Analysis of the Influencing Factors of Changes in Foxtail Millet Planting Area in Hebei Province

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Abstract Since reform and open to the outside world, foxtail millet planting area in Hebei Province has constantly reduced, and its planting region has changed from the whole province into some regions, with obvious changes. In this paper, by using qualitative and quantitative approaches like chart analysis, summarizing, Delphi method and osculating value model, the influencing factors of changes in millet growing region in Hebei Province were studied. The results showed that the changes of millet planting area were closely related to many factors, such as little investment in scientific research, weak policy support, a single consumer product demand, the rapid development of other staple crops, labor migration, relatively low comparative effectiveness and physiological characteristics of the millet itself. Then some suggestions were put forward, such as increasing research support, strengthening scientific research strength, researching and developing deeply processed products, expanding consumer groups, improving millet policy support, providing subsidies for planting the improved varieties, researching and developing various types of machinery, and increasing millet production technology training.

Key words Millet area, Changes, Influencing factors, Osculating values, Hebei Province

Derived from China, millet is one of the oldest crops in the world, which has been confirmed by archaeological excavation, text research and diversity study of genetic resources. According to Cishan cultural sites in Hebei Province, Chinese millet has been planted for more than eight thousand years[1-2]. Among the five grains, millet ranks first, and has always been as China's major grain since Xia and Shang Dynasty, pre – Qin period, and Sui and Tang Dynasty[3]. By the end of Tang Dynasty, production area of millet decreased gradually due to improvement of water conditions and popularization of multiple cropping and rotation of millet and wheat. At the beginning of liberation, Chinese millet had an area of about 10 million hm^2 in China, and it is also chief grain crops like wheat and corn in North China. Millet area of Hebei Province and China has reduced gradually, decreasing from 1.67 million hm^2 in 1949 to 0.146 million hm^2 in 2009 in Hebei Province, so it reduced by 91.3%[4]. Meanwhile, millet planting area in Hebei Province has moved towards dry land in mountainous areas and hills.

At present, there are more studies on millet breeding, cultivation and plant protection, biotechnology and so forth, but fewer macro researches on millet, as well as the reasons for the decrease of its planting area. According to previous studies[5-6], the decrease of millet in planting area is closely related to low yield, taking a lot of work to remove grass and redundant seedlings, changes in structure of the labor force in rural areas, low degree of millet production mechanization, and bird pest problems. Another study showed that the reduction of millet area resulted from high cost of millet production and high wages of farmers working in cities. Therefore, according to the changes of millet area, we would analyze the changes of millet planting area in Hebei Province, and by using qualitative and quantitative approaches like chart analysis, summarizing, Delphi method and osculating value model, the influencing factors of changes in millet growing region in Hebei Province were studied, so as to provide scientific references for the planning of millet planting area, production research, industrial development and decision making by scientific research and government departments.

1 Changes of millet area in Hebei Province

As shown in Fig. 1, millet area of Hebei Province decreased rapidly from 1.84 million to 0.56 million hm^2 during 1952 – 1960, with annual decrease of 0.18 million hm^2; from 1961 to 1984, millet area fluctuated greatly, and the maximum value reached 1.04 million hm^2, while the minimum value was only 0.54 million hm^2, and it increased to 0.71 million hm^2 in 1984; millet area decreased from 0.71 million hm^2 in 1985 to 0.15 million hm^2 in 2009, reducing by 22 400 hm^2 every year[4].

2 Changes in the planting region of millet in Hebei Province

Based on the data of millet planting area in each county of Hebei Province during 1980 – 2007, seven maps about the changes in the planting region of millet were drawn with the aid of ARCGIS soft-

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ware, and the millet planting area were grouped into eight grades, namely 0, 1 – 500, 501 – 1 000, 1 001 – 2 000, 2 001 – 4 000, 4 001 – 8 000, 8 001 – 16 000 and 16 001 – 32 000 hm^2. From Fig. 2, we could find that millet planting area of Hebei Province went down gradually from 1980 to 2007, and large areas of millet mainly distributed in Wu'an, Chixian and Shexian in Taihang Mountains, Baxia region in Zhangjiakou as well as Kuancheng and Pingquan in Yanshan Mountains, and Jizhou, Nangong, Weixian and Zhaoqiang in Heilonggang region[8].

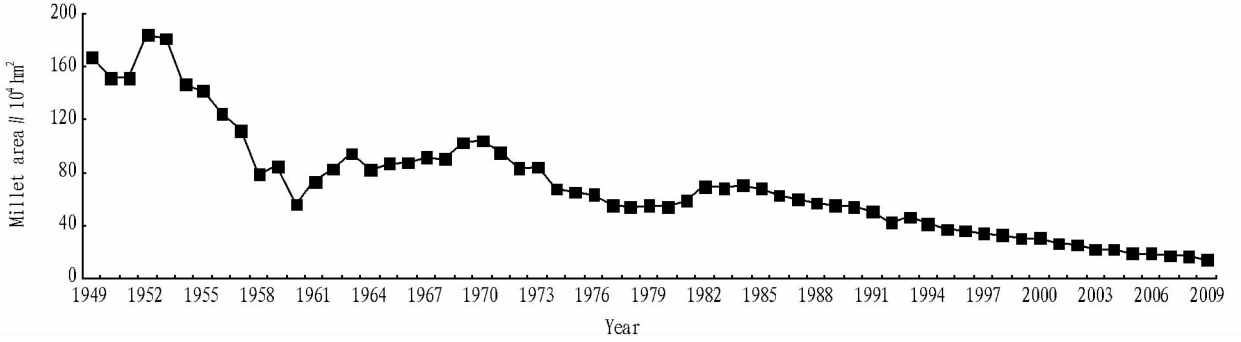
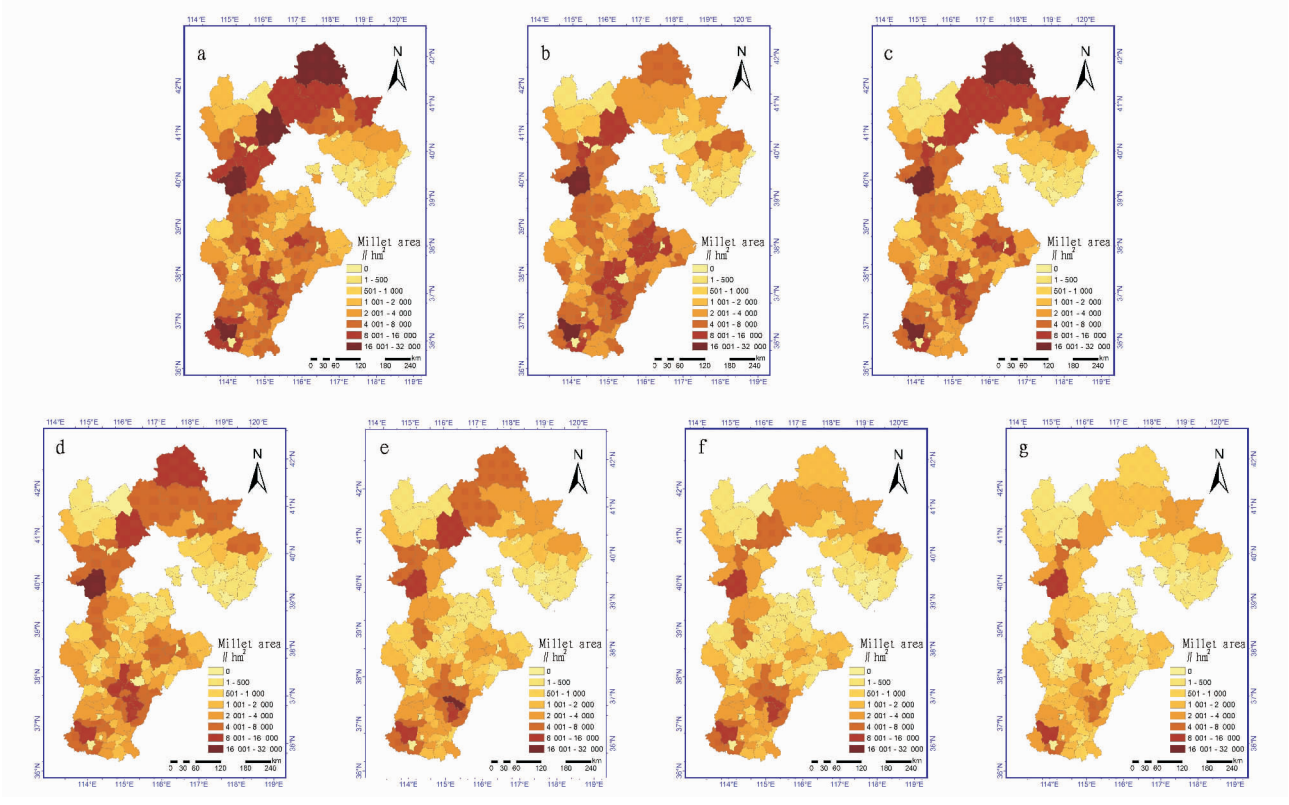


Fig. 1 Annual variation of millet area in Hebei Province from 1949 to 2009



Note: a. 1980 – 1983; b. 1984 – 1987; c. 1988 – 1991; d. 1992 – 1995; e. 1996 – 1999; f. 2000 – 2003; g. 2004 – 2007.

Fig. 2 Millet distribution in Hebei Province during 1980 – 2007

3 Analyses on the influencing factors of changes in millet planting region in Hebei Province

By using Delphi method[9], we could list the factors influencing the decrease of millet area in Hebei Province as well as the characteristics of millet, and then the major influencing factors of millet planting region changes in Hebei Province could be obtained as follows through expert discussion.

3.1 Low comparative effectiveness of millet planting There have been many reports on the comparative effectiveness of crops by using osculating value method[10 – 11], which is a common method to assess effectiveness. According to the analyses above, millet mainly distributed in Taihang Mountains, Heilonggang region and Yanshan Mountains, so the comparative effectiveness of crops was analyzed among the three regions. Choosing three first-level indicators (output, cost and effectiveness) and six second-level indicators (yield, output value, labour cost, profit and labour number), the comparative effectiveness of crop production was measured based on the data from *Cost-benefit Compilation of Agricultur-*

al Products in Hebei Province during 2000 – 2009. Representative counties or cities were chosen from Taihang Mountains, Yanshan Mountains and low plains (Heilonggang region) to analyze the comparative effectiveness of crops in each region. In Taihang Mountains and Heilonggang region, millet, corn, cotton, peanut and soybean were selected, while in Yanshan Mountains, millet and corn were chosen to analyse their comparative effectiveness.

3.1.1 Comparative effectiveness of millet in Taihang Mountains. As shown in Table 1, cotton had the best effectiveness in Taihang Mountains from 2000 to 2006, followed by peanut and corn, while the effectiveness of millet ranked fourth; during 2007 – 2009, the effectiveness of millet became better, ranking first or second. On the whole, the effectiveness of millet in Taihang Mountains was lower.

3.1.2 Comparative effectiveness of millet in Heilonggang region. From 2000 to 2007, cotton in Heilonggang region also had the best effectiveness, followed by peanut and corn, while the effectiveness of millet ranked fourth; during 2008 – 2009, the osculating value of millet ranked second or third. In general, the effectiveness of millet in low plains was also lower.

3.1.3 Comparative effectiveness of millet in Yanshan Mountains. According to their osculating values, the effectiveness of corn was superior to that of millet in Yanshan Mountains from 2000 to 2009.

In general, compared with cotton, corn and peanut, the effectiveness of millet was lower in the three regions in most years, but it slightly higher than that of peanut in a region. The increasing decrease of millet area in Hebei Province after liberation also shows that the comparative effectiveness of millet was always lower, which resulted in the decrease of millet planting area.

3.2 Transformation of millet from a major grain into a auxiliary grain, low consumption and few products processed Compared with wheat and rice, millet has bigger starch granules, a crude and dry taste, low content of bran gluten, and big difficulty of machining, and its traditional cooking takes a lot of time and work, so it can not adapt to fast modern life [12]. In addition, millet has become an accessory food instead of a main food, and its consumption is low due to the single consumption pattern, that is, its consumption per capita is only 2 kg/a. Moreover, the study level of millet in respect of post-processing, development of functional foods and comprehensive utilization is low, so relative products are scarce. The nutritive value of millet is high[13], but millet has not been studied deeply, and there is no longer industrial chain and high consumption like corn. In a word, single consumption pattern and lagging post-processing of millet have directly affected millet consumption, and thereby leading to the decrease of millet area.

3.3 Little investment in scientific research of millet Compared with staple crops like corn, wheat and rice, the investment in the scientific research of small crops is very less. As the gradual decrease of millet area, millet has changed into a small crop from previous staple crop. Due to the reform of science and technology system during the "Tenth Five – Year Plan" period, the number of millet research units decreased from 41 in 1985 to 21 in 2005, and the quantity of scientific researchers reduced from 200 to 70. Large numbers of scientific researchers engaging in millet field changed their profession or research directions, so millet breeding reached a plateau[14]. Additionally, little investment in scientific research of millet has made millet lag behind staple crops like corn, wheat and rice in the level of scientific and technological innovation. For instance, the quality and yield of some old varieties like Shanxi "Jingu 21" and farm variety "Huangjinmiao" of Inner Mongolia have decreased in recent 20 years. Besides, a survey shows that the mechanization rate of millet in China is lower than 30%. Lacking science and technology innovation of millet has seriously restricted its industrial development, which has resulted in the constant reduction of millet area[15].

3.4 Weak agricultural policy support To increase farmers' income and promote grain and agricultural production, China should continue to increase the implementation of agricultural policies. However, these policies are only beneficial to staple crops like corn, wheat, rice, soybean and cotton instead of small crops like millet, and farmers in few regions can be given millet seed subsidies. Thus, affected by agricultural policies, farmers have adjusted planting structure, that is, corn has been planted in the region with better water and fertilizer conditions and has a high yield, while millet has been planted in poor soil, so low yield of millet has led to the decrease of millet area.

3.5 Physiological characteristics of the millet itself Because of drought resistance and fertilizer tolerance, millet is called the oasis of dryland agriculture, so the changes in the planting region of millet in Hebei Province is related to environmental factors. At present, the planting region of millet expands towards mountainous areas, hills and other dry and barren regions. In Hebei Province, Yanshan and Taihang Mountains with little water and barren soil are suitable for millet growth; Heilonggang region is also dry, so the area of corn and other crops consuming more water during growth should be reduced, while more millet should be planted here; the plains are rich in rainfall, so corn and other high-yield crops should be planted here.

3.6 Labor transfer After reform and open to the outside world, there have been relatively more jobs and high profit in cities, so surplus labor force and population moved from rural areas into cities, which has affected the stability of agricultural production and rural economy. As the transfer of rural labor, weak farmers left like to plant wheat, corn and other crops with simple management and little investment, but the planting area of millet with many disadvantages like low yield, taking a lot of work, narrow sales channels and low benefit has reduced greatly[16].

3.7 Decrease of farmland area and rapid development of staple crops

3.7.1 Reduction of farmland area. According to statistics, per capita arable land area of Hebei Province increased to 7.616 million hm^2 in 1952 from 1949, and then decreased from 1952 to 2008[17]. To obtain higher economic benefit from limited farm-

land, farmers are inclined to plant grain and economic crops with higher benefit, but millet is an auxiliary food, so few farmers want to plant millet, leading to the gradual decrease of millet area. In addition, the reduction of farmland area caused by drought and returning farmland to forestland has also affected the decrease of millet area.

Table 1 Comparative effectiveness of crops in the three regions of Hebei Province during 2000 – 2009

Year	Crop	Taihang Mountains		Low plains		Yanshan Mountains	
		Osculating value	Sequence	Osculating value	Sequence	Osculating value	Sequence
2000	Millet	1.809 49	3	1.536 99	4	4.667 98	2
	Corn	1.830 96	4	1.418 91	3	3.697 60	1
	Cotton	0.665 80	1	0.636 06	1	–	–
	Soybean	2.197 29	5	1.735 68	5	–	–
	Peanut	1.380 63	2	1.308 40	2	–	–
2001	Millet	1.817 08	4	1.553 84	4	4.699 28	2
	Corn	1.781 15	3	1.350 69	3	2.841 38	1
	Cotton	1.283 70	1	0.959 08	1	–	–
	Soybean	2.304 10	5	1.698 25	5	–	–
	Peanut	1.436 47	2	1.321 81	2	–	–
2002	Millet	1.853 78	4	1.380 36	3	4.733 13	2
	Corn	1.813 39	3	1.405 21	4	2.561 60	1
	Cotton	0.818 83	1	0.800 77	1	–	–
	Soybean	2.113 97	5	1.688 35	5	–	–
	Peanut	1.493 89	2	1.344 51	2	–	–
2003	Millet	1.762 51	3	1.499 77	4	4.234 84	2
	Corn	1.791 12	5	1.270 14	3	1.786 04	1
	Cotton	0.460 31	1	0.209 76	1	–	–
	Soybean	1.786 63	4	1.525 24	5	–	–
	Peanut	1.164 56	2	1.063 85	2	–	–
2004	Millet	1.689 51	4	1.372 90	4	3.249 68	2
	Corn	1.517 33	3	1.221 47	3	1.154 34	1
	Cotton	0.211 47	1	0.602 51	1	–	–
	Soybean	1.936 45	5	1.470 11	5	–	–
	Peanut	1.153 45	2	1.113 98	2	–	–
2005	Millet	1.643 58	4	1.403 69	4	3.062 32	2
	Corn	1.577 30	3	1.121 03	3	1.343 67	1
	Cotton	0	1	0.300 22	1	–	–
	Soybean	2.069 35	5	1.499 23	5	–	–
	Peanut	1.226 60	2	1.095 69	2	–	–
2006	Millet	1.560 20	4	1.336 74	4	2.544 80	2
	Corn	1.475 36	3	1.018 76	3	1.009 36	1
	Cotton	0.216 88	1	0.390 86	1	–	–
	Soybean	2.001 27	5	1.622 99	5	–	–
	Peanut	1.023 18	2	0.920 50	2	–	–
2007	Millet	0.879 34	2	1.063 18	4	3.588 68	2
	Corn	1.143 55	3	0.924 23	3	0.592 95	1
	Cotton	–	–	0.206 50	1	–	–
	Soybean	1.332 03	4	1.158 53	5	–	–
	Peanut	0.398 89	1	0.367 58	2	–	–
2008	Millet	0.905 36	1	0.57718	2	1.048 20	2
	Corn	1.303 99	3	0.969 26	4	0	1
	Cotton	–	–	0.316 56	1	–	–
	Soybean	1.693 20	4	1.401 92	5	–	–
	Peanut	1.010 74	2	0.766 34	3	–	–
2009	Millet	0.882 82	2	0.746 29	3	1.120 77	2
	Corn	1.045 09	3	0.779 34	4	0.705 76	1
	Cotton	–	–	0	1	–	–
	Soybean	2.045 91	4	1.313 00	5	–	–
	Peanut	0.592 14	1	0.539 84	2	–	–

3.7.2 Rapid development of staple crops. Due to the Rapid development of staple crops like corn, vegetables and cotton, the planting region of millet have been occupied. In 1949, the planting areas of corn and millet in Hebei Province accounted for 16.9% and 22.7% of total area of grain, and then the proportion of corn increased to 47.9% in 2010, while the proportion of millet decreased to 2.5%[4]. The production of vegetables in Shandong Province ranks first in China, followed by Hebei Province. According to statistics, since the 1990s, the area of vegetables increased from 0.328 million hm^2 in 1990 to 1.139 million hm^2 in

2010, with an increase of 39 000 hm^2 every year, and the area began to exceed millet area from the period[4]. The area of cotton in Hebei Province showed a decreasing trend on the whole, but it went up fast since the 21st century, especially in Heilonggang region. From Fig. 3, we can find that the planting area of millet in Hebei Province was higher than that of corn, cotton and vegetables at the beginning of liberation, but with the popularization of new technology of corn, cotton and vegetables as well as increase of production benefit, the planting area of corn, cotton and vegetables exceeded that of millet, while millet area reduced continuously. Therefore, when farmland area went down or was constant, the increase of corn, vegetable and cotton area would make millet area decrease.

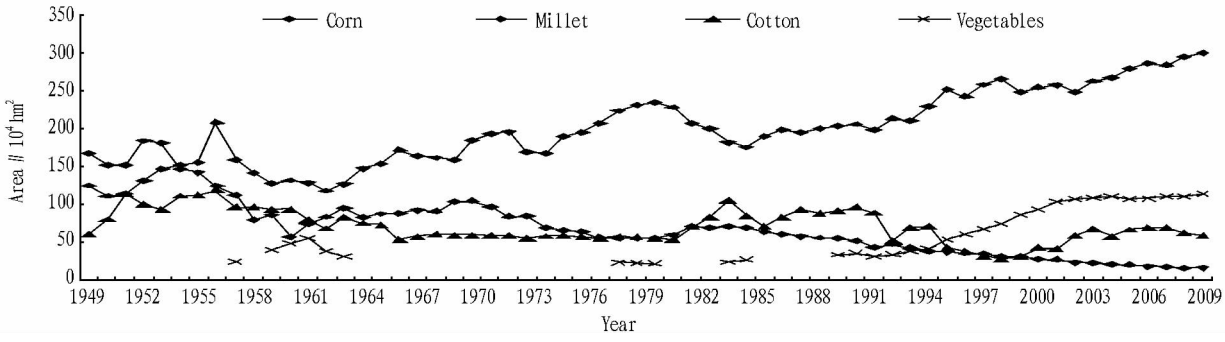


Fig. 3 Planting areas of major crops and vegetables in Hebei Province during 1949 – 2009

4 Conclusions and discussion

By using qualitative and quantitative approaches like chart analysis, summarizing, Delphi method and osculating value model, the influencing factors of changes in millet growing region in Hebei Province were studied. It is concluded that the changes of millet planting region in Hebei Province were closely related to many factors, such as little investment in scientific research of millet, weak policy support, a single consumer product demand, the rapid development of other staple crops, labor migration, relatively low comparative effectiveness and physiological characteristics of the millet itself. Therefore, we should increase research support, strengthen scientific research strength, culture high-tech talent to improve scientific research level of breeding, cultivation, plant protection and processing, research and develop deeply processed products, expand consumer groups, expand farmland area, improve millet policy support, provide subsidies for planting the improved varieties, research and develop various types of machinery to improve mechanization rate of millet, and increase millet production technology training to improve farmers' production skills. These conclusions can provide scientific references for the planning of millet planting area, production research, industrial development and decision making by scientific research and government departments. However, the influence degree was not analyzed quantitatively, and the quantitative analysis needs to be studied further.

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