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How do risk preferences influence forage planting behaviors among farmers in the agro-pastoral ecotone of China?

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Introduction: This study analyzes the influence of risk preference on the forage planting behavior of farmers in the agro-pastoral zone from three aspects-whether or not to plant forage, the scale of forage planting, and the duration of forage planting—and pays attention to the indirect effect of credit on the farmers' forage planting behavior, as well as the heterogeneity of the influence of risk preference on the forage planting behavior of farmers from the perspectives of different farming scales, types of farmers, and differences between generations.

Methods: Experimental economics, a two-stage model, is used to analyze this problem.

Results and conclusion: The results show that, first, risk preference can significantly promote farmers' forage planting probability, expand forage planting scale, and increase forage planting duration. Specifically, when risk preference increases by one unit, the probability of farmers choosing to plant forage increases by 7.8%, the planting scale increases by 0.205 hm^2, and the planting duration increases by 0.519 years. This conclusion remained robust after changing the explanatory variables. Second, risk preference not only directly affects farmers' forage planting behavior but also indirectly affects farmers' forage planting behavior by influencing farmers' participation in credit. Third, heterogeneity analysis shows that risk preference has a significant effect on forage planting behavior among farmers with a medium breeding degree, among pure farmers and concurrent farmers, as well as middle-aged and elderly farmers.

KEYWORDS

risk preference, farmers' forage planting behavior, experimental economics, agro-pastoral ecotone, farmer heterogeneity

1. Introduction

In response to the upgrading of the food consumption structure of the people and the prominent structural contradictions in agriculture, the Chinese government put forward the concept of establishing large grain in 2015 to ensure food security. The big food concept requires not only ensuring the safety of rations but also ensuring the safety of non-rations, such as meat, eggs, and milk (Dong et al., 2015). Under the premise of absolute food safety, how to guarantee the adequate supply of livestock products and quality safety are important problems that need to be solved urgently. Being influenced by traditional farming culture, the feeding mode of "straw + concentrate" is extended in our animal husbandry. Due to the long-term lack of high-quality forage as "staple food" to develop herbivore animal husbandry, resulting in low production efficiency of animal husbandry, livestock product quality and safety are not large issues (Chen et al., 2012; Zhang et al., 2013). Related research shows that, if the feeding method of herbivorous livestock is changed, the bottleneck of animal husbandry development will be alleviated (Ren, 2013). In this way, the development of high-quality forage has become a necessary way to speed up the transformation of herbivorous animal husbandry and ensure an adequate supply of livestock products.

In 2015, the Chinese government vigorously implemented the policy of "food-fodder change". This policy is aimed at the development of herbivore animal husbandry, encouraging and guiding farmers to plant high-quality forage grass such as whole-plant silage corn (Shi and Hu, 2022). These silages are harvested, processed, and converted into herbivore livestock such as cattle and sheep in the form of silage, forming a development model of circular agriculture combining planting and feeding (Guo, 2019). As a circular agricultural production and management mode, it can not only promote China's agricultural structure adjustment but also increase the supply of high-quality forage and ensure the quantity and quality safety of livestock products. In 2022, the 14th Five-Year Plan for the Development of the National Forage Industry further proposed to actively promote grain conversion in the agro-pastoral ecotone, and by 2025, the national yield of high-quality forage grass is expected to reach 98 million tons. This means that the forage planting degree in China will continue to expand in the future, and the farmers involved will also be further expanded. However, the problem is that the policy of "food-fodder change" has been implemented for 8 years. Also, the forage planting rate of farmers is still low, the forage planting is not continuous, and the high-quality forage supply is at a low level (Guo et al., 2020; Yang et al., 2023). In this context, it is an important issue that government departments and academia need to explore the factors that affect forage planting behavior decision-making of farmers. This is of great practical significance for promoting the sustainable development of "food-fodder change" policy, comprehensively consolidating the foundation of food security and practicing the concept of big food.

A review of the existing literature revealed that scholars investigated the important factors affecting farmers' behavioral decisions on forage planting from the aspects of farmer characteristics, policy incentives, and crop prices. For example, Wang et al. (2018) based on the micro-survey data of two provinces found that household characteristics (age of household head, number of livestock, and amount of forage) and regional characteristics all had a positive impact on the operation behavior of combined planting and breeding. Zhang et al. (2018), based on the survey data of farmers in the agro-pastoral intercropping zone in Ningxia, found that policy support (participation in the feeding-shed project) could significantly increase the planted area of artificial forage land. Wang (2021), based on the data from 19 major alfalfa-producing provinces in China from 2001 to 2017, found that the high transportation cost of alfalfa has an inhibitory effect on the expansion of alfalfa production scale, and increasing the per capita arable land area has an incentive effect on promoting alfalfa planting. Irungu (1998), in a study of smallholder dairy farmers in the Kiambu region, found that the head of household's farming years, horticultural/dairy area affiliation, off-farm employment, and dairy cooperative/farmer organization affiliation had a positive impact on the probability of adopting Napier grass. Milk price has a negative impact on the probability of adopting Napier forage among sample farmers. Javeed et al. (2020) conducted personal interviews with dairy farmers in the Northeast Transition Zone of Karnataka, India, and found that group size, land holdings, annual income, distance to veterinary institutions, extension participation, decision-making ability, scientific orientation, and economic variables, such as orientation and risk orientation, were significantly associated with attitudes toward green forage crop cultivation. Age and education level were negatively correlated with attitudes toward green forage crop cultivation. Wang et al. (2015) analyzed the influencing factors of farmers' alfalfa planting behavior in the Huaihai area by using statistical data and found that corn prices had a significant positive effect on the alfalfa planting area. However, as a forage with relatively high risk, especially after converting grain corn into whole silage corn, it may face risks such as inadequate technical suitability, uncertain market conditions, and natural disasters. Therefore, the influence of risk preference on the forage planting behavior of farmers cannot be ignored.

In terms of risk appetite perspective, existing studies have also shown that risk preference plays an important role in farmers' behavioral decision-making (Wossen et al., 2015; Xu et al., 2020). Chavas and Holt (1996) found that farmers' risk preferences will have an impact on land allocation decisions in the process of agricultural production through the study of corn and soybean planting areas. Using data from a preliminary survey of onion growers in India, Khanal et al. (2019) explored the relationship between risk appetite and farm diversification strategies. Hasibuan et al. (2022) conducted a study on citrus growers and considered the role of risk in household fertilizer and pesticide expenditure decisions. Salimonu and Falusi (2007) measured the risk preference of food crop farmers and found that risk preference will have an impact on resource use and allocation patterns in agricultural production. Vollenweider et al. (2011) focused on the adoption of pro-environmental behaviors in pasture planting and studied the impact of risk preference on the probability of farmers participating in the Rural Environmental Protection Program (REPS). However, at present, only Gao (2020) studied farmers' forage planting behavior decisions based on risk management strategies and confirmed the role of risk management strategies. The conclusion of this study has a certain reference value, but there are still some shortcomings: in terms of research content, on the one hand, this study only focused on the impact of risk management strategies on farmers' forage planting area but did not involve farmers' forage planting decisions and forage planting duration and other issues, so the dynamic change description and investigation of farmers' forage planting decision-making behavior were not comprehensive and in-depth. On the other hand, only the influence of risk management strategies on the forage planting decisions of farmers was discussed, but the mechanism of such influence was not deeply analyzed. From the perspective of research, it focuses on the discussion of risk management strategies but lacks the analysis of how risk preference affects farmers' forage planting behavior. This provides a space for further study in this article.

Therefore, based on the 1,479 survey data of the agro-pastoral ecotone, this study intends to analyze how risk preference affects farmers' forage planting behavior. The reason why this area is chosen as the research object is because the agro-pastoral ecotone is the edge intersection zone, the key area where the terrestrial ecosystem responds to global environmental changes and human disturbance, which is also the transition zone between grassland and cultivated land and between animal husbandry and planting (Li et al., 2018). Specifically speaking, this region has a fragile resource background, dry, windy, and heavy rainfall climate, loose soil texture, high content of sand and silty sand, sparse and low vegetation, and is an area where water erosion, desertification, and sandstorms occur and develop strongly (Li et al., 2015). These factors lead to the disruption of grain production and yield loss in the study area. It also threatens local and global food security (Shi et al., 2021). Considering that this area is an advantageous area for animal husbandry development, to improve the efficiency of land use, the Chinese government encourages local farmers to plant high-quality forage, especially whole silage corn. Many studies have shown that, under the same conditions, they have more advantages than other crops and the returns of forage cultivation are higher than that of food crops (Du and Han, 2020). Meanwhile, planting forage can reduce feed costs, help farmers manage costs during market fluctuations, and reduce financial risks associated with livestock rearing (Nong et al., 2021). However, we believe that there is still a great risk for farmers to plant forage. Such as, first, in the policy of promoting forage planting, a complete policy system has not been formed, and the specific implementation and subsidy methods are not perfect. Second, in the production of farmers, the technology of planting forage is not skilled, and the problem of insufficient planting equipment hinders farmers from planting forage. Third, in the sales process, there are contradictions such as a poor connection between forage production and sales and lagging cultivation in the order market. This means that farmers' forage planting decisions will be influenced by their risk preferences.

Compared with the existing literature, the marginal contribution of this study is mainly reflected in the following two aspects: First, analyzing farmers' forage planting behavior and exploring its mechanism from the perspective of risk preference is helpful to enrich the lack of research on farmers' forage planting behavior in related fields and provide a new direction for the study of key factors of farmers' forage planting behavior. Second, the experimental economics method is adopted to measure the risk preference of farmers in the farming-pastoral ecotone, to make the measurement results more scientific and accurate, and to enrich the relevant research on the influence of risk preference on the decision-making behavior of farmers.

2. Material and methods

2.1. Study area and data collection

The data used in this study are from the micro survey of farmers in Shaanxi and Gansu provinces in August 2022. The choice of this study area mainly considers the following three factors: First, from the perspective of geographical location, the Shaanxi and Gansu provinces cover the different agricultural ecosystems of the desertification degradation area along the Great Wall of China and the loess hilly-gully region. Second, from the perspective of agricultural conditions, the corn planting area in this region is large but the yield is low and unstable. It is the dominant area of animal husbandry, but the production efficiency of animal husbandry is low. Third, from the perspective of natural conditions, under the influence of continental climate, agricultural production in the research area faces great risks.

After confirming the sample provinces, based on the comprehensive consideration of regional agricultural and animal husbandry development scale, economic development level, and other factors, stratified sampling and random sampling methods were adopted to finally select Huan County, Zhenyuan County, Zhengning County, Yuyang District, and Dingbian County, a total of 5 sample counties (Figure 1). Then, approximately 4–5 sample towns were selected in each sample county. Later, approximately 4–5 sample villages were selected in each sample town. Finally, approximately 14–17 grain farmers were randomly selected in each sample village for one-to-one questionnaire interviews. The survey involved 96 administrative villages in 24 towns and villages in 2 provinces, 2 cities, and 5 counties. A total of 1,600 questionnaires were issued to farmers in total. After eliminating the questionnaires of key information mismatch, serious missing variables, and extreme values, 1,479 effective questionnaires were obtained from farmers, with an effective rate of 92.43%. The contents of the questionnaire mainly include the basic characteristics of farmers and families, input and output information of farmers planting whole silage corn, input and output information of livestock breeding, farmers' risk perception, and social capital.

2.2. Theoretical analysis

2.2.1. Effect of risk preference on farmers' forage planting behavior

Risk preference refers to a subjective psychological attitude of farmers in the face of risks associated with agricultural production and operation, which can be divided into risk preference, risk neutral, and risk aversion. According to prospect theory (Kahnemand and Amos, 1984), farmers' risk preferences affect their risk decision-making behavior, and there are significant differences between different farmers' risk preferences under the situation of uncontrollable production risks and asymmetric information. For example, risk-averse farmers will inhibit agricultural technology adoption (Visser et al., 2020; Yu et al., 2021), as well as fertilizer and pesticide reduction (Pan et al., 2020; Qiao and Huang, 2021). However, farmers with strong risk preferences are more inclined to adopt technology or produce risky behaviors (Liu and Huang, 2013).

The agro-pastoral ecotone is a temperate continental climate with obvious climate change, especially heavy rain and drought. In terms of farmers in the region planting whole silage maize, when it comes to dry seasons, using corn as silage can reduce yield losses and protect farmers' incomes. However, when the silage harvest season meets the rainy season, the silage machinery cannot enter the cultivated land and miss the best harvest time, which not only leads to the decrease of forage yield but also decreases the nutritional value of forage silage. Meanwhile, planting whole silage corn also has the risk of insufficient technical suitability and lag in order market cultivation, which means that, when farmers make forage planting decisions, in addition to considering cost

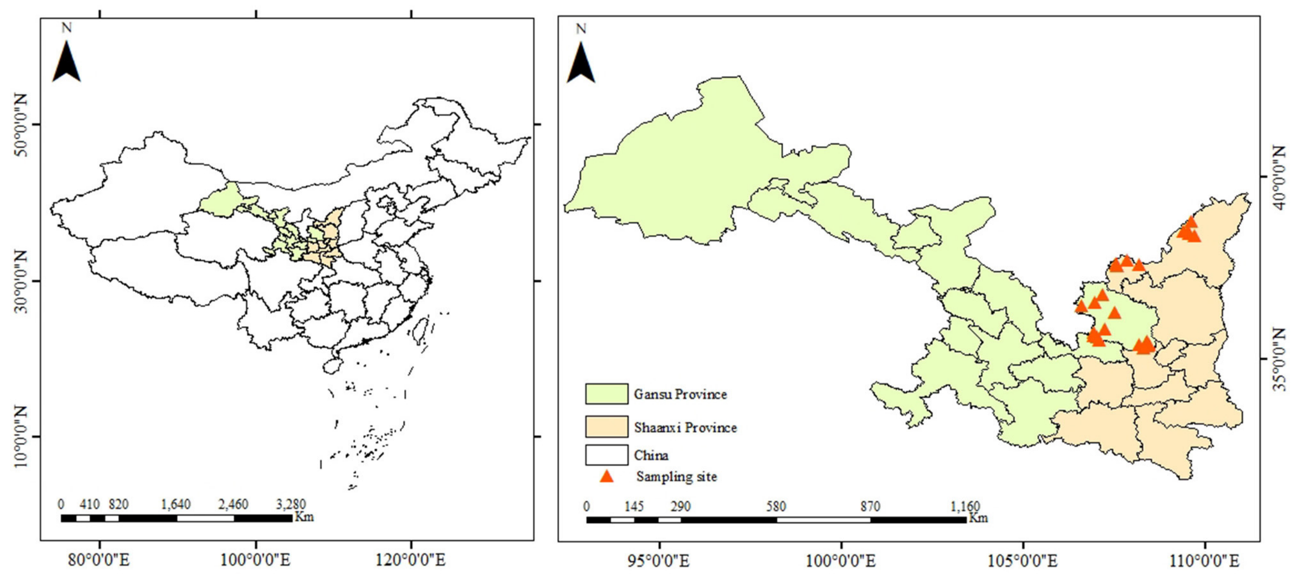

FIGURE 1
Location of sampling sites.

and benefit factors, they also need to comprehensively consider the risk factors they face. Therefore, when farmers have a high-risk preference, they pay less attention to technical and market risks brought by forage planting and more attention to economic benefits brought by forage planting, promoting the forage planting behavior. Relevant studies have shown that risk preference has a significant positive impact on farmers' behavior decision-making, decision-making scale, and duration (Mao et al., 2022). Based on the above analysis, the following assumptions are proposed:

> Hypothesis 1: Risk preference may affect the forage planting behavior of farmers in the agro-pastoral.
> Hypothesis 1a: The higher the risk preference of farmers, the greater the possibility of forage planting behavior, the larger the forage planting scale, and the longer the forage planting duration.

2.2.2. The mediating effect credits

In terms of planting whole silage corn, on the one hand, a large amount of productive financing is needed in the early stage, such as the construction of silage cellars, the purchase of silage packages, and the leasing of silage machinery. Therefore, the shortage of funds is an important factor restricting farmers' forage planting (Imail et al., 2012). By participating in credit, farmers can obtain financial credit support, relieve the financial pressure in the process of farming and animal husbandry operation, and promote the degree of agricultural investment, which can solve the transformation of agricultural production mode and stimulate farmers to plant forage (Fu et al., 2022). However, it is a fact that agricultural production is greatly affected by natural conditions, and farmers' credit is risky, so whether farmers participate in credit is affected by their risk preferences. In other words, although farmers' participation in credit can alleviate the constraints of fund shortages in farming and animal husbandry production when forage grass cultivation suffers losses, they must repay the loan within the stipulated loan period; otherwise, they will bear huge compensation for breach of contract (Gine and Yang, 2009). According to this logic, risk preference farmers pay more attention to the substantial increase in economic benefits brought by planting whole corn, have higher enthusiasm to participate in credit, and are more likely to choose forage planting. However, risk-averse farmers are less likely to participate in forage planting through loans. Based on the above analysis, the following assumptions are proposed:

> Hypothesis 2: Credit has a mediating effect on the influence of risk preference on the forage planting behavior of farmers.
> Hypothesis 2a: The higher the probability of farmers participating in credit, the greater the possibility of planting forage, the larger the planting forage scale, and the longer the planting forage duration.

2.2.3. Effects of risk preference on forage planting behavior of heterogeneity farmers

Under the background of an incomplete factor market, farmers cannot rely on the market to alleviate the problem of insufficient initial capital endowment, which makes farmers with different breeding scales have relatively different demands for forage, and thus produce different forage supply behaviors, that is, risk preference has different effects on the forage planting behavior of farmers with different breeding scales. Needless to say, small-scale farmers and medium-sized and above farmers have completely different production goals and production capacities (Tan et al., 2022). Compared with small-scale households, medium-scale and above farmers have a stronger demand for forage grass and a stronger ability to regulate production factors. At the same time, with the development of the social economy, the deepening division of labor makes the transfer of labor in agricultural and non-agricultural sectors an inevitable choice. In terms of peasant households, the division of labor leads to the division of part-time and non-part-time labor resources in the household, which then leads to changes in the input mix of production factors, such as changes in land management decisions, including land management area decisions and crop planting decisions (Luo, 2020). For farmers with different degrees of differentiation, their resource endowment and dependence on agriculture differ in land management decisions. Therefore, the influence of risk preference on farmers' forage planting behavior also varies. Compared with other farmers, pure farmers and I-concurrent farmers are more dependent on agricultural production, and they prefer to plant forage grass to meet the food nutrition of livestock and increase the income of animal husbandry. Relevant studies have shown that the same social events have different influences on different age groups, which leads to different group characteristics in preferences, attitudes, and behaviors among different generation groups (Joshi et al., 2010). As far as the current situation of China's rural areas is concerned, it is common for the young generation to go out for work. The rural labor population force is mostly middle-aged and elderly. This group is mainly engaged in agriculture and hopes to improve their agricultural income by changing the existing agricultural management model. Based on the above analysis, the following assumptions are proposed:

Hypothesis 3: The effects of risk preference on the forage planting behavior of farmers are different in terms of breeding scale, differentiation type, and intergenerational issues.
Hypothesis 3a: Compared with small-scale farmers, risk preference has a more obvious influence on the forage planting behavior of farmers with medium-scale and above farming.
Hypothesis 3b: Compared with other types of farmers, risk preference has a more obvious influence on the forage planting behavior of pure farmers and I-concurrent farmers.
Hypothesis 3c: Compared with the young generation, the influence of risk preference on forage planting behavior of the middle-aged and elderly generations is more obvious.

2.3. Variable selection

2.3.1. Explained variable

The explained variable of this study is the farmers' forage planting behavior, which includes farmers' forage planting decision, forage planting scale, and forage planting duration. In this study, farmers' forage planting decision is defined by the question: "Whether farmers will plant whole silage corn in 2021?" Values are 1–0. According to statistics, there were 664 whole silage corn growers and 815 non-growers in the survey area. Forage planting scale refers to the area of whole silage corn planted by farmers in 2021. Forage planting duration refers to the number of years for farmers to plant whole silage corn by 2022.

TABLE 1 Design of risk preference game scheme for farmers.

Game coding	A: Win a lottery ticket	B: Get a fixed amount
01	50% chance of getting 100 RMB	1
02	50% chance of getting 100 RMB	5
03	50% chance of getting 100 RMB	10
04	50% chance of getting 100 RMB	15
05	50% chance of getting 100 RMB	20
06	50% chance of getting 100 RMB	25
07	50% chance of getting 100 RMB	30
08	50% chance of getting 100 RMB	40
09	50% chance of getting 100 RMB	50
10	50% chance of getting 100 RMB	60
11	50% chance of getting 100 RMB	70
12	50% chance of getting 100 RMB	80
13	50% chance of getting 100 RMB	90
14	50% chance of getting 100 RMB	99

2.3.2. Explanatory variable

Drawing on relevant research (Holt and Laury, 2002), experimental economics is used to measure farmers' risk preferences. Specifically speaking, the experimental game consists of 14 questions, each containing two options A and B (Table 1). Option A of the 14 questions is set up the same way, that is, if the farmer buys a lottery ticket, they have a 50% chance of winning 100 RMB. Option B is that farmers will definitely receive a certain amount of reward, increasing gradually from question 1 to question 14. For each question, farmers have to choose between option A and option B. Rules of the game: researchers are asked to start with the first question and ask farmers for answers one by one. If the farmer chooses A from the first question, then the researchers begin to ask the second question, if the farmer continues to choose A, then the researchers continue to ask the third question, and so on, until the end of the 14th question. However, as long as the farmer's answer is directed from option A to option B, the game is over, and the answers to the remaining questions should all be defined as B. Of course, there are also farmers who choose option B in the first set of games, then the game is over, and the farmer's choice in the subsequent 13 sets of games is defined as B. Through 14 groups of game schemes, we can more accurately measure and analyze farmers' risk preferences. The calculation formula for farmers' risk preference degree is as follows:

$$RP = 1 - \frac{choose\ the\ number\ of\ B}{14} \tag{1}$$

In Formula (1), RP is the value of farmers' risk preference degree, if farmers choose option B in all 14 groups of game schemes, then the RP value indicates that farmers have extreme risk aversion. On the contrary, if farmers choose option A in all 14 groups of game schemes, then the RP value is 1, indicating that farmers have extreme risk preferences.

TABLE 2 The meaning of variables and descriptive statistics.

Variable name	Variable assignment and its meaning	Mean	Standard deviation
Explained variable			
Forage planting decisions	Plant whole silage corn = 1;unplanted whole silage corn = 0	0.449	0.497
Forage planting scale	Area of farmers planting whole silage corn in 2021 (hm^2)	0.643	2.691
Forage planting duration	By 2021, the number of years that farmers have planted whole silage corn (year)	2.090	3.935
Explanatory variable			
Farmers' risk preference	Expressed as an index of risk preference	0.303	0.348
Mediating variable			
Credit	Farmers loans amount in 2021(RMB¥ 10,000)	5.793	14.933
Control variable			
Age	Respondent age	53.832	10.534
Education	Length of schooling	6.864	3.647
Breeding duration	Breeding duration of respondent (year)	16.564	14.709
Agricultural labor force	Household labor force size (person)	1.766	0.876
Operating area of cultivated land	Operating area of household cultivated land in 2021 (hm^2)	1.319	13.718
Number of livestock raised	Number of Livestock in 2021 (Standard sheep Units)	78.632	137.419
Government training	Participated in whole silage corn training: 1 = yes; 0 = no	0.125	0.332
Government propaganda effort	Government publicity for whole silage corn: 1 = never; 2 = very small; 3 = general; 4 = greater; 5 = large	2.536	1.499
Trust degree of farmers	Do you agree or disagree that most people in this society can be trusted: 1 = disagree; 2 = less agree; 3 = general; 4 = more agree; 5 = strongly agree	4.060	0.966
The frequency of communication	Frequency of communication with agricultural technology extension personnel: 1 = no contact; 2 = less frequent; 3 = general; 4 = more frequently; 5 = very often	2.221	1.200
Village status	When there are important things in the village, will you consult your opinion: 1 = no; 2 = Occasionally; 3 = general; 4 = yes; 5 = often	3.663	1.184
Whole silage corn sales cognition	Cognition of marketing difficulty of whole silage corn: 1 = very easy; 2 = easier; 3 = general; 4 = more difficult; 5 = very difficult	2.535	1.014
Price cognition of whole silage corn	Cognition of whole silage corn price: 1 = very low; 2 = lower; 3 = general; 4 = higher; 5 = very high	3.308	1.109

2.3.3. Control variable

There are abundant research results on the analysis of factors affecting farmers' decision-making behavior (e.g., Meng et al., 2019; Feng et al., 2020; Andries et al., 2023). With reference to existing studies, this study selected control variables that may affect farmers' forage planting behavior, including five aspects: farmers' personal characteristics, family management characteristics, external environment characteristics, social capital, and farmers' cognition of forage grass. The meanings and descriptive statistics of variables are shown in Table 2.

2.4. Model construction

2.4.1. Based model setting

This article constructed an econometric model to analyze the influence of risk preference on forage planting decision, planting degree, and planting duration of farmers. The benchmark measurement model is set as follows:

$$Y_1 = \beta_0 + \beta_1 Risk + \beta_2 X + \varepsilon_1 \tag{2}$$

$$Y_2 = \gamma_0 + \gamma_1 Risk + \gamma_2 X + \varepsilon_2 \tag{3}$$

$$Y_3 = \delta_0 + \delta_1 Risk + \delta_2 X + \varepsilon_3 \tag{4}$$

Y_1, the forage planting decision of farmers, that is, whether to plant whole silage corn. Y_2, the forage planting degree, namely the planting area of whole silage corn. Y_3, forage planting duration, that is, planting time of whole silage corn until 2022; *Risk*, the degree of farmers' risk preference; X, control variable; β_0, γ_0, and δ_0, the constant term; β_1, γ_1, δ_1, β_2, γ_2, and δ_2 are the coefficients to be estimated; ε_1, ε_2, and ε_3 are the random perturbation term.

It should be noted that, when the explained variable is whether farmers plant forage grass, it belongs to the binary variable, and the Probit model is selected for estimation. When the explained variable is forage planting degree and planting duration, it belongs to the blocking variable, including the 0 value. If the model is set as a linear equation and the least square method is used to estimate the regression, biased estimation results will be obtained (Sun and Guo, 2016). Therefore, the Tobit model is used for estimation in this study.

2.4.2. Mediation effect test

To test the mediating role of farmers' credit, this study draws on relevant literature on the mediating effect test method (Wen and Ye, 2014) and constructs the following measurement model:

$$Y_i = \alpha_0 + \alpha_1 Risk + \alpha_2 X + \varepsilon_3 \quad (5)$$

$$M_i = \delta_0 + \alpha_1 Risk + \alpha_2 X + \varepsilon_4 \quad (6)$$

$$Y_i = \zeta_0 + \alpha_1 Risk + \alpha_3 M + \alpha_4 X + \varepsilon_5 \quad (7)$$

Y_i, the farmers' forage planting behavior; M_i, intermediate variable, that is, credit; α_1, α_2, α_3, and α_4 are parameters or parameter matrices to be estimated; α_0, δ_0, and ζ_0 are constant terms; and ε_3, ε_4, and ε_5 are random disturbance terms.

3. Results and discussion

3.1. Results of hypothesis 1

Table 3 reports the baseline estimation results of the influence of risk preference on the forage planting behavior of farmers. Among them, columns (1), (3), and (5) only consider the influence of risk preference on the forage planting behavior of farmers when no control variables are added. To avoid the endogeneity problem caused by missing variables, control variables are added in columns (2), (4), and (6). The estimated results showed that the marginal coefficient and significance level of risk preference did not exhibit significant changes, indicating that risk preference had a significant promoting effect on farmers' forage planting behavior after controlling other factors. Specifically:

The regression columns (1)–(2) are the estimation results of the influence of risk preference on farmers' forage planting decisions. According to the results, after the introduction of control variables, risk preference has a significant positive impact on farmers planting forage decisions at the statistical level of 5%, indicating that the stronger risk preference farmers have, the greater likely they are to plant forage. The marginal effect estimation coefficient of the model further indicates that when other characteristics remain unchanged, the possibility of farmers choosing forage planting increases by 7.8% for each unit increase in the risk preference index of farmers.

The regression columns (3)–(4) are the estimated results of the influence of farmers' risk preference on their forage planting scale. The results showed that, after controlling the influence of other variables, risk preference significantly positively affected farmers' forage planting scale at the statistical level of 1%. The marginal effect coefficient of the model indicated that the forage planting scale of farmers would increase by 0.205 hm^2 with each increase of one unit of the risk preference index.

The regression columns (5)–(6) are the regression results of the influence of farmers' risk preference on their forage planting duration. It can be observed from the results that farmers' risk preference positively affects the forage planting duration at the significance level of 1%. The marginal effect coefficient indicates that the forage planting duration increases by 0.519 years for every unit increase in the risk preference coefficient of farmers.

In summary, the higher the risk preference of farmers, the higher the probability of participating in forage planting, the larger the planting scale, and the longer the planting time. Therefore, the results support Hypothesis 1 and Hypothesis 1a. These results are similar to those of Wang and Zhao (2023). The study area's economic structure was single, with traditional animal husbandry as the main industry. Compared with traditional corn, high-quality whole silage corn can significantly improve livestock production characteristics such as lactation and daily gain (Cheng et al., 2022; Huo et al., 2022) and thus increase the economic benefits for farmers (Chen et al., 2018). Planting whole silage corn will also face some risks such as technology, market, and so on, which cannot be ignored. Therefore, for risk-seeking farmers, their sensitivity to benefits is higher than their sensitivity to risks, and they are more willing to try the new farming mode of "forage + concentrate" to improve their income.

3.2. Robustness test

To verify the robustness of the baseline regression results, this study replaces "farmer household risk preference index" with "farmer household stock investment preference" and adopted the same econometric model to re-estimate the relationship between risk preference and farmers' forage planting behavior. It is worth explaining that the specific measure of farmers' preference for stock investment is "Suppose 10% loss occurs in the stock you invested in, how will you deal with the stock? 1 = sell everything; 2 = sell 50%; 3 = Hold, not sell." If the farmer answers 1, the farmer is identified as risk averse. If the farmer answers 2, it is risk neutral. If the farmer answers 3, it is defined as risk preference. The estimated results are shown in Table 4. The results showed that the coefficient and significance of stock investment preference had no substantial change and had a significant positive effect on forage planting behavior, indicating that risk preference significantly promoted the forage planting behavior of farmers.

3.3. Results of hypothesis 2

According to the process of mediating effect test, Table 5 reports the results of the mechanism test of credit. For the convenience of comparison, the regression results of column (2) in Table 3 are added to column (1) in Table 5. Table 5 (2) shows the regression

TABLE 3 Estimation results of the effect of risk preference on farmers' forage planting behavior.

	Forage planting decisions		Forage planting scale		Forage planting duration	
	(1)	(2)	(3)	(4)	(5)	(6)
Risk preference	0.150*** (0.036)	0.078** (0.037)	0.591*** (0.108)	0.205*** (0.064)	0.825*** (0.194)	0.519*** (0.198)
Age		−0.004*** (0.001)		−0.007*** (0.002)		−0.024*** (0.007)
Education		−0.010*** (0.004)		−0.016*** (0.006)		−0.046** (0.019)
Breeding duration		−0.004*** (0.001)		−0.004** (0.002)		0.005 (0.005)
Agricultural labor force		0.027* (0.015)		0.067*** (0.024)		0.129* (0.076)
Land area		0.000 (0.000)		0.004*** (0.000)		0.001* (0.000)
Number of livestock		0.000 (0.000)		0.000 (0.000)		0.000 (0.000)
Government training		0.174*** (0.039)		0.254*** (0.068)		1.891*** (0.649)
Government propaganda effort		0.004 (0.009)		−0.012 (0.015)		−0.019 (0.150)
Trust degree of farmers		0.009 (0.013)		−0.002 (0.024)		−0.004 (0.073)
The frequency of communication		0.006 (0.011)		0.019 (0.019)		−0.005 (0.060)
Village status		0.007 (0.011)		0.046** (0.020)		0.082 (0.062)
Whole silage corn sales cognition		−0.075*** (0.014)		−0.144*** (0.022)		−0.372** (0.069)
Price cognition of whole silage corn		0.079*** (0.012)		0.103*** (0.020)		0.371*** (0.063)
Constant term	−0.389 (0.070)	0.153 (0.512)	−34.605 (2.938)	−0.267 (0.606)	−2.074*** (0.311)	0.335 (1.815)
Sample number	1,479	1,479	1,479	1,479	1,479	1,479
Prob>chi2	0.000	0.000	0.000	0.000	0.000	0.000
Pseudo R^2	0.008	0.077	0.004	0.189	0.003	0.018

Robust standard error in brackets. ***, **, and * are statistically significant at 1, 5, and 10%, respectively. The parameter in the model is a conditional marginal effect.

TABLE 4 Robustness test.

	Change the core explanatory variable					
	Farmers' Stock investment preference	Constant term	Control variable	Sample number	Prob>chi2	Pseudo R^2
Forage planting decisions	0.025* (0.014)	−0.411	Yes	1,479	0.076	0.002
Forage planting area	0.101** (0.044)	−2.390	Yes	1,479	0.020	0.001
Forage planting duration	0.180*** (0.067)	−0.317	Yes	1,479	0.000	0.020

Control variables are the same as Table 3; Robust standard error in brackets; ***, **, and * are statistically significant at the level of 1, 5, and 10%, respectively. The parameter in the model is the conditional marginal effect.

results of credit on farmers' plant forage decisions. The results show that farmers' participation in credit significantly positively influences farmers' forage planting decisions. Column (3) is the estimation result of risk preference on farmers' participation in credit. The results show that risk preference has a significant positive effect on farmers' participation in credit. Column (4) is the estimated result of introducing both risk preference and credit. It can be observed from the estimation results that both risk preference and farmers' credit passed the significance test at the 1% statistical level, and compared with column (1), the coefficient value of risk preference decreased, indicating that credit played a partial intermediary role in the process of risk preference affecting farmers' forage planting decision. Furthermore, through the value of the intermediary effect, it can be found that the intermediary effect value of farmer's credit is 0.004, and its proportion in the total effect is $ab/c = 1.403 \times 0.003/0.078 = 0.054$. To some extent, approximately 5.4% of the effect of risk preference on whether farmers choose forage planting is realized through the intermediary role of credit, which shows the transmission mechanism of risk preference-credit-farmers' forage planting decision. According to this logic, this study also tested the mediating effect of credit in the influence of risk preference on farmers' forage planting scale and duration. The regression results were shown in Tables 6, 7, respectively. As can be observed from column (4) of Tables 6, 7, both risk preference and credit coefficients were positive and were statistically significant at least by 10%, indicating that credit is part of the intermediary variable that risk preference affects the forage planting scale and planting duration of farmers, that is,

TABLE 5 Mechanism test of the influence of risk preference on forage planting decisions of farmers.

Variable name	Forage planting decision (1)	Forage planting decision (2)	Credit (3)	Forage planting decision (4)
Risk preference	0.078** (0.037)		1.403** (0.683)	0.072*** (0.037)
Credit		0.003** (0.001)		0.003*** (0.001)
Control variable	Under control	Under control	Under control	Under control
Constant term	−4.001(9.092)	0.215 (0.493)	20.858 (6.675)	0.027 (0.503)
Observed value	1,479	1,479	1,479	1,479
Prob>F	0.000	0.000	0.000	0.000

Values in brackets are robust standard errors. ***, **, and * shows significance level at 1%, 5% and 10%. The parameter in the model is a conditional marginal effect.

TABLE 6 Mechanism test of the influence of risk preference on forage planting degree of farmers.

Variable name	Forage planting scale (1)	Forage planting scale (2)	Credit (3)	Forage planting scale (4)
Risk preference	0.205*** (0.064)		1.403** (0.683)	0.194*** (0.063)
Credit		0.005*** (0.001)		0.005*** (0.001)
Control variable	Under control	Under control	Under control	Under control
Constant term	−0.267(0.606)	−0.037 (0.593)	20.858 (6.675)	−0.402 (0.604)
Observed value	1,479	1,479	1,479	1,479
Prob>F	0.000	0.000	0.000	0.000

Values in brackets are robust standard errors. ***, **, and * shows significance level at 1%, 5% and 10%. The parameter in the model is a conditional marginal effect.

risk preference will promote farmers' participation in credit and further promote the forage planting scale and planting duration of farmers. In conclusion, farmers' credit plays a partial mediating role in the influence of risk preference on farmers' forage planting behavior. Therefore, the results support hypotheses 2 and 2a. The results are similar to the study conducted by Mao et al. (2022). Based on the methodology of experimental economics, this paper explores the mediating role of credit in relation to risk aversion and farmers' adoption of climate adaptation technology. The results indicate that farmers who are more risk-averse are less likely to participate in credit and adopt climate adaptation technology. This leads to a lower degree of adoption as well as a shorter duration of adoption. We believe the possible reason is that, in the early stage of whole silage corn planting, large capital needs to be invested, and farmers' participation in credit can alleviate financial constraints and promote their forage planting behavior. However, due to climate, technology, market, and other reasons, agricultural investment cost is difficult to recover and there is the possibility of an increase in the cost of credit default (Gine and Yang, 2009). Therefore, risk-averse farmers will reduce the possibility of credit, and the shortage of funds further inhibits farmers' enthusiasm in forage planting.

3.4. Results of hypothesis 3

3.4.1. Cultivation scale heterogeneity

According to the standards of breeding scale of <30, between 30 and 100, and ≥100, the farming scale of farmers was divided into three groups of "small," "medium," and "large," and control variables were included in each group for grouping regression. Table 8 shows the estimated results of the marginal effect of the model (similarly below). The results showed that risk preference significantly promoted forage planting behavior (decision, scale, and duration) of medium-scale farmers, and the effect of promoting forage planting of farmers is the largest among all groups. Specifically, when farmers have the medium cultivation scale, the forage planting probability can be increased by 14.2%, the planting scale can be increased by 0.418 hm^2, and the forage planting duration can be increased by 0.752 years. However, the findings in the current study are inconsistent with the study of Tan et al. (2022), who concluded that farmers with smaller farming scales are more likely to produce green production behaviors. Although forage planting behavior is also a kind of green production, in our study region, the main livelihood of medium-scale farming households comes from agricultural income, and the main goal of agricultural production is to save costs and increase efficiency. The studies of Wang (2015) showed that, if 3 kg of alfalfa was added to the livestock diet, the daily concentrate could be reduced by 1–1.5 kg, and the cost of disease control in the whole feeding process could be reduced by approximately RMB¥ 1,000. However, the influence of risk preference on forage planting decisions of large-scale farmers is not significant. We believe that the possible reason is that large-scale farmers themselves have good bargaining power and can meet the forage needs of livestock by themselves. Therefore, risk preference has a limited promotion effect on the forage planting of these farmers. Therefore, hypothesis 3a is partially verified.

3.4.2. Household differentiation heterogeneity

According to the definition of standard of household types based on China's national statistical data, farmers were divided into pure households, I-concurrent households (agricultural concurrent

TABLE 7 Test of the mechanism of influence of risk preference on forage planting duration of farmers.

Variable name	Forage planting duration (1)	Forage planting duration (2)	Credit (3)	Forage planting duration (4)
Risk preference	0.519*** (0.198)		1.403** (0.683)	0.503** (0.198)
Credit		0.008* (0.004)		0.007* (0.004)
Control variable	Under control	Under control	Under control	Under control
Constant term	0.335 (1.815)	1.025 (1.786)	20.858 (6.675)	0.115 (1.819)
Observed value	1,479	1,479	1,479	1,479
Prob>F	0.000	0.000	0.000	0.000

Values in brackets are robust standard errors. ***, **, and * shows significance level at 1%, 5% and 10%. The parameter in the model is a conditional marginal effect.

TABLE 8 Grouping regression of farmers' breeding scale.

	Degree of cultivation	Risk preference	Control variable	Prob>chi2	Sample number
Forage planting decision	Small-scale	0.048 (0.057)	Under control	0.000	573
	Medium-scale	0.142** (0.058)	Under control	0.000	562
	Large-scale	0.026 (0.252)	Under control	0.000	344
Forage planting area	Small-scale	0.066 (0.080)	Under control	0.000	573
	Medium-scale	0.418*** (0.126)	Under control	0.000	562
	Large-scale	0.086 (0.105)	Under control	0.000	344
Forage planting duration	Small-scale	0.496 (0.316)	Under control	0.000	573
	Medium-scale	0.752** (0.311)	Under control	0.000	562
	Large-scale	0.210 (0.437)	Under control	0.000	344

***, **, and * shows significance level at 1%, 5% and 10%.

households), and II-concurrent households (non-agricultural concurrent households) according to the proportion of household agricultural income ≥80%, between 50 and 80% (including 50%), and between 0 and 50% (excluding 0%). Group regression was carried out. The estimated results are shown in Table 9. According to the results, risk preference can significantly increase the forage planting probability of pure farmers by 16.9%; increase the forage planting scale of pure farmers and I-concurrent farmers by 0.383 hm^2 and 0.226 hm^2, respectively, and increase the forage planting duration of pure farmers by 1.114 years. In general, risk preference mainly promoted the forage planting behavior of pure farmers, followed by I-concurrent farmers, but had a small promoting effect on II-concurrent farmers, and both failed the significance test. This finding was supported by Cheng et al. (2021). This is mainly because pure farmers and I-concurrent farmers are more dependent on agriculture and want to stimulate the increase in income by changing their production and management mode. According to the author's investigation, 15 hectares of medium farmland planting grain corn yield is basically approximately 400–750 kg, and planting whole silage corn per mu yield can reach approximately 2,000–4,000 kg and can replace approximately 400–800 kg concentrate. At the same time, relevant studies showed that if 15 Kg silage corn was added to the dairy cow diet, the milk yield could be increased by 2.3 kg/day compared with free feeding of hay (Li and Liu, 2010). This means that forage planting can save the purchase cost of forage, increase the output of agriculture and animal husbandry, and thus increase the income of farmers. Hypothesis 3b is tested.

3.4.3. Household differentiation heterogeneity

Referring to relevant literature, we define the farmers born before 1982 as the middle-aged and elderly generation and those born after 1982 as the young generation. Grouping regression is carried out to analyze the possible heterogeneity of risk preference affecting farmers' forage planting behaviors (Table 10). According to the estimation results, the influence coefficients of risk preference on forage planting decision, planting scale, and planting duration of the middle-aged and elderly generation were higher than those of the young generation, and all passed the significance test. Specifically, risk preference can increase the forage planting probability of the middle-aged and elderly generation by 9%, expand the forage planting scale of the middle-aged and elderly generation by 0.23 hm^2, and increase the planting time of the middle-aged and elderly generation by 0.65 years. However, the findings in the current study are inconsistent with the study of Belay et al. (2017) and Wu and Li (2023), who concluded that the middle and older generation has a stronger tendency to leave farming. The main source of these differences is that the region they studied is the North China Plain, where agricultural and non-agricultural employment is common. However, our study region is in the agro-pastoral ecotone, where farmers' livelihoods are based on agriculture, and the middle-aged and elderly generations became the main force of agricultural production, so risk preference is more likely to affect the forage planting behavior of these groups. Hypothesis 3c is tested.

To sum up, hypothesis 3 has been verified.

TABLE 9 Group regression of farmer types.

	Farmers type	Risk preference	Control variable	Prob>chi2	Sample number
Forage planting decisions	Pure farmer	0.169*** (0.064)	Under control	0.000	415
	I farmer	0.046 (0.078)	Under control	0.000	313
	II farmer	0.012 (0.252)	Under control	0.000	751
Forage planting area	Pure farmer	0.383** (0.150)	Under control	0.000	415
	I farmer	0.226* (0.137)	Under control	0.000	313
	II farmer	0.071 (0.057)	Under control	0.000	751
Forage planting duration	Pure farmer	1.114*** (0.421)	Under control	0.000	415
	I farmer	0.491 (0.378)	Under control	0.000	313
	II farmer	0.041 (0.270)	Under control	0.000	751

***, **, and * shows significance level at 1%, 5% and 10%.

TABLE 10 Grouping regression of intergenerational perspective.

	Intergenerational classification	Risk preference	Control variable	Prob>chi2	Sample number
Forage planting decisions	The middle-aged and elderly generation	0.090** (0.040)	Under control	0.000	1,293
	Young generation	0.061 (0.097)	Under control	0.000	186
Forage planting area	The middle-aged and elderly generation	0.233*** (0.071)	Under control	0.000	1,293
	Young generation	0.136 (0.144)	Under control	0.021	186
Forage planting duration	The middle-aged and elderly generation	0.648*** (0.221)	Under control	0.000	1,293
	Young generation	0.164 (0.450)	Under control	0.009	186

***, **, and * shows significance level at 1%, 5% and 10%.

4. Conclusion and implications

4.1. Conclusion

Based on the micro-survey data of 1,479 farmers in the farming-pastoral ecstatic zone, this study used the two-stage econometric model to comprehensively and systematically analyze the influence of risk preference on farmers' forage planting behavior and its mechanism from three aspects: forage planting decision, forage planting scale, and planting duration. The heterogeneity of the effects was further investigated from three dimensions: cultivation scale, household differentiation, and intergenerational difference.

The study found the following: First, risk preference has a significant positive effect on farmers' forage planting behavior, that is, risk preference can significantly improve farmers' forage planting probability and increase forage planting scale and duration. This means that farmers who tend to have risk preferences have a higher possibility of forage planting, a higher scale of planting, and a longer planting duration. In the risk-aversion farmers, the forage planting possibility is smaller, the planting scale is smaller, and the planting duration is shorter.

Second, risk preference can affect forage planting behavior through farmers' credit. The more risk preferences farmers have, the more likely they are to participate in credit, the more likely they are to plant forage, the greater the forage planting scale, and the longer planting duration.

Third, the influence of risk preference on the forage planting behavior of farmers was significantly heterogeneous in terms of cultivation scale, household differentiation, and intergenerational difference. Specifically, risk preference significantly promoted the forage planting behavior of farmers with medium cultivation levels but had no significant effect on small and large farmers. Risk preference mainly promoted the forage planting behavior of pure farmers and I-concurrent farmers but had no significant effect on II-concurrent farmers. Risk preference significantly increased the forage planting probability, the forage planting degree, and the planting time of the middle-aged and elderly generation.

4.2. Policy implications

The research conclusion of the article has certain policy significance. First, risk preference can significantly promote the forage planting behavior of farmers. Since most farmers in China are risk-averse farmers and there is a lack of formal risk avoidance mechanisms in rural China, farmers tend to deviate from the profit maximization goal in their production decisions to avoid risks, and they are very cautious when making forage planting decisions. Therefore, to reduce the risk of forage planting for farmers and improve the avoidance mechanism of forage planting, an insurance system suitable for forage planting in China should be constructed.

Second, increase financial support, relax credit amount and credit time constraints on farmers, relieve credit rationing pressure on farmers, promote agricultural insurance and loan linkage mechanism, improve farmers' risk coping ability, promote farmers' participation in credit, and improve their enthusiasm in forage planting. Third, in view of the fact that farmers with a medium breeding degree, pure farmers, I-concurrent, and the elderly generation have a strong dependence on agriculture, the sunk cost of forage planting is high, but the promoting effect of risk preference is relatively strong. This study argues that, on the one hand, more attention and financial support should be given to these groups to ensure that forage planting subsidy funds are timely and fully issued, to reduce the worries of farmers in forage planting. On the other hand, the forage planting publicity and education should be focused on this part of the population to improve their forage planting intention. At the same time, relevant training work should be done to solve the technical bottleneck of forage planting and reduce potential technical risks by innovating training forms and enriching training content.

There are also some limitations in this study. First of all, this study only considers the situation of farmers planting whole silage corn and needs to carry out research on how risk preference affects farmers' participation behavior for different high-quality forage. Second is the limitation of space. The research carried out in this study is based on the micro-survey data of farmers in the agro-pastoral ecotone. So, this study has not observed the participation of farmers' forage behavior in other regions and whether the study conclusion is applicable to the whole of China needs to be further discussed in the follow-up study.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

WZ: conceptualization, investigation, methodology, data curation, writing—original draft, writing—review, and editing. AK: writing—review and editing. YL and TQ: investigation. MZ: project administration, resources, supervision, writing—review, and editing. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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