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Evaluation of Farmers' Ecological Cognition in Responses to Specialty Orchard Fruit Planting Behavior: Evidence in Shaanxi and Ningxia, China

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Abstract: Developing specialties in orchard fruits productions with ecological and economic benefits is a practical and effective way to guarantee eco-friendliness and increase farmers' income in the Loess Plateau area. Therefore, to understand these factors, the study constructs an agriculture ecological cognition index from three dimensions of eco-agriculture cognitions (increase income cognition, water conservation cognition and eco-product price cognition). Our analysis was based on micro survey data from 416 farmers in Shaanxi and Ningxia, China. The study used two main econometric models, double-hurdle and Interpretative Structural Modeling (ISM), to examine the relationship and influence pathways between cognition of ecological agriculture and farmers' specialty orchard fruit planting behavior. The results show that: (i) the cognition of eco-agriculture affects whether farmers plant specialty fruits (participation decision). The cognition of eco-agriculture increases income and the cognition of eco-product price significantly affect the scale of specialty orchard fruits planting (quantity decision). (ii) Household resource endowments influence specialty orchard fruit planting responses through ecological farming cognitions. (iii) The factors influencing the participation and quantity decisions of orchard fruit planting are significantly different. Therefore, when the government actively encourages farmers to participate in specialty orchard planting, it should fully consider the cognitive factors of ecological agriculture of the growers and develop targeted training strategies.

Keywords: ecological agriculture; water conservation; double-hurdle model; interpretative structural modeling; adoptions

1. Introduction

In the new era of modernization and globalization, agribusiness, especially orchards management, becomes a challenging venture as there is a pressing demand regarding the quality of products [1]. The overexploitation of natural resources and agriculture intensification are two major drivers which significantly threaten natural landscapes and global sustainability [2]. All the fundamental components of agricultural production, from the seed or plant planting to culture and nourishing them, until harvesting and marketing, need to be managed carefully with a higher intensity for coping with the challenges of current food demands without hampering the ecological balances and diversity. Nowadays, the careful management of farms has become a focal point that supports the current trends of production intensification in a specialized way while facilitating ecological friendliness [3]. However, facilitating specialized fruits production tactics has become a prominent way to promote ecological construction while enabling farmers' poverty alleviation and economic development [4].

Interestingly, specialty fruit crops represent an innovative production method that enhances the substantial portion of agricultural production value [5]. The United States Department of Agriculture (USDA) defines specialty crops by covering fruits and vegetables, tree nuts, dried fruits, horticulture and nursery crops. Specifically, the study focuses on fruit production because it represents many specialty crops [6]. However, China's orchard fruit industry mainly covers cultivating, managing and processing grapes, citrus, apples, pears, peaches and other related fruit production and processing industries [7]. Seemingly, the orchard fruit industry is an essential component of China's agricultural industry structure [8] which has higher competitive advantages, fosters benefits than conventional agriculture and helps farmers achieve rapid growth in agricultural income [9,10]. The government is also highlighting the importance of specialty crops in various ways. For example, in November 2016, the State Council of China issued the notice regarding the 13th five-year plan for poverty alleviation to combat poverty, which proposed combining the national ecological construction project and highlighted the importance of several orchard industries with ecological and economic benefits [11]. Moreover, in 2018, the "No. 1 Central Document of China" emphasized to "further promote the greening, quality supervising, specializing and branding the specialty agricultural products [12]".

However, as the main agribusiness agent, the behavioral responses of the farmers should be captured effectively for understanding the development of the special orchard-based fruit industry [13,14]. According to Corris [15], farmers' ecological cognition mostly relies on their interpersonal understanding, perception and plan of action, which is mostly altered by several externalities. Yang et al. [16] defined farmer ecological responses behavior as "the set of knowledge, skills and thought that can alters or minimize the negative externalities" which lead them to face external environmental changes spontaneously for taking the planting decisions and behavior accordingly. Some scholars have roughly divided the key factors affecting farmers' behavioral decisions into external and individual factors [17,18]. While some scholars highlighted that individual characteristics such as household characteristics, household heads perceptions, social impacts, educational status, training facilities and interpersonal innovativeness could be decisive factors in understanding farmers' behavior [19–21]. However, some academics have different opinions on whether farmers' cognition influences their decision-making behavior [22,23]. Some scholars believe that there is a positive correlation between behavioral cognition and behavioral actions, which leads behavioral cognition directly to the actor's behavioral intention and decision [24,25]. Seemingly, some scholars also point out the inconsistency between farmers' cognition and behavioral decision-making process and they also pointed there is no significant causal relationship between farmers' cognition and decision-making [26,27]. The divergence between cognition and behavior of economic agents is reflected as cognitive conflict [28,29].

The existing studies on farmers' responses and decision-making behavior towards new technology and its influence have been relatively wealthy [30–32]. In contrast, very few publications have been traced to quantify the farmers' ecological cognition in response to special orchard fruit planting behavior. There is a lack of research on whether a specific technology or measure will affect farmers' decision-making behavior [33,34]. However, maximizing the orchards fruit farmer's economic return and the ecological benefits of specialty orchard fruit planting still need to be explored compressively [35]. Fewer studies have focused on the ecological factors on farmers' decision-making and response behavior within the context of orchard farmers [36]. Several external and internal factors frequently influence farmers' decision-making behavior and these variables should be explored cohesively [37]. Seemingly, the key factors that affect farmers' ecological behavior regarding specialty orchard fruit planting have not been explored adequately yet. The inner relationship between these critical factors has not been explored critically also by existing pieces of literature.

Therefore, the study intends to analyze the following research questions: (i) Does farmers' cognition of ecological agriculture influence their response to specialty fruit productions? (ii) Does farmers' adoption of water conservation measures influence their response to specialty orchard fruit planting? (iii) What other factors influence farmers' response to specialty orchard fruit planting? (iv) Finally, which factors are the deep-rooted root causes of constraints on farmers' response to specialty orchard fruits planting? The answers to the above questions are convenient in screening the potential driving forces affecting farmers' planting of specialty orchard farming and opening up the channel to increase farmers' income and protect the ecology simultaneously. The study selects Shaanxi and Ningxia provinces as the research area covering the Loess Plateau region of China. The research focuses on how the adoption behavior of planting specialty fruits and its degree impacts the farmers' income, water conservation and eco-product price cognition, which quantifies as the prime strength and novelty of the study. Interestingly, to the best of our knowledge, the inner relationships between specialty fruit productions behavior and farmers' ecological cognition have not been studied previously.

2. Conceptual Framework

The specialty forestry and fruit industry and its planting decision have a significant relationship between economic benefits and ecological protection maximization [38]. The primary purpose of planting any sort of crops or orchards is to sell products to gain income, so the study takes the theory of farmers' behavior as the primary theoretical basis [39]. According to the theory, the rational farmer can be further subdivided into complete rational and limited rational farmers. The complete rational farmers believe that the rational person's goal depends on optimization or utility maximization, but the hypothesis of complete rationale is relatively complicated [40]. Therefore, Russell and Simon [41] proposed the "limited rationality hypothesis," which argues that farmers' decision-making behavior is "subjectively perfectly rational, but objectively limited to do so." Therefore, from the most basic gist of the limited rationality hypothesis, the maximization of benefits in farmers' decision-making process is only for the subjective knowledge of decision-makers [42].

In contrast, cognition plays a vital role in farmers' decision-making process and, specifically, the level of ecological agriculture cognition is an essential factor influencing farmers' special forestry and fruit planting [43]. Different scholars have different definitions of ecological agriculture cognition. For example, Tang et al. [44] defined farmers' cognition as the interpersonal concern and perception regarding any specific situation that impacts their interests. Zhu and Wang [45] defined ecological agriculture cognition as farmers' subjective knowledge and thought about the ecological agriculture production models. By evaluating the above definition, the study defines ecological agriculture cognition as "how farmers obtain information through various channels, analyze and understand it in order to capture the maximum value within limited resources". We evaluate farmers' cognition of ecological agriculture as three distinct criterion (cognition of eco-agriculture in increasing income, water conservation and eco-product price).

The cognition of eco-agriculture in increasing income reflects the objective reality of farmers' cognition by capturing the household's economic solvency from the ecological development [46,47]. Farmers who understand this issue deeply will be optimistic about the future income increase brought by planting unique orchard fruits and then paying more attention to ecological agriculture and specialty orchards fruits industry [48]. Mouron et al. [49] studied Swiss Apple orchards and found that environmental cognition substantially helps choose the best pesticides and organic farming tactics, which eventually helps farmers' increase household income. As a result, it could be estimated that farmers will be more enthusiastic about planting specialty orchard fruits and expanding the planting rate. Based on this, the study proposes Hypothesis 1:

Hypothesis 1 (H1). *The cognition of eco-agriculture increase income positively influences farmers' response to specialty forestry and fruits planting.*

The cognition of eco-agriculture water conservation reflects the result of farmers' awareness of the objective reality that the development of eco-agriculture can maintain maximum use of soil and water resources [50]. Therefore, the development of ecological agriculture, especially in the unique forestry and fruit industry, farmers' ecological cognition can positively affect soil and water conservation [51]. The more farmers know about the importance of ecological soundness, the more they can understand the criticality of developing specialty forestry and fruits for soil and water conservation and ecological protection [52]. Therefore, it can be assumed that the more the farmer possesses a positive attitude regarding ecological safety, the more they will be willing to develop unique forestry and fruits and expand the planting rate. Based on this, the article proposes Hypothesis 2:

Hypothesis 2 (H2). *The cognition of eco-agriculture water conservation positively influences farmers' response to specialty forestry and fruits planting.*

The cognition of eco-product price reflects the result of farmers' objective reality that the price of ecological agricultural products is different from the other conventional products [53]. Product price is an important driving force for farmers to improve the mode of the agricultural operation and adjust the structure of agricultural operation [54,55]. Specialty orchard fruit products are an essential type of ecological product that is found to gain more price than the other fruit as it is widely recognized as organic and relatively safer food [4]. In several studies, it has been found that ecological friendly oriented fruit successfully refers to high-value fruit than the other conventional fruits (such as Weibel et al. [56] and Canavari et al. [57]). The higher the price recognition of unique orchard fruit products farmers can get, the more they will develop their particular orchard fruit industry and expand the planting scale [58,59]. Based on this, the study proposes Hypothesis 3:

Hypothesis 3 (H3). *The cognition of eco-product price positively influences farmers' response to specialty forestry and fruits planting.*

The above hypotheses are graphically illustrated in Figure 1, which we used as the study's conceptual framework.

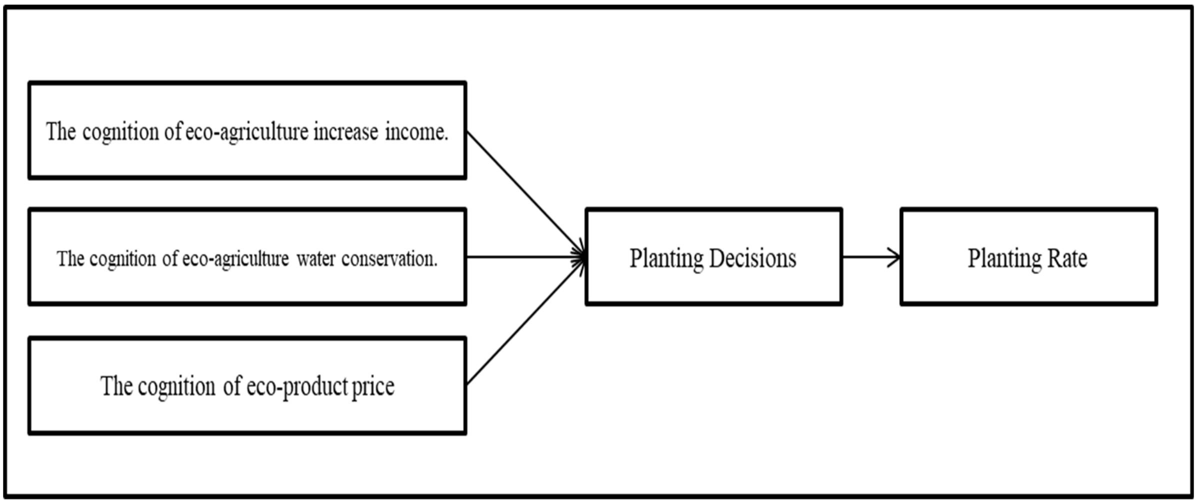


Figure 1. Conceptual framework of ecological cognition and response to specialty orchard fruit planting.

3. Materials and Methods

3.1. Data Collection

The study developed a cross-sectional survey in Shaanxi Province and Ningxia Hui Autonomous Region, China (Figure 2), to capture the empirical data. Geographically the two regions are sound for orchards farming. The largest river in China, the Yellow River, flows through Shaanxi Province and Ningxia Hui Autonomous Region. In addition, Shaanxi and Ningxia are located in the Loess Plateau region of China, where the climate is arid and soil erosion is more severe than in other regions. However, the Loess Plateau region is not fertile enough for conventional farming with severe soil erosion, serious sanding, salinization, stone desertification and arable land with low and unstable grain yield. According to local conditions, the Chines government encourages the farmers of these regions to exercise planned and systematic cultivation and relace the vegetation land by afforestation and grass planting. Moreover, Shaanxi and Ningxia are important pilot areas of China's "Returning Farmland to Forestry Project".

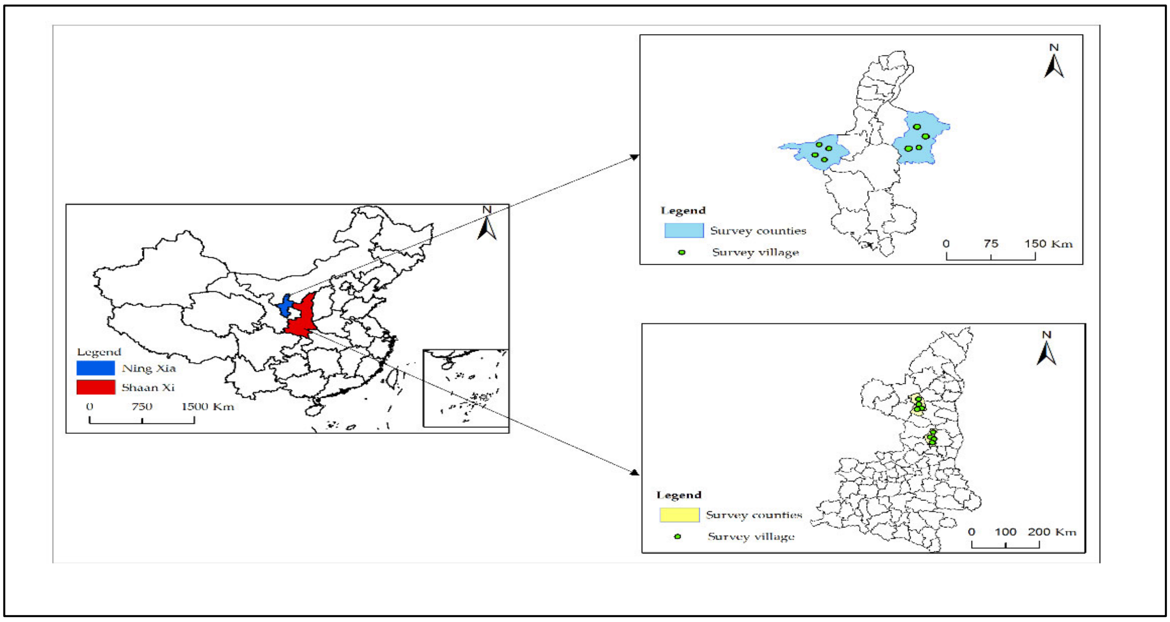


Figure 2. The study area.

The study utilized multi-stage stratified random sampling methods to select the sample. First, two counties were selected from Ningxia and Shaanxi provinces according to the size of the specialty orchard planting (out of the two largest scale specialty orchard fruit planting counties). Second, four towns were selected from each county (out of the four largest scale specialty orchard fruit planting towns). Finally, we selected four villages with sound planting characteristics for orchard farming. The final investigation includes 10 to 15 farmers from each village, which leads us to 476 respondents. After eliminating invalid samples and samples with significant problems, the final sample consisted of 309 farmers engaged in specialty orchard fruit cultivation and 107 farmers not engaged in specialty orchard fruit cultivation. We conducted face-to-face interviews with farmers who planted specialty orchard fruit. However, the sample distribution of the farmers in this study follows the basic principles of random sampling and stratified sampling. In the questionnaire, the study uses the five-level Likert scale to measure the responses. A high score means better farmers' cognition of ecological agriculture.

According to the respondents' essential characteristics (Table A1), the respondents were mainly male, with a proportion of 94.47%. Fewer growers were under 50 years old and most of the growers were above 50 years old. The educational background of the interviewed farmers was mostly below junior high school education and the overall education level was relatively low. There were not many farmers with village cadres and party members among the interviewees, of which only 46 were members of village cadres and 63 were party members. In addition, most of the respondents had a total household size of fewer than six people and fewer (1.93%) had a total household size of more than ten people.

3.2. Methods

The study first uses the double hurdle model to analyze the influencing factors of farmers' specialty orchard fruit planting response focuses on whether the cognition of ecological agriculture increases income, water conservation and product price influences farmers' specialty orchard fruit planting response. Then, according to the influencing factors extracted by the double-hurdle model, the Interpretative Structural Model (ISM) was used to evaluate the hierarchical structure and the relationship among the influencing factors as suggested by Cheung et al. [60]. The study uses STATA 12.0 software (StataCorp LLC, College Station, TX, USA) to analyze the sample data empirically. The explanatory variables' variance inflation factor (VIF) was calculated to test the collinearity among explanatory variables and avoid biased results due to multicollinearity issues, as suggested by Wang et al. [61].

3.2.1. Double-Hurdle Model

The double-hurdle model is derived from the Probit and truncreg models [62], which correspond to the two decision-making stages of farmers' response to specialty orchard fruit planting. The selected model is participation decision (whether to plant specialty orchard fruits) and quantity decision (planting rate of specialty orchard fruits). The participation decision is described in Equations (1) and (2).

$$Z_i^* = \alpha_0 + \sum_i \alpha_i Z_i + \sum_i \alpha_i' control_i + D_i + \varepsilon_i \quad \varepsilon_i \sim N(0,1) \tag{1}$$

$$P_i = \begin{cases} 1 & Z_i^* > 0 \\ 0 & Z_i^* \le 0 \end{cases} \quad i = 1, 2 \ldots n \tag{2}$$

Among them, $Z_i{}^*$ in Equation (1) is the potential variable to participate in decision-making, which cannot be directly observed. While P_i in Equation (2), the decision-making participation and represents whether farmers plant specialty orchard fruits, which is a binary choice variable. When $Z_i^* > 0$, $P_i = 1$, it means the i^{th} farmer planting specialty orchard fruits and when $Z_i^* \le 0$, $P_i = 0$, it means that the i^{th} farmer does not plant specialty orchard fruits. Seemingly, Z_i is the core explanatory variable or potential variable, $control_i$ is the control variable of potential variable, D_i is the regional dummy variable of potential variable, ε_i is the error term and obeys the standard normal distribution $\varepsilon_i \sim \mathrm{N}(0,1)$. Here n represents the number of variables, α_0, α_i, α_j' are the parameters to be estimated and the decision is described in Equations (3) and (4).

$$Y_i^* = \beta_0 + \sum_i \beta_i X_i + \sum_i \beta_i' control_i + D_i + \mu_i; \quad \mu_i \sim N(0, \sigma^2) \tag{3}$$

$$Y_i = \begin{cases} Y_i^* & P_i = 1 \\ 0 & P_i = 0 \end{cases} ; \quad i = 1, 2 \ldots n \tag{4}$$

If $Z_i^* > 0$ and $P_i = 1$, then $Y_i = Y_i^* = \beta_0 + \sum_i \beta_i X_i + \sum_i \beta_i' control_i + D_i + \mu_i$. In Equation (3), Y_i^* is the planting rate of the specialty orchard fruits of the i^{th} farmer is the continuous variable. Seemingly, X_i represents the core explanatory variable and μ_i is the error term and obeys the normal distribution. If $Z_i^* \le 0$ and $P_i = 0$, then $Y_i = 0$; β_0, β_i, β_j' and σ are the parameters to be evaluated.

3.2.2. ISM Analysis Method

In recent years, the ISM method has been widely used to analyze and identify influencing factors of farmers' behavior [63]. The study's basic principle comprises a combination of incidence matrix and computer technology principle to clarify the correlation and hierarchy among factors [64]. The methodology is also helpful for determining the main influencing factors and exploring their internal relationships [65]. The specific steps are as follows:

The first step is to establish the adjacency matrix between the factors. We assume that there are k significant influencing factors, denoted by S_i ($i = 0, 1, \ldots, k$), then S_0 denotes the farmer's characteristic orchard fruit planting response. The Delphi method is used to determine the logical relationship between the significant factors, represented by the adjacent order matrix R. The element $r_{ij} = 1$ in the matrix indicates that the factor S_i has a direct impact on S_j and $r_{ij} = 0$ means that factor S_i has no effect on S_j, where $i = 0, 1, \ldots, k$; $j = 0, 1, \ldots, k$.

The second step is to establish the reachability matrix among the factors. The calculation of the reachability matrix has portrayed in Equation (5), where I denotes the identity matrix $2 \leq \lambda \leq k$ and the matrix is obtained by Boolean operations using Matlab (R2019, MathWorks, Inc., Natick, MA, USA) software for power operations (for more details, please check Yang et al. [66]).

$$M = (S + I)^{\lambda+1} = (S + I)^{\lambda} \neq (S + I)^{\lambda-1} \neq \ldots (S + I)^2 \neq (S + I)^1 \quad (5)$$

The third step is to determine the level-by-level division. First, the reachability matrix is divided into the reachable set $M(S_i)$ and antecedent set $A(S_i)$. Among them, the following two equations have been used: (i) $M(S_i) = \{S_i | n_{ij} = 1\}$ and (ii) $A(S_i) = \{S_j | n_{ji} = 1\}$, where n_{ij} and n_{ji} are factors in the reachability matrix. Seemingly, the set expression derived by the following equation has been used to find each layer's feature set: $M(S_i) = \{S_i | M(S_i) = M(S_i) \cap A(S_i); i = 1, 2, \ldots, k\}$. More specifically, the following steps have been taken as per the suggestion of Sarkar et al. [67]: First, find the highest element set, then cross out the corresponding rows and columns from the reachable matrix and then find the new highest element (i.e., the second layer element) from the remaining reachable matrix to find the set of elements of each layer. The fourth step is to determine the hierarchical structure of factors according to the level. The hierarchical structure of the influencing factors of the response of the specialty orchard fruits planting of farmers is obtained by connecting the factors between the adjacent layers and the same level with directional arrows.

4. Results

4.1. Variables and Description Statistics

The farmers' response to specialty orchard fruits planting was the behavioral interaction of farmers, including whether to plant the fruits and the planting rate. Among the sample farmers, 309 households (74.28%) planted specialty orchard fruits, with an average planting scale of 4.29 mu and the average planting rate of specialty orchard fruits was 49.86%. However, another vital issue that reflects the behavior of farmers is endowment impact. Farmer endowment refers to the family members' natural and acquired resources and abilities, representing the whole family [68]. As the endowment of farmers played an essential role in the response of farmers to the planting of specialty orchard fruits [69], the study endorsed the variables from three dimensions: (i) individual characteristics of the head of household, (ii) family characteristics and (iii) production and operation characteristics. Table 1 shows all the variables used in the study and the corresponding descriptive statistics.

4.2. Correlations among Farmers' Responses to Specialty Orchard Fruit Planting and Influencing Factors

Figure 3 shows the heat map of the correlation between the specialty orchard fruit planting behavior and its influencing factors. The darker color denotes a more excellent absolute value of the correlation coefficient between the variables. According to Figure 3, cognition of eco-agriculture increase income, cognition of eco-agriculture water conservation and cognition of eco-product price were positively correlated with whether to plant special orchard fruits. The findings suggest that the cognition of eco-agriculture has a positive influence on farmers' response to planting specialty fruits. In addition, annual household income, agricultural planting scale, degree of agricultural specialization and effective irrigation rate were positively correlated with whether to plant unique orchard fruits. However, weaker correlations were found between age, gender and whether to plant unique orchard fruits. These findings suggest that age and gender may not have a substantial effect on whether to plant unique orchard fruits.

Table 1. Variable meaning and description statistics.

Serial Number	Variables	Definition	Mean	SD	Min	Max
S01	Whether to plant special orchard fruits	No = 0, Yes = 1	0.74	0.44	0.00	1.00
S02	Planting rate of specialty orchard fruits	The proportion of planting area of family specialty orchard Fruits in its actual cultivated land area (%)	49.86	30.38	1.79	100.00
S1	Cognition of eco-agriculture increase income	Can the development of ecological agriculture increase income? No effect = 1, small effect = 2, general = 3, large effect = 4, very large effect = 5	3.37	1.63	1.00	5.00
S2	Cognition of eco-agriculture water conservation	Can the development of ecological agriculture maintain soil and water? No effect = 1, small effect = 2, general = 3, large effect = 4, very large effect = 5	3.21	1.75	1.00	5.00
S3	Cognition of eco-product price	Is the price of ecological agricultural products higher than that of general products? No action = 1, less action = 2, general = 3, more action = 4, very big action = 5	4.23	1.23	1.00	5.00
S4	Age	The actual age of the head of household	55.10	10.24	27.00	83.00
S5	Ecological agriculture training	Have you participated in ecological agriculture training? No = 0, yes = 1	0.55	0.50	0.00	1.00
S6	Annual household income	Net income of the family in 2016 (RMB 10,000)	6.42	5.17	0.25	32.95
S7	Agricultural planting scale	The actual cultivated land area of households in 2016 (mu)	13.35	12.91	0.00	100.00
S8	Degree of agricultural specialization	The proportion of annual household planting income to annual household income (%)	33.77	27.11	0.00	99.50
S9	Province	Ningxia = 0, Shaanxi = 1	0.51	0.501	0.00	1.00
S10	Gender	Female = 0, Male = 1	0.95	0.23	0.00	1.00
S11	Education	Actual educational years of the head of household (years)	6.62	3.92	0.00	15.00
S12	Effective irrigation rate	The proportion of effective irrigation area in total cultivated land	18.42	35.70	0.00	100.00
S13	Agricultural technicians	Are they agricultural technicians? No = 0, yes = 1	0.05	0.21	0.00	1.00
S14	Number of family workers	Number of the labor force engaged in agricultural production in the family (person)	2.95	1.46	0.00	8.00

4.3. Analysis of Factors Influencing Farmers' Response to Specialty Orchard Fruit Planting

4.3.1. The Effect of the Cognition of Eco-Agriculture Increases Income on Farmers' Response to Planting Characteristic Orchard Fruits

The specific regression results obtained by fitting the double-hurdle model are shown in Table 2. The cognition of eco-agriculture increase income positively affected whether farmers planted characteristic orchard fruits at the 1% significance level. The cognition of eco-agriculture increased income positively affected whether farmers planted specialty orchard fruits and positively affected the rate of planting specialty orchard fruits at a 5% significance level. This indicates that farmers were more willing to develop eco-agriculture and plant specialty orchard fruits to gain increased income from eco-agricultural products. Second, farmers' awareness of ecological agriculture income increase was a decisive factor in the perceived usefulness of ecological agriculture and determining farmers' acceptance of planting specialty orchard fruits. Based on the above discussion, Hypothesis 1 is supported.

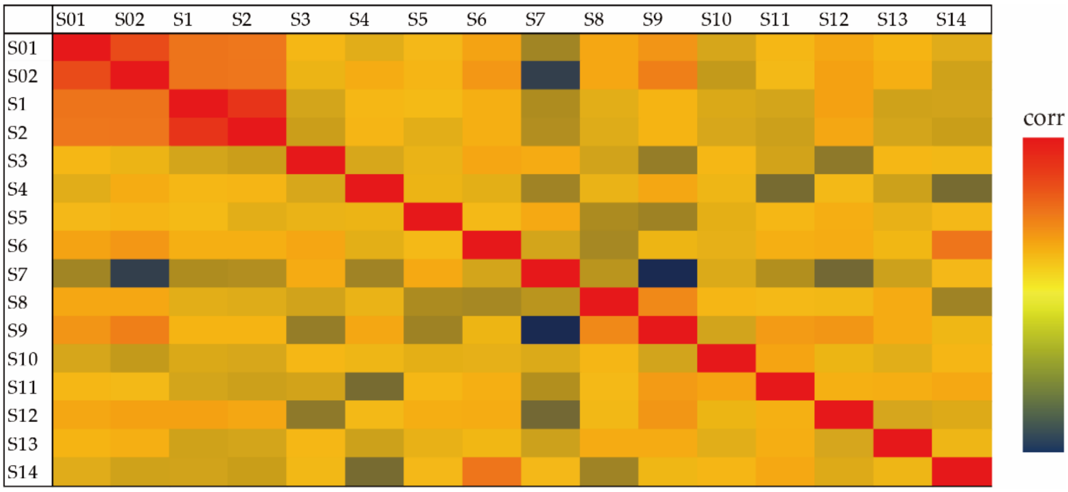


Figure 3. The heatmap of correlation coefficient (corr) matrix among variables. Note: S01–S14 is in the same order as the variable names in Table 1. Darker colors imply larger absolute values of the correlation coefficients among variables.

Table 2. Results of ecological agriculture cognition on farmers' response to specialty orchard fruit planting.

Variables	Participation Decision Model (Probit)		Quantitative Decision Models (Truncreg)	
	Marginal Effects	Standard Error	Coefficient	Standard Error
Cognition of eco-agriculture increase income	0.057 ***	0.015	4.976 **	2.188
Cognition of eco-agriculture water conservation	0.043 ***	0.015	1.607	1.925
Cognition of eco-product price	0.030 *	0.015	2.753 *	1.651
Age	−0.003 *	0.002	0.135	0.194
Gender	−0.052	0.088	−8.105	7.569
Education	−0.001	0.005	−0.213	0.509
Ecological agriculture training	0.093 **	0.038	11.832 ***	3.827
Agricultural technicians	0.084	0.102	7.450	7.523
Number of family workers	−0.018	0.014	−1.609	1.509
Annual household income	0.014 ***	0.005	1.348 ***	0.373
Agricultural planting scale	0.001	0.001	−2.353 ***	0.310
Degree of agricultural specialization	0.002 **	0.001	0.151 **	0.072
Effective irrigation rate	0.001	0.001	−0.068	0.049
Province	Control	Control	Control	Control
Constant			19.744	17.114
Observations	416		309	
Sigma	--		27.472 ***	
Log-Likelihood	−169.059		−1386.628	
Wald-chi2 (14)	--		115.96	
Prob > chi2	0.000		0.000	

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

4.3.2. The Effect of the Cognition of Eco-Agriculture Water Conservation on Farmers' Response to Planting Characteristic Orchard Fruits

The cognition of eco-agriculture water conservation positively affects farmers who planted specialty orchard fruits and passed the test at a 1% significance level. However, the effect on the planting rate of characteristic orchard fruits was not significant, indicating that the higher the farmers' cognition of eco-agriculture water conservation, the more they could realize the importance of eco-agriculture for soil and water conservation. Therefore, ecological agriculture water conservation cognition promotes farmers' specialty orchard fruit planting response. Hypothesis 2 is supported based upon the above discussion.

4.3.3. The Effect of the Cognition of Eco-Product Price on Farmers' Response to Specialty Orchard Fruit Planting

The cognition of eco-product price positively affected whether farmers planted specialty orchard fruit and the rate of specialty orchard fruit planting at the 10% significance level. It indicates that farmers' perception of eco-friendliness and the cognition of eco-product price was a crucial factor influencing farmers' production and planting decisions. Therefore, farmers are more sensitive to their prices and their ecological agricultural price cognition was positively related to the planting degree of characteristic orchard fruits. Based on the discussion mentioned above, Hypothesis 3 is verified.

4.4. Mechanism Analysis of Influencing Factors of Farmers' Specialty Orchard Fruits Planting Response

The farmers' decision-making process is a complex system, where each element is independent of the other and connected layer by layer and it constitutes a complete system of influencing factors [67]. Therefore, according to the logical relationship among elements, the logical relationship diagram is constructed using the Delphi method, as shown in Figure 4. It represents that the column factors impact the row factors, V represents that the row factors impact the column factors and 0 represents no relationship between them.

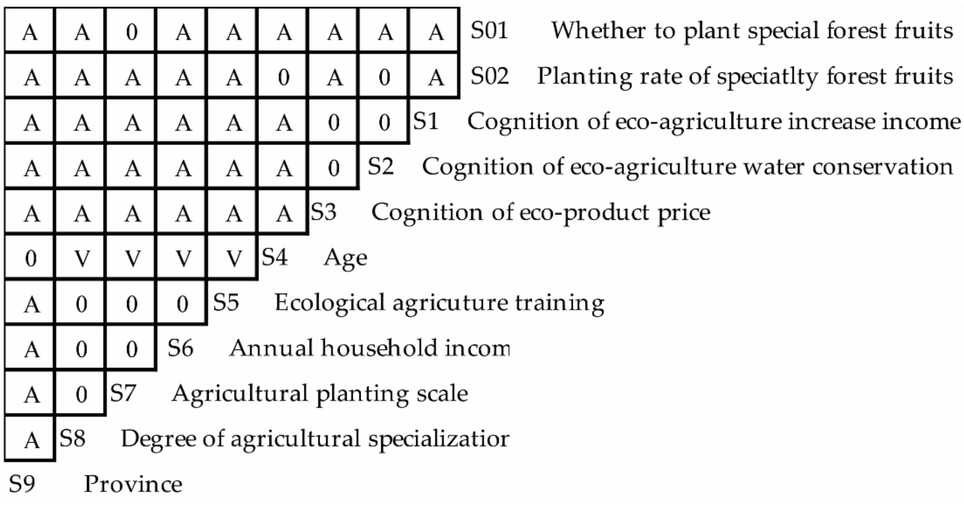


Figure 4. Relationship between factors affecting response to the planting of specialty orchard fruits.

According to the logical relationship of the factors affecting farmers' response to the planting of specialty orchard fruits, as shown in Figure 1. From Figure 1, we can obtain whether to plant specialty orchard fruits and the adjacency matrix of the planting rate within specialty orchard fruits. Combined with Equation (5), the study calculates the reachability matrix and then determine the method of level according to the level division and can obtain whether the farmers have planted specialty orchard fruits in each level as follows: $L_1 = \{S_{01}\}$, $L_2 = \{S_1, S_2, S_3\}$, $L_3 = \{S_5, S_6, S_8\}$, $L_4 = \{S_4, S_9\}$. The critical elements of planting rate of specialty orchard fruits of farmers are as follows: $H_1 = \{S_{02}\}$,

$H_2 = \{S_1, S_3\}$,$H_3 = \{S_5, S_6, S_7, S_8\}$. The reachability matrix after reordering is shown in Figures 5 and 6.

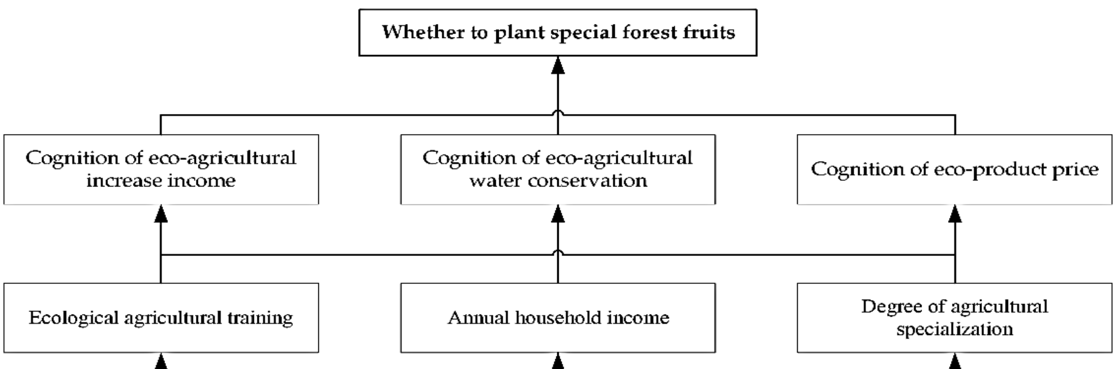
According to the reachability matrix sorted in Figures 5 and 6, the factors at the same level are represented by a box at the same level. According to the logical relationship among the influencing factors, the explanatory structure model that affects farmers' response to planting specialty orchard fruits can be obtained, as shown in Figures 7 and 8. The surface factors that directly affect whether farmers plant specialty orchard fruits are the cognition of eco-product price, eco-agriculture increased income, eco-agriculture water conservation (Figure 7). Among them, the deeper root factors of influence are age, ecological agriculture training, the annual income of families and the degree of agricultural specialization. It can be seen that whether farmers plant unique orchard fruits or not are as follows: "age and province" → "training in ecological agriculture, annual household income, degree of agricultural specialization" → "cognition of eco-agriculture increase income, cognition of eco-agriculture water conservation, cognition of eco-product price" → "farmers planting special orchard fruits." Therefore, it is an effective measure to promote the motivation of farmers to plant orchard fruits by providing relevant training and formulating corresponding incentive measures according to their individual and family endowment differences.

	S01	S1	S2	S3	S9	S4	S5	S6	S8
S01	1	0	0	0	0	0	0	0	0
S1	1	1	0	0	0	0	0	0	0
S2	1	0	1	0	0	0	0	0	0
S3	1	0	0	1	0	0	0	0	0
S9	1	0	0	0	1	0	0	0	0
S4	1	1	1	1	0	1	0	0	0
S5	1	1	1	1	0	0	1	0	0
S6	1	1	1	1	0	0	0	1	0
S8	1	1	1	1	0	0	0	0	1

Figure 5. Reachability matrix after participating in decision ranking.

	S02	S1	S3	S5	S6	S7	S8
S02	1	0	0	0	0	0	0
S1	1	1	0	0	0	0	0
S3	1	0	1	0	0	0	0
S5	1	1	1	1	0	0	0
S6	1	1	1	0	1	0	0
S7	1	1	1	0	0	1	0
S8	1	1	1	0	0	0	1

Figure 6. Reachability matrixes after ranking of quantitative decision making.



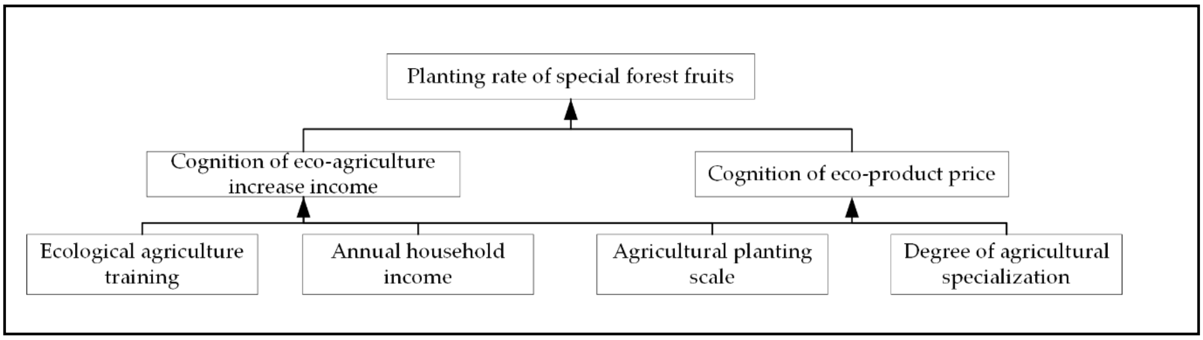


Figure 8. Explanatory structural model of planting rate of specialty orchard fruits.

As shown in Figure 8, it can be seen that the direct factors influencing the cultivation rate of specialty orchard fruits are the cognition of eco-agriculture increased income and the cognition of eco-product price. In contrast, ecological agriculture training, annual household income, degree of agricultural specialization and agricultural cultivation scale are significant influencing factors. As can be seen above, the critical paths influencing the cultivation rate of specialty orchard fruits by farmers are mainly along with the following relationship: "ecological agriculture training, annual household income, degree of agricultural specialization, agricultural cultivation scale" → "cognition of eco-agriculture increase income, cognition of eco-product price" → "Planting rate of specialty orchard fruits".

5. Discussion

This study crafted its findings based on research data from 416 farmers in specialty forest fruit growing areas in China's Shaanxi and Sichuan provinces. Regression analysis was conducted using an econometric model to explore the influence of ecological agriculture cognition on the response behavior of specialty forest fruit growing. The study first found that ecological agriculture cognition significantly influenced farmers' specialty forest fruit planting and quantity decisions. The finding also highlights that farmers' ecological agriculture cognition could dramatically improve farmers' specialty forest fruit planting behavior. The findings of this study are consistent with Xue et al. [70], Wang et al. [71], Li et al. [72], Azadi et al. [73] and Das V. et al. [74], who also found that farmers' cognition is an essential factor in farmers' behavioral decisions. The above findings are also consistent with the theory of planned behavior [75], which suggests that attitudes, subjective norms influence individuals' actual behavior and perceived behavioral control, which influences individuals' cognition and rectifies their actual decision-making behavior [25,76]. In particular, the study by Zhang et al. [77] indicated that farmers' perceptions of pesticide residues would positively impact farmers' adoption of eco-friendly agricultural production, which is consistent with the study's findings.

The effect of the cognition of eco-agriculture increases income on farmers' response to planting specialty orchard fruits is positive. It shows that the higher the expectation of ecological agriculture income increase, the more farmers are willing to develop ecological agriculture. The possible explanations are as follows: first, ecological agriculture improves the economic benefits of farmers by improving agricultural land-use efficiency and labor productivity. The economic benefit is the primary factor to stimulate farmers to engage in ecological agriculture, which determines farmers' planting behavior [78]. Seemingly, the effect of the cognition of eco-agriculture water conservation on farmers' response to planting specialty orchard fruits is positive. The possible explanation is that ecological agriculture is resource-saving agriculture, which can improve the land-use rate, output rate and have a water-saving effect [79]. In developing ecological agriculture, the "green" vegetation cover reduces water evaporation and conserves water sources, essential for soil and water conservation. However, soil and water conservation can protect scarce cultivated land resources, reduce crop yield risk, bring long-term benefits to farmers [80] and improve the level of ecological agriculture specialization [50]. Therefore, soil and water conservation and ecological agriculture promote each other. Specialty orchard fruits are typical representatives of commercialized ecological agriculture [81]. The effect of the cognition of eco-product price on farmers' response to specialty orchard fruit planting is also positive. The possible explanations are as follows: first, the market demand for ecological products is increasing with the improvement of social and economic movement, green transition and healthier food supply options. On the other hand, the market price is also relatively higher. Thus, price cognition of ecological products is steadily improving, promoting ecological agriculture and gradually transforming the ecological advantages of ecological agriculture into economic advantages [82].

The production mechanism and style of smallholder farmers have their particularity. In pursuing utility maximization, it should meet the consumption needs of family members and obtain market profits by participating in market transactions [83]. Typically, farmers seek a balance between consumer needs and market profits. With the implementation of ecological agriculture, the family planting structure has been adjusted and farmers increase their total income by planting crops with relatively high market prices. Compared with other agricultural products, the commercialization rate of specialty orchard fruits is higher [84], which means that the proportion of the specialty forest and fruits used in the market transaction is relatively large and the marketization degree is also high [85].

However, the study differs from some of the existing studies. For example, our study showed that gender did not affect farmers' specialty forest fruit growing behavior. This is not consistent with the investigations of He et al. [86] and Abdulai et al. [87]. The main reason for this difference is that with the increasing labor exodus in China, the labor force for agricultural production in rural areas has shifted mainly from male to female producers, thus leading to a gradual dilution of the gender factor [88,89]. In addition, our study found significant differences in the factors influencing farmers' decision-making behavior and quantity decisions for specialty forest fruit planting, where the scale of agricultural planting was not the main factor influencing whether farmers planted specialty forest fruit. In contrast, ecological agricultural training was an essential factor influencing farmers' specialty forest fruit planting rate. Zakaria et al. [90] found that farmers can learn about new technologies through training and application courses and by learning to promote new technologies, they can enhance their agricultural operations. It is similar to our study. Therefore, the government should consider strengthening the empowerment of decision-makers, raising their awareness of environmental protection by planting special forest fruits and encouraging their active participation to improve the decision-making behavior of farmers in the planting of unique forest fruits.

6. Conclusions

Based on micro survey data of 416 orchard farmer's households in Shaanxi and Ningxia provinces, the study uses the bounded rationality theory as a theoretical framework. A double-hurdle model was used to analyze farmers' responses for quantitative decision-making behavior. Moreover, the study uses the ISM model to analyze how the cognition of eco-agriculture increases income, the cognition of eco-agriculture water conservation and the cognition of eco-product price affecting farmers' behavior regarding specialty orchard fruit planting. Seemingly, the study also constructs a hierarchical structure relationship among the influencing factors and profoundly explores the root factors affecting orchards farmers' characteristics by using ISM. The main conclusions of this paper are as follows: first, the farmers who planted specialty orchard fruits accounted for 74.28% of the total sample farmers. The average planting scale was 4.29 mu and the average planting rate of characteristic orchard fruits was 49.86%. Second, farmers' ecological agriculture cognition has directly affected farmers' behavior and it has acted as a root factor to influence the farmer's behavior. The higher the degree of farmers' cognition of eco-agriculture increase income, eco-agriculture water conservation and eco-product price, the more inclined they are to plant specialty orchard fruit, which also verifies the correctness of hypotheses 1 and 2. The higher cognition level regarding eco-agriculture increases income and eco-product price lead the farmer to expand the specialty orchard fruit planting and it verifies the correctness of Hypothesis 3. Third, farmers' endowment differences and regional factors are found as root factors affecting farmers' responses to specialty orchard fruit planting. Fourth, regional variables, farmers with younger household heads, more training in ecological agriculture, higher annual household income and a higher degree of agricultural specialization have a higher probability of planting specialty orchard fruits. At the same time, farmers with more training in ecological agriculture, higher annual household income, smaller agricultural planting scale and a higher degree of agricultural specialization develop specialty orchard fruits on a larger scale.

The development of specialty orchard fruits has both ecological and economic benefits, which is a practical and effective way to ensure ecological security and increase farmers' income in the Loess Plateau area. However, how to promote farmers' response to the planting of specialty orchard fruits has become a vital issue. Therefore, the government departments should introduce policies to strengthen government guidance and improve farmers' awareness of ecological agriculture based on farmers' diversity characteristics. The specific recommendations are as follows:

The government should highlight the benefit of ecological products and the betterment of ecological agriculture. The government should also uphold the special characteristic of the ecological orchard to produce a brand effect, economic benefit and social benefit. For this thrives, concerned authorities should promptly arrange cultural festivals and experience exchange meetings to capture the added value of ecological products. The government should extend the supports of agricultural demonstration zone to practically displays the innovative tactics, methods and another technological advancement should also be properly circulated. The concerned authorities should also arrange specialized training facilities to enhance farmers' expectations of the rising price of characteristic orchard fruits, improve the ability to capture market equilibrium power and promote the peaceful development of characteristic orchard fruits. The government should strengthen the information-sharing platform to minimize the knowledge gap. Modern planting techniques and management concepts should also be highlighted via agricultural skills training programs. The farmers and agricultural service providers should be integrated for solving technical problems in agricultural production to improve farmers' specialization in specialty fruit production. There is a rising concern to refine the existing agro-environmental policies based on differences in individual farm household characteristics. The farmers' diversity and micro incentive measures should be introduced from the regional capital structure, technology, land and water use. The policies should focus on promoting large-scale operations and give small farmers space for being developed.

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Appendix A. Demographic Data

Table A1. Basic characteristics of interviewed farmers.

Variable	Category	Count	Frequency (%)
Gender	Male	393	94.47
	Female	23	5.53
Age	[1, 30]	3	0.72
	(30, 50]	147	35.33
	(50, 60]	128	30.77
	>60	138	33.18
Educational background	None	61	14.66
	Primary school	139	33.41
	Junior high school	154	37.03
	Senior high school	55	13.22
	College and higher	7	1.68
Village cadre member	Yes	46	11.06
	No	370	88.94
Party member	Yes	63	15.14
	No	353	84.86
Total household population	[1, 3]	136	32.69
	[4, 6]	218	52.40
	[7, 9]	54	12.98
	≥10	8	1.93

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