered as one of the most important tools for producing the healthy food without any chemicals. Given the importance of farmers' role in the move toward sustainable agriculture, protecting the environment and producing the healthy food for preserving human's health, studying and achieving awareness on their knowledge, attitude and behavior related to clean and pro-environmental technologies are vital for achieving the sustainable agriculture.

Agricultural soils are imposed on the problems such as decreasing fertility, erosion, as well as being squeezed, polluted and salty. Soil ability for supplying the feeding and growth needs of plants and producing the crop guarantees the fertility which depends on physical, chemical and biological factors. Farmers could enhance soil conditions by performing various activities such as improving crops and species, enhancing health, increasing the fertilizers without chemicals and supplying water, which lead to soil fertility and an increase in the quality of crops. Organic substances are considered as one of the effective factors in protecting the soil. Organic substances influence physical, chemical and fertility properties of soil constructively, which are known as one of the fertility factors. The soils of the arid and semi-arid regions are poor in terms of organic substances. The amount of organic substances in most areas under cultivation is less than 1% and is less than 0.5% in most parts. Since achieving the potential performance of soil under cultivation

Table 10 The direct, indirect and total standardized effects of research variables on farmers' environmental behavior

Variables	Direct effect	Indirect effect	Total effect	Sig. level
Social norms	0.320	–	0.320	0.0001
Perceived behavioral control	0.264	–	0.264	0.0001
Moral norms	0.266	− 0.037	0.228	0. 001
Environmental responsibility	0.200	–	0.200	0.0001
Extension education accessibility	0.187	–	0.187	0.0001

is not possible without supplying the adequate organic substances in soil, studying all the methods which could increase or protect soil organic substances, should be prioritized. Given the results, the most pro-environmental behaviors among the studied farmers are the environmental activism behaviors, which means that they will attend extension classes and join farmers' group among pro-environmental behaviors. Therefore, since a local cooperative and association in the field of adoption of and producing the local rich compost has not yet been established, they could be established in all counties. Thus, farmers' awareness of clean technologies can be increased by holding some related classes.

After adoption of the local rich compost, the fertilizer consumption per hectare decreased for wheat significantly. Given the high consumption of chemical fertilizers in Iran, consuming chemical fertilizers will decrease significantly by increasing the use of clean technologies, especially local rich compost. This issue is highly crucial for movement toward the production of healthy crops. Organic fertilizers and manures, in addition to positive environmental effect and modifying physical and chemical properties of soil, are less polluting for the environment, because their nutrients are released gradually. In addition, during the last years, the food security has become an important issue, along with protecting the environment. Thus, organic fertilizers and manure as the alternative to chemical fertilizers could play an essential role in the sustainable management of soil and the health of agricultural ecosystems.

The significant effect of "perceived behavioral control" on farmers' behavior demonstrates that their feeling of financial inability for adopting the local rich compost is regarded as one of the most important factors preventing farmers from performing pro-environmental behavior. It has many effects on farmers' behaviors. Therefore, wealthier farmers feel more control on the external factors and adoption of the local rich compost more than others maybe because most of the pro-environmental behaviors are expensive and late-yielding. Thus, a situation should be provided to facilitate the farmers' access to external factors.

Based on the pro-environmental behavior model of the present study, social norms compel farmers to perform pro-environmental behavior. Thus, encouragement and opposition by other farmers and prestigious people in village highly impact adoption of the clean technologies by the farmers. In addition, moral norms influence the farmers' pro-environmental behavior. The farmers with stronger moral obligations related to clean technologies accept these technologies more. Further, responsibility for pro-environmental behavior affects the farmers' behaviors. Adoption of the pro-environmental behavior such as using the local rich compost is increased by enhancing the farmers' responsibility for nature and the environment. The farmers enjoying the extension educations accept clean technologies more. Based on the results, the farmers who had some meetings with specialists attended educational classes more and found the education highly effective. Farmers' regular meeting with the specialists of Agriculture Jihad

Table 11 The direct, indirect and total standardized effects of research variables on continuing to produce clean technology by farmers

Variables	Direct effect	Indirect effect	Total effect	Sig. level
Moral norms	0.440	0.038	0.478	0.0001
Awareness of consequences	0.336	–	0.336	0.0001
Environmental responsibility	− 0.185	0.033	− 0.152	0.004
Environmental affections	0.179	− 0.005	0.174	0.002
Environmental behaviors	0.165	–	0.165	0.020
Agricultural background	0.106	–	0.106	0.028

Organization and holding more classes related to production and use of local rich compost could be recommended. Through enhancing the wheat crop yield after using the local rich compost, Agriculture Jihad Organization can encourage farmers to adopt clean technologies by holding exhibitive farms in the lands of farmers who adopt local rich compost, in order to show the sensible effects of clean technologies to other farmers. Furthermore, the farmers with pro-environmental behaviors tend to produce and use local rich compost continuously.

Abbreviations
VBN: Value–Belief–Norm; NFI: Normed Fit Index; CFI: Comparative Fit Index; RMSEA: Root mean square error of approximation.

Acknowledgements
We are thankful to the agricultural extension experts and the farmers and rural people of Fars province for answering the questionnaires, patiently.

Authors' contributions
KR-M: conceived and designed the experiments; contributed reagents, materials, analysis tools or data; wrote the paper. NV: conceived and designed the experiments; performed the experiments; analyzed the data; contributed reagents, materials, analysis tools or data; wrote the paper. AA: conceived and designed the experiments; contributed reagents, materials, analysis tools or data; wrote the paper. All authors read and approved the final manuscript.

Funding
The article has been extracted from a master thesis and a kind of student work. There is no special fund to this research.

Availability of data and materials
The datasets generated and/or analyzed during the current study are not publicly available (because all of the data was gathered by the research team), but are available from the corresponding author on reasonable request.

Ethics approval and consent to participate
I approved the ethics guideline of the journal.

Consent for publication
All of authors have informed regarding submitting the manuscript to the journal of *Chemical and Biological Technologies in Agriculture*.

Competing interests
The authors declare that they have no competing interests.

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Appendix

Appendix 1: Introduction of research variables and their items in questionnaire

Variables	Items
Social norms	I do not pay attention to rural leaders and elders regarding the use of local rich compost, I know better myself
	I use local rich compost because it has profit for the other rural people as well
	I do not use local compost because it is inconsistent with cultural aspects of the village
	I would never use local compost if it has effect on profit reduction of farmers in the village
	I use local compost whether the others are disagree in this regard
	I consult with my family members in terms of using local rich compost or not
Environmental affections	I enjoy being in the nature
	I like to spend some parts of my time in the nature
	Environmental degradation would upset me
	Humans should not interfere in the nature
	Humans and plants have the same right in living in the nature
	People have inappropriate use of the natural resources
	Rules and regulations should be acted in order to respect the nature.
	There are limitations in human's use of natural resources
	Human must appreciate the nature
Moral norms	I try to increase my agricultural productions using more chemical fertilizers
	I prepare the farm for the next cultivation by burning the plants residue in order to increase the income
	Using local rich compost will improve soil fertility
	I try to decrease the chemical fertilizers consumption in agricultural activities
	I would use the local rich compost instead of chemical fertilizers in order to soil fertility and water conservation even though it reduces my income
	I try to prevent water waste by local rich compost use
	I try to inform other farmers regarding the disadvantages of chemical fertilizers
	Using local rich compost instead of chemical fertilizers make my conscious be more comfortable
Environmental responsibility for soil management	I am responsible if the health of consumers be in danger through using my productions because of chemical fertilizers' use
	I will responsible myself if the soil fertility of my farm decrease because of the chemical fertilizers' use
	I feel guilty if the life of soil organisms (insects, bees, ants, butterflies and worms) destroy due to my activities including chemical fertilizers and pesticides' use as well as burning plant residue
	Conservation of water, soil and environment is the government duty not farmers
	I have long-term plans for the soil conservation of my farms for the next 10 to 20 years
	I like to increase my agricultural production for now, I do not care what happen in the future

Variables	Items
	We should preserve resources for future generation and should not destroy them by our agricultural activities
	I try to prevent overuse of water with local rich compost use in my farm
Perceived behavioral control of clean technology	I can use the local rich compost instead of chemical fertilizers
	It is easy for me to transform the plants residue into local compost
	I could afford the costs of soil conservation activities including soil test
	I could afford the cost of compost production from the plants residue
Awareness of environmental consequences	Local rich compost would decrease the water use
	Using local compost will make my land weaker year by year
	Local compost use would increase the soil salinity
	Local compost would increase the quality of the food productions
	Using chemical fertilizers would pollute the water ground resources
	Continuous use of local compost would decrease the soil fertility
	High use of chemical fertilizers and pesticides would poison the soil and water
	Burning of plant residue would destroy many of organisms in the soil
Attitude toward the environment	Using local compost would increase the soil quality
	Farm's soil would be weakening due to chemical fertilizers use every year
	Local compost maintain the water in the soil better than other fertilizers
	Using local compost would preserve natural resources (water and soil) for our children in future as well
	Local compost improve soil texture
	We should use less chemical fertilizers because of their effects on soil pollution
	Chemical fertilizers would not destroy farms so we could use them as much as we think
	Soil fertility would be decrease after burning the plants residue
Continue to produce clean technology	I would use residue in order to make compost in future as well
	I would produce local compost if the circumstance is provided
	I would use local rich compost instead of chemical fertilizers in future
	I would recommend other farmers to make local compost from the plants residue on their farms
	I would recommend other farmers to consume local compost instead of chemical fertilizers

- The items of each variable are the exact sentences that were in the main questionnaire. These items were asked in Likert scale and were filled by respondent farmers.
- Some items which were written in negative form and reverse from other items, were homogenized and gotten revers weight, then analyzed.

Received: 16 September 2019 Accepted: 12 December 2019
Published online: 23 April 2020

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