Zonal Origin of Dry Farming in Northern China

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Abstract Environmental changes in Pleistocene and the breeding of primitive agriculture in late Paleolithic Age are discussed. Natural environment in China has changed significantly since the Quaternary Period. Under the cold climatic conditions at late Pleistocene, most parts of northern China were not suitable for the growth of millet and other crops preferring warm surroundings. But some microlithic remains in the warm southeastern edge of northern China have entered the stage of gathering agriculture, which might become a part of agricultural original zones of millet agriculture. Environmental change and the emergence of dry farming in northern China at early Holocene are analyzed, which is an unstable heating period (about 12 – 8 kaBP). Millet production may be first conducted in the southeast valley of the Loess Plateau, hillside and tableland, valley terraces in Qinling Mountain, mountains in the upper reaches of the Huaihe River, valley and tableland in southern hills of Shandong Province. At the end of early Holocene or middle Holocene, natural conditions have changed in sandy loess zone from eastern Qinghai along the line of mid-eastern Gansu, Ningxia, northern Shaanxi, mid-northern Shanxi, northern Hebei, mid-eastern Inner Mongolia, and mid-western Liaoning, which might be the most important origin of broomcorn millet agriculture.

Key words Agricultural origin; Dry farming; Origin zone in China

China set off a heat wave in exploration of the origin of agriculture after the 1980s, due to a large number of archaeological discoveries, which led to a lot of research results and caused a certain impact on international academic circle. Chinese academic circle has made remarkable achievements from the four aspects including the driving force for agricultural origin, the developmental stage, the origin of rice agriculture, and its origin areas in China. However, study on the origin of agriculture has still been in development stage so far due to the lack of references and inference support. Though some research progresses were made at the end of the 20th century, the precise origin of agriculture still can not be determined. Huang Qixu argues that Yellow River basin is the origin of foxtail millet according to the thermophilic and drought-resistant characteristics, and the natural features of Yellow River basin, such as dry winter and spring, rainy summer and loose loess[1]. Some academics have suggested other origin theories, mainly in northern China, Baoji Wei River Valley, Taihang Mountain, West Liao River Basin, and Guanzhong Area[2-7]. Some scholars have different opinions on the above points of views, pointing out that cultural remains about foxtail millet agriculture at the Neolithic Age are not its origin, but its developmental area. Foxtail millet agriculture originates in relatively barren mountain areas, which are scattered all over China, rather than propagated outward from a particular area[8].

It is reasonable to seek for the origin of millet from the areas suitable for their growth. But geographical environment is ever-changing due to the change of climate impact. Therefore, when seeking for the origin of millet, we should start from the natural environment before and after the origin time, so that to get close to the authentic history.

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1 Environmental changes of Pleistocene and the breeding of primitive agriculture at late Paleolithic Age

Natural environment in China has changed dramatically ever since the Quaternary Period. Climate gradually turned cold and dry at Early Pleistocene (2 000 – 1 000 kaBP). Biota in northern and southern China were formed with Qinling Mountain as a dividing line at middle Pleistocene (1 000 – 100 kaBP); and biota in northern China mainly includes brown bear, cave bear, wooly rhinoceros and other animals preferring cold condition. At late Pleistocene (100 – 12 kaBP), northern China (including the upper reaches of Jing and Wei Rivers) became even more dry and cold; a lot of fossils of fallow deer, wooly rhinoceros and wild horse are found in plain deposits; Malan loess contains fossils of *Bos primigenius*, red deer and ostrich egg, indicating that this area might be a cold and dry steppe[9]. Researches on remains of ancient marine mollusk at continental shelf of the East China Sea and the old coastline of mainland also have demonstrated the cold climate at late Pleistocene. It is estimated that sea level at Dali Glaciation (40 – 30 kaBP) was 70 – 80 meters lower than it is now[10]. Sea level rose sharply at 24 – 22 kaBP, but was still 30 – 40 meters lower. Then, at the end of 18 – 15 kaBP, the water retreated to 110 meters lower with annual average temperature being 10 ℃ lower than it is now. Millet crops are suitable to be planted in warm and humid areas with 1 600 – 3 000 ℃ annual accumulated temperature(≥10 ℃) and 400 – 600 mm annual precipitation. Therefore, climate conditions in most areas in northern China were not suitable for the stable growth of annual millet plants at late Pleistocene Age.

Affected by the cold climate, people at that time were mainly distributed in mid-and low-latitude regions. At late Paleolithic Age, there were two most intensive areas for human beings to live in the east part of the geographical boundary of

Heihe-Tengchong. One is Guangdong, Guangxi and Yunnan limestone cave development zone in Lingnan Area at about 25 degrees north latitude; the other is 35 degrees north latitude, mainly in the mountain, hillside and valley staggered areas of the southern edge of Loess Plateau and the southern hilly edge in Shandong Province, as well as the upper and middle reaches of the Jing and Wei Rivers.

Human beings found in northern China at late Paleolithic Age (50 –12 kaBP) lived a gathering, hunting and fishing life. Upper Cave Men (18 kaBP) lived in humid Longgu Mountain near the sea with limestone cave as the shelter and forest and lake as their food resources. It seems that this area has better conditions for agricultural experiment than the grassland region. But they still lived a life of long-distance seasonal migration due to the threat of cold. Thus, they have no time to engage in agricultural life[11].

However, there are still evidences of foxtail millet agriculture in the area along 35 degrees north latitude. Important microlithic remains about foxtail millet agriculture discovered are all located in the southern edge of Loess Plateau and the warm areas nearby[10]. Southern Shanxi Xiachuan Site at the late stage of Xiachuan Culture (16 – 13 kaBP) appeared a large number of large and mid-sized grinding discs, grinding rods, chop devices made from gravel, and sickle and cutting tools made by microlith. At previous Yangshao Culture and Yangshao Culture, especially the Banpo Stage, there still remained similar types of cultural goods with the cultural nature of both agricultural harvesting and gathering[4]. These microlithic remains representing by Xiachuan Culture should be a part of the origins for foxtail millet agriculture.

2 Environmental change and production of dry farming in northern China at early Holocene Age

2.1 Dry farming sites at early Neolithic Age Period after Dali Glaciation (about 12 – 8 kaBP) is an unstable warming stage of Holocene. Natural conditions in eastern area were improved firstly; then, vegetation zone moved rapidly from south to north. Northern border for warm temperate deciduous broad-leaved forest changed from 36 to about 38 degrees north latitude; and the south border for cold-temperate coniferous forest changed to about 38 degrees north latitude correspondingly. This region might first enter the early Neolithic Age (12 – 9 ka BP). Archaeological discoveries indicate that human beings at that time invented pottery, polished stone tools and the domestic industry based on gathering agriculture at late Paleolithic Age. So far, early Neolithic sites discovered (about 10 kaBP) are mainly located in the valley plains of east side of Taihang Mountain and south side of Yanshan Mountain. Nanzhuangtou Site, about 10 thousand years from now, locates in the east side of Taihang Mountain and central Hebei Province. There are 15 broken pottery pieces, 4 stone implements, 1 artificial wooden rod, and 1 artificial wood block in this site. Potteries are crude and stone implement with 1 grinding rod and 1 grinding disc in each. Animal bones there might be from wild animals, domestic chicken, dog and pig[10]. Cultural relics excavated from Nanzhuangtou site indicate that people lived there might have settled down, and attempted to train animals and to process plant seeds. But it is difficult to determine whether the seeds processed are cultured artificially or not, and whether these seeds are aquatic or terrestrial, because there are no excavated plant seeds in the site. Thus, it is deduced that Nanzhuangtou site is at advanced gathering agriculture stage. Besides, cultural relics at early Neolithic Age (about 10 kaBP) are found at the south side of Yanshan Mountain in North China Plain.

2.2 Further discussion on origin zones of millet agriculture

2.2.1 Three modes of Macleish agricultural origin and three cultural zones in China. Based on the researches on the archaeological data of America, R. S. Macleish, a famous scholar in the United States, argues that the origin process of agriculture can be divided into three different modes according to the prerequisite and sufficient conditions for agricultural production. The three modes are primary mode, secondary mode and three-level mode. And ecological condition for primary mode is not very good; but there are a variety of domesticated plants and corresponding cultivation environment. Secondary mode is the staggered distribution of both flourishing and sterile vegetation in circumseribed ecogone. There are several subregions there; and domesticated plants are less than the region of primary mode. Three-level mode is uncircumseribed ecogone with superior environment, easy cultivation of crops, and abundant food everywhere. Shi Xingbang points out that situations of these three origin modes are similar with three culture belts of China[3].

2.2.2 Further discussion on the origin sites of foxtail millet agriculture. Research result shows that foxtail millet are most suitable to be planted in loam, sandy loam, and clay loam with deep layer, good structure, high organic matter content, and soft texture. Land with good drainage and high and dry terrain is suitable for the cultivation of foxtail millet than that with poor drainage and low and wet land[11]. According to the requirement of foxtail millet for soil and landform, origin area of foxtail millet agriculture should be in the Loess Plateau and the hilly areas, but not low and wet plains, such as Northeast Plain, North China plain, Huang-Huai-Hai Plain, and valley plains of Jing, Wei, Fen, Qin and Yiluo Rivers.

However, foxtail millet agriculture can not be originate in any place of the Loess Plateau or hilly areas. Just as the Carl Ortwin Sauer, a famous scholar of historical geography and cultural geography in the United States, said that agriculture can not be a human's response to starvation. It is the residents having enough food and time who started the earliest plant domestication. Early agriculture can not occur in grassland or river valley, because there are deep grass roots extremely difficult to be removed. Thus, cultivation has to be conducted in forest land. Domestication center should be located in regions rich in plant and animal species. And hills with diverse landforms and complex climate become a reservoir of genes for plants and an-

imals, and provide necessary conditions for the activities of domestication[12]. Research shows that the Yuan surface, gully slope and areas with thick loess in the Loess Plateau were grassland in historical period; while mountain, gully bottom, and middle and lower valley side covered with bedrock and thin loess used to be forest. According to Carl Ortwin Sauer, foxtail millet agriculture should originate in gully bottom, and middle and lower valley side, which have forest and is suitable for human to settle down. However, Shi Xingbang argues that herbosa of foxtail millet should be in the grassland of tableland edge, gully bottom, and intermediate region of forest thin layer, such as cordillera, terrace or slope of tableland edge, where there are water supply and no forest. Thus, these places and environment are suitable for domestication and cultivation of early crops[4].

I believe that loess is distributed in humid and warm areas along 35 degrees north latitude in east China, that is, the valley, tableland and basin of south-eastern edge of Loess Plateau, valley terraces of Qinling mountain, mountains in upper reaches of the Huaihe River, valley and tableland of southern hills of Shandong Province. At last Glaciation, these areas become a natural refuge for plants with staggered distribution of forest and grassland, and abundant plant resources. They are the convergence of microlithic technique in northern China and the nidged stone-tool technique in southern China. Thus, these areas should be important origins for millet agriculture in China.

2.2.3 Further discussion on the origin sites of broomcorn millet agriculture. Broomcorn millet is the most drought-tolerant gramineous plant with short growing season; and sand soil of the Loess Plateau is sufficiently hospitable for the growth of broomcorn millet. According to the research by Liu Dongsheng, soil of Loess Plateau can be classified into three zones, which are the sandy loess zone, the loess zone and the clayey loess zone. Among them, sandy loess zone includes areas north to Haiyuan, Huanxian, Zhidan, Suide and Wuzhai, connecting Maowusu Desert in the north. Loess zone is to the south of sandy loess zone, located in south of Weiyuan, Qin'an, Tongchuan, Qinyuan and Yangquan. And clayey loess zone is to the south of loess zone, and north to Qinling[13]. Therefore, origin of broomcorn millet agriculture should be at eastern Qinghai, mid-eastern Gansu, Ningxia, northern Shaanxi, mid-northern Shanxi, northern Hebei, eastern Inner Mongolia, and mid-western Liaoning, which are at the sandy loess zone and the transitional zone of sandy loess zone and clayey loess zone. These areas having relatively poor natural conditions are located in ecological transitional zone and environmental sensitive zone, and should be a primary mode of agricultural origin. The vast majority of agricultural sites of broomcorn millet discovered so far are located in sandy loess zone and the transitional zone from sandy loess zone to clayey loess zone, such as Gansu Majiayao Culture and Chifeng Hongshan Culture in Inner Mongolia[4,7].

Origin time of broomcorn millet agriculture can be traced back to the middle Holocene or even earlier. Semi-arid grassland along the line of eastern Qinghai, mid-eastern Gansu, Ningxia, northern Shaanxi, mid-northern Shanxi, northern Hebei, eastern Inner Mongolia, and mid-western Liaoning used to be the sandy loess zone and the transitional zone of sandy loess zone and clayey loess zone. This area used to be grassland from the Pleistocene to early Holocene. According to Carl Ortwin Sauer, natural conditions in this area were not suitable for the emergence of primitive agriculture. Until the Megathermal Period in Holocene (8 500 – 3 000 aBP), ecological outlook there changed greatly. Analysis on the deposition layer of first terrace in Dadiwan Site (11 000 – 8 500 aBP) shows that the small suffrutescent *Artemisia* was the dominant vegetation in Longxi Loess Plateau. Pollen from Gramineae plants was not found in the region mentioned above; and vegetation zone belonged to warm temperate semi-arid grassland. But at 8 500 – 6 000 aBP, large scale of temperate deciduous broad-leaved forest grew in the drainage basin of Hulu River, the first grade tributary of Weihe River, such as birch, hornbeam, filbert, and walnut. Meanwhile, pine, fir, spruce and other coniferous forests also existed in mountainous areas. Temperate steppe in the Loess Platea of southern Shanxi used to be a temperate coniferous forest composed of Chinese Pine and landing broad-leaved tree at 7 000 – 2 500 aBP. During the period of 8 100 – 3 000 aBP, temperate coniferous forest and broad-leaved forest developed at arid and semi-arid areas of eastern Inner Mongolia[14]. Southern Liaoning belonged mid temperate semi-arid and semi-humid climate at 11 000 – 8 000 aBP, and warm-temperate humid climate at 8 000 – 4 000 aBP. It is speculated that its western part was warm-temperate forest-steppe landscape[10]. Areas around Qinghai Lake gradually entered a stable and prosperous growth stage for forest at 8 000 – 3 000 aBP, and now become alpine shrub and alpine meadow[14]. However, main vegetation in Loess Plateau has always been shrubs and herbaceous plants since the Holocene; even in high temperature period of Holocene with abundant rainfall, there was no existence of forest[15]. Ecological environment became superior in middle Holocene, offering human beings abundant food sources. Therefore, human beings settled down there have the condition to create broomcorn millet agriculture. Broomcorn millet found in Xinglonggou Site in Inner Mongolia (8 000 – 7 000 aBP) was small and relatively long, very close to the long and flat shape of wild foxtail millet. Thus, it is estimated that it is not long before it became a domesticated crop[7]. And I believe that broomcorn millet agriculture originates in the middle Holocene or even earlier; its origin time might be later than that of foxtail millet agriculture.

3 Conclusion

According to the natural environment at present, Yellow River Basin, including the Loess Plateau, is undoubtedly the most suitable area for dry farming. However, due to the environmental change from Pleistocene to early Holocene, the southern edge of northern China or the warm areas farther north are the ideal places for millet agriculture, including valley, tableland and basin in south-eastern edge of Loess Plateau, valley terraces in Qinling Mountain, mountains in upper reaches

of Huaihe River, valley and tableland in southern hills of Shandong Province. If we accept the theories of Holocene's catalysis on Neolithic Age and the agriculture originating in woodland, the earliest origin time of broomcorn millet in sandy loess zone should be the middle or the end of early Holocene in eastern Qinghai, which is along the line of mid-eastern Gansu, Ningxia, northern Shaanxi, mid-northern Shanxi, northern Hebei, eastern Inner Mongolia, and mid-western Liaoning.

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中国北方旱作农业带状起源论

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摘要 探讨了更新世环境变迁和旧石器时代晚期原始农业的发展情况。第四纪以来,中国的自然环境发生了显著变化。在更新世末期寒冷的气候条件下,中国北方大部分地方不适宜于喜温暖的黍、粟等作物生长,但其东南边缘温暖地带的一些细石器地点已进入采集农业阶段,可能成为后来黍作和粟作农业起源地带的一部分。分析了全新世早期北方环境变迁与旱作农业的产生。介绍了麦克尼什农业起源的3种模式和中国的3个文化地带。3个模式分别为初级模式、次级模式和三级模式。石兴邦认为这3个起源模式与中国的3个文化带,即黄河流域、淮河中介生态带和长江及其以南地区无界生态带的情况是大体相若的。全新世早期(大约12~8 kaBP)为不稳定升温期,黄土高原东南边缘的沟谷、山前坡地和台地,秦岭山地的河谷阶地,淮河上游山地和平原,山东丘陵南部的河谷和台地即有黄土分布,又相对温暖湿润,森林草原交错分布,植物资源丰富,处于北方细石器工艺和南方琢制石器工艺的交汇地带,有可能率先开始粟作农业;全新世早期末段或中期,从青海东部经甘肃中东部、宁夏、陕西北部、山西中北部、河北北部、内蒙古中东部至辽宁中西部的沙性黄土地带,由于自然条件的改善,可能成为黍作农业最重要的起源地带。

关键词 农业起源;旱作农业;起源地带

(From page 34)

基于生态足迹模型的河南省耕地可持续性研究

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摘要 简述了中国河南省的区域概况,介绍了生态足迹模型的原理及生态足迹与生态承载力的计算公式。当生态足迹大于生态承载力时,会出现生态赤字,表明人类对该区域自然生态系统的压力超过了区域的生态承载力;反之,亦然。根据河南省1998~2007年的相关数据,首先计算了河南省人均生态足迹和人均生态承载力。结果表明:1998~2007年,河南省耕地表现为生态盈余,耕地利用处于可持续发展状态,且生态盈余自2003年以来一直处于持续增长状态。其次,对河南省耕地生态足迹进行了动态分析。10年间,耕地生态足迹基本呈减少趋势,说明人们对区域内耕地的依赖程度在逐渐降低,耕地生态承载力总体呈增加趋势。再次,研究了2007年河南省18个地市的人均耕地生态足迹需求与供给情况。18个地市的耕地生态呈可持续发展状态,耕地生态盈余和人均生态承载力最多的是驻马店市,人均生态足迹最高的是南阳市。基于此,提出了保证粮食增产的五点建议:一是进一步集约利用土地;二是加强后备资源的开发、整理、复垦与整治;三是加强农业科技的研究与应用,提高耕地的产出效率;四是大力改良中低产田,增强耕地的生态承载力;五是建立耕地动态监测管理体系,促进耕地资源的永续利用。

关键词 生态足迹;耕地;可持续利用