# A Critical Appraisal of Ancient Agricultural Genesis in China Emphasis on Rice, Millet, and Mixed Farming: An Archaeobotanical Endeavor

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## Abstract

China has been noted as one of the three sovereign hubs of the origin of ancient agriculture. Specifically, millets like foxtail millet (*Setaria italica*) and broomcorn millet (*Panicum miliaceum*) and rice (*Oryza sativa*), were and are imperative crops for the ancient as well as present Chinese people. In this regard, rice and millets are valuable crops in the history of China. It is also a fact that rice and millets belong to the important river such as Yellow River (North China) and Yangtze River (South China) which are the ancient centers of Chinese civilization as well. It is also unanimously accepted that rice and millets were domesticated at the same time within a solitary expanse in China but in different regions. The available archaeobotanical record also suggests the emergence and development of the mixed farming of millets and rice in different regions in China during the Neolithic age. This paper illustrates the archaeobotanical perspectives and retrospectives of the important crops such as foxtail millet, broomcorn millet, and rice. With this, the imperative archaeological sites, ancient agricultural activities, agricultural philosophy, crop dispersal, and further archaeobotanical scenarios since Pre-historic age in China are also the chief themes of this manuscript.

**Keywords:** Chinese agriculture, rice, millet, mixed farming, archaeobotany, crop dispersal

## Introduction

It is unanimous fact that the origin and dispersal of agriculture have been provided a steady economic base for the gradual development of human society and the establishment of ancient civilizations. After the 1960s, many scholars have talked about some of the features about the agriculture origin in China [1, 2]. It is believed that China is one of the centers for an aboriginal origin of agriculture of millets (foxtail millet and broomcorn millet) and rice as the chief crops [3]. There are two imperative rivers in China such as Yangtze River, 6500 km long and Yellow River, 5500 km long, which have been associated with significant staple cereals such as rice attributed to the Yangtze and millets to the Yellow Rivers respectively [4]. It shows the importance of these two rivers in the context of rice and millets agriculture in ancient China. It was generally observed that the beginning of Chinese Civilization was first started along the Yellow River in the north rather than the Yangtze River in the south [5, 6]. Many writings are in support of the origin of rice in South China as well as the origin of millets in North China. In addition, the research on the origin of millets and rice proves that the beginning of millets and rice farming is dating back to 10,000–11,000 BP [7]. Later on, in Neolithic China, rice and millet were cultivated separately and then linked to each other during their expansion and then a vast region of mixed farming formed [8]. The boundaries and origins of rice, millets, and mixed farming (Fig. 1) have been observed as the vital regions to search on. So, the important crops of rice and millets have been portrayed as crucial to pounce upon their origins. As far as the rice is concerned, after the 1970s, the whole world attention was focused in China, specifically Yangtze River [9-12], where the evidence of the earliest rice was found. On the other side, the millets were grown and have been dominant crops in the northern parts of China [13, 14]. The available archaeobotanical data shows the facts about the interplay of these two crops in many parts

of China. This mixed farming was mainly recorded and observed in the south, north, and east central China. [15].In this manuscript, the origins of ancient rice and millets, agricultural philosophy, earliest agricultural domestication, and spread of crops would be conversed with the help of available archaeobotanical data. It would also be an analytical approach, through which further constructive and experimental research would also be suggested with the reference of plant archaeology.

**The Historical Facts about Ancient Chinese Rice**

The ancient Chinese history and the history of rice cannot be split up from each other [16] There is an immense impact of the early rice on the lives of ancient Chinese people. Because rice has been noted as a crucial crop in the economy of East Asia, Southeast Asia, and South Asia respectively [17]. In this respect, Chinese rice is also a key to study the early lives of the Chinese people. Therefore, through the minute study on the historical grounds and examinations over rice can be proved a good hand to establish the facts about the ancient agriculture of this region. Moreover, much of the population of this region has been provided dietary staple by the rice as well. On the broader spectrum, this crop is also important for the other nationals including Southeast Asia, India, and Sri Lanka, which have also been dependents on the rice as their food resource. As far as the origin of the rice is observed, some of the researches proved that the center of the rice in China. In this regard, many archaeological expeditions were executed to find out the dispersal and origins of this crop since 1970s [18, 19]. Often, the Asian rice is ascribed and attributed to the Yangtze River basin that is the origin of the agriculture of early rice [20]. Some scholars believe that there are more than one origins of the rice as the land of India [21], South China [22] , Southeast Asia [23], and the Yangtze River [24] , got attentions of the researchers as being the ancient hubs of the rice. In addition, there are two other theories surround the facts that the Yangtze River basin is the epic center of early rice and rice dispersed towards the other places within the country or outside the country like Southeast Asia. Another theory is the archaeological theory that provides the facts that there are some other centers of the rice except China too. According to [20], the centers of the early rice are the middle or lower Yangtze River of South China and the Ganges Valley of India. For the actuality, more archaeobotanical expeditions (microremains and macroremains) are required about the Ganges Valley and South China (the Yangtze River). Therefore, rice agriculture has been inevitable for both East and South Asia. On the other hand, we have also some clues to establish the facts that the Chinese rice spread from China to Indus Valley (South Asia), Ganges Valley, Mekong, and the central plains of China [16]. Another evidence portrays the fact that the *indica* form of rice dispersed towards Ganges Valley, may be in the form of the loans of Chinese crops, which has also been proved by the Chinese legends. According to Chinese legends, there was a trade between China and India. Overall, rice is one of the most significant cereal crops in the world, and in South and East Asia, its appearance as a cultivated subsistence plant has been examined well in the sense of archaeology [25]. Frequent archaeobotanical studies suggested the Yangtze River as the origin of rice, because this river is proved as the dwelling of ancient rice. On the other side, lower Yangtze, Huai River, Houli culture, southwest Henan, and Shandong [16], are also admitted proofs as being the ancient hubs of this crop in China. After1970s, some discoveries and researches proved that the center of the rice farming is the Yangtze River basin with the important and critical Hemudu site (7000-6300 BP) which is a waterlogged Neolithic site where the quantities of rice were recovered. With the collective arguments, this site was said to be the earliest center of rice agriculture. The site of Hemudu is vital and emblematic because the rice domestication was concluded well after the phase of Hemudu culture [26]. Other important archaeological sites of this region such as Bashidang and Pengtoushan (ca.6500-5500 B.C) are also claimed the ancient centers of the rice farming. The site of Bashidang has the enormous rice grains, which are mostly wild rice. In further archaeological expeditions proved that, the region of the Yangtze River (early and middle reaches) is actually, the starting point of the early rice agriculture [27,24,28,7]. Except for this, Pleistocene cave and Early Holocene residents in the southern part of China are also measured as the primordial regions of rice

farming [16]. Indirectly, there are also some precipitate arguments that the early ceramics in China between 18000-15000 years ago can be linked with the earliest farming habits in this region. It is unfair to link these earliest ceramics with the earliest farming activities [29]. The auxiliary study may fetch the accurate realities of the true verdict. Again moving towards the middle Yangtze River region, the Daxi culture about 6000 years ago and the Majiabang culture in the lower Yangtze River exhibit the portrait of the early vital nutrition of the ancient societies including rice that belongs to the Neolithic. In the later Neolithic period, Chengtoushan site (Daxi culture) from 4400-3300 B.C. has been scrutinized the paddy field acquainted with rice. Another archaeological site called Kuahuqiao has also been associated with the early rice farming, and interestingly the earliest textile activities observed in this site like Hemudu site. From these archaeological sites, rice dispersed towards some other regions of the southern parts of China such as Fujian, Guangdong, and Guangxi in between 5000- 4500 BP. Overall observation is in favor of the Hemudu as the center of the earliest rice [24]. Furthermore, in the centeral east parts of China, the Huai River, and Han River, are indicated as the additional hubs of the early rice farming. The site of Yuezhuang (ca. 8000 BP) and the site of Xihe (ca. 8000 BP) [30] have also been entitled with the pivotal sites of East China for the early record of rice farming, accompanied by Xianrendong and Diaotonghuan sites in Jiangxi Province, have also been proposed as the earliest sites for the rice cultivation [25]. Again talking about the southern side, the evidence of the early rice field systems from the eastern side of Choudun and Caoxieshan sites (Taihu Lake) shows the small hollows with the negation of puddle fields too. As far as the wild rice is concered, it belongs to Zhejiang province (*Zhujiajian* site), where this crop is recoded dated back to 8750–6200 BP. This wild rice, which was intact in form with the length of 2.0 mm (inner side) and 2.2 mm glumes (outer side), is also considered to be the vital progress about the history of the rice. Interestingly, whether rice was also recovered from the eastern part of China but three wild rice species only found in the southern side such as; O. perennis, O. officinalis and O. meyeriana [31]. This discovery of the rice may have solid proofs of the rice dispersal from the southern side to the eastern side of China. In coastal southeast China, such as Fujian province, the available archaeobotanical record proves the rice farming around 5000 cal. BP that is also the region of Yangtze River [32]. From the northern part of China, the Jiahu site is worthy because the discovery of rice from this site is well intentioned that shows the early stage of rice farming in the north of China. Possibly, the early rice of the Lower Yangtze, The Middle Yangtze, Lower Huaihe River, Lower Hanshui and Upper Huai River Basin are considered the earliest centers of ancient rice. In addition, all of the ancient Chinese rice circulated around its three stages, the primary stage (8000 B.C) secondary stage (8000-5000 B.C), and the Mature stage(5000 B.C).

**Millets: origin and development**

Generally speaking, foxtail millet (Setaria italica), broomcorn millet (Panicum miliaceum), bulrush millets (*Permise turn spp*.), finger millet (*Eleusine corocaaa*), and barnyard millets (*Echinocloa spp*.) have been categorized in the species of millet. In broader spectrum, in the land of China, almost 14 species of *Setari* have been noted through which seven are suggested in the northerner part that shows the vital place for the millets is North China, specifically along the Yellow River and its tributaries. As far as the earliest millets agriculture of northern side is observed, many of the archaeological sites have existed which have the record of millet cultivation in the middle reaches of the Yellow River in the loess plateau along the foothills. According to Ming author Wang Xiangjin, foxtail millet and broomcorn have been thought to be as Northern rather than southern crops in China. In addition, not only in the past but Setaria, in the present era is still economically imperative crop in North China and here millets are known as the dominant traditional crops [3]. Many times the word “North China” has been discussed in different writings that is renowned as being the center of millets cultivation has been referred as the massive area from the Yellow River Valley to Inner Mongolia, where Nanzhuangtou, Donghulin, and Shizitan sites have also existed. As far as the wild ancestor of foxtail millet is observed, the *Setaria viridis* can also be judged on the upper floodplains of Yellow River in the north of China. In this respect, the northern part of China is believed to be the abode of ancient millets as rice in southern part. Except for China, the remains

of millets like Setaria and Panicum, have also been obtained from the archaeological sites in the other part of the world [33]. In esteemed observation, foxtail millet and broomcorn are thought to have origination in the northern part of China. Moreover, present archaeobotanical evidence has proved that no later than 8000 cal. BP, both foxtail and broomcorn millets were cultivated in northern China [34, 35] . With the available archaeobotanical record, the Cishan site in the Northern part of China has broomcorn millet as early as 10000 BP, and foxtail millet 8700 BP. At some other sites like in northwestern China, Xinglongguo site [36] and in the lower Yellow River region, Yuezhuang site, foxtail millet has been recovered which is given the dates no earlier than 8700 BP and 7800 BP respectively. The new data about the millets from the site of Dadiwan also gives the well-built arguments, which denominate the new prospect in the field of ancient agriculture. There are also some other sites like Nanzhuangtou (11500-1100 BP) and Donghulin (1100-900 BP) have been documented with the presence of millets earlier than above-mentioned sites in the plain of North China. Again, in the northern China, at the site of Xiachuan, the cultivation of millet is observed which is dated back to 9000 years. In the Shanxi, the Yangshao site of Banpo has the record of foxtail millet (c. 5000 years) that depicts the wide range of millet cultivation in North China too. The region of middle Yellow River is also very crucial because the sites named Shawoli [37] and Peiligang [38] portray the existence of millets, which leads the new horizon in the research of millets agriculture. The millets from Xinglonggou site were recovered by flotation method, with their accurate dating and clear recognition, are also thought to be some of the earliest domesticated millets in China. In the Yiluo Valley of North China, millets have been noted with other plant fossils. Here, foxtail millet was cultivated during the Early Neolithic period and was the chief crop for at least four millennia. As far as broomcorn millet is observed, it was considerably less important throughout the sequence. This fixture can also be assumed as the cross-examination of the millet agriculture in Yiluo Valley. With the help of starch granules, it was observed that foxtail millet and broomcorn millet in the site of Shizitan (North China) are key factors to know about the ancient agricultural activities of the people that is dated back to ca.12700-11600 BP. In central China, the Yangshao, Dawenkou, and Longshan traditions, as well as the existence of millets, portray the ancient habits of the ancient people of this region [13]. In Shandong, Liangchengzhen site also has the existence of millets dualistically with the domestication of animals [39]. The archaeobotanical record suggests that Cishan, southern Hebei, Peiligang, northern Henan, Houli culture sites, West Shandong, Xinglongwa, Manchuria, and Dadiwan culture, Gansu have been noted as the ancient hubs of millets. In addition, foxtail millet and broomcorn millet were among the world's most vital and ancient domesticated crops. They were staple foods in the semiarid regions of China, Japan, Russia, India, and Korea and even in the whole Eurasian continent before the fame of rice and wheat respectively [20].

**Mixed Farming**

The study of mixed farming in China is a key in in the field of agriculture, which opens separate discussion of ancient agriculture in this region. Interestingly, in the early 1990s, the idea of the mixed farming of rice-millet was suggested. Later on, keen research on rice, millets, and then mixed farming also got the attention of the researchers to ponder over it. Comparing the mixed farming of China with Southwest Asia and Mesoamerica, Chinese mixed farming portrays the significance of a dualistic configuration with millet in the north and rice in the south. It is also observed that the rice and millet cultivation were equally exchanged during their growth and shaped a vast region of mixed farming in China. In a broader spectrum, the contact between millet and rice cultivation, the crop formation of the four central mixed farming expanses is in a continual progression of regulation, with the assortment of foxtail millet in the southward dispersal of millet agriculture and moderate Oryza *japonica* in the northern dispersal of rice farming. Mixed farming is considered not to be an inaccessible form of agriculture but is the result of the dispersal of millet and rice farming. As far as the routes of the dispersal of millet are

concerned, some of the researches were conducted to sketch the route of the dispersal of millet across Eurasia in early food habits [40] then dispersal of rice in East Asia connected with theoretical language family spread models. In China, the unanimous accepted point is that millet and rice farming are alienated along the edges of the Huaihe River and the Qinling Mountains [41]. It is also a reality that China has long been recognized as a center of origin for both rice and millets. The millet is one of the significant cereal crops, which have also been judged as a single or dualistic crop in China. Whether millets have been cultivated in North China in earliest times but the interplay of millets with rice in Neolithic central China has also been noted, the specific accomplishment of this verdict can be seen in the site of Baligang and in the Huai River Valley [42]. With this, another source of mixed farming can also be observed in the Province of Shandong [3]. Some other renowned sites which are known to mixed farming such as Yiluo Valley [43], Hanshui Valley (Weisskopf et al. 2015a), Chengdu Plain [44], Yungui Plateau [45], and Guanzhong Basin [46], are valuable sites in China/.. In the Middle Yellow River region, a key site named Tanghu site, which also reveals a new proof of broomcorn millet and rice mixed farming in 7800 BP that is a worthy source to understand the farming process of the two crops in the ancient Yellow River Civilization. In the south and north China, rice and millet farming was dispersed into each other's zone leading to mixed farming, specifically in between 4500-3800 B.C. (Yangshao Period). In addition, mixed rice and millet farming prolonged between the two rivers like the Yellow River and the Middle Yangtze by around 4000 B.C. Around 4000–3500 cal. BP. In South China, millets were also domesticated with rice in the two renowned sites Huangguashan and Pingfengshan in Fujian province through which the local ancient activities can also be judged with this example of mixed farming in China [47]. There are some interesting points about the beginning of mixed farming as in Shandong's Houli culture where millets and rice were cultivated together in the earliest times， still it is ambiguous. However, according to [48], in 4000 B.C, the cultivation of millets and rice was begun. Furthermore, mixed farming existed not only in China but also in the Taiwan region, Japan, Thailand, and Korea, which depicts the importance and value of this kind of farming.

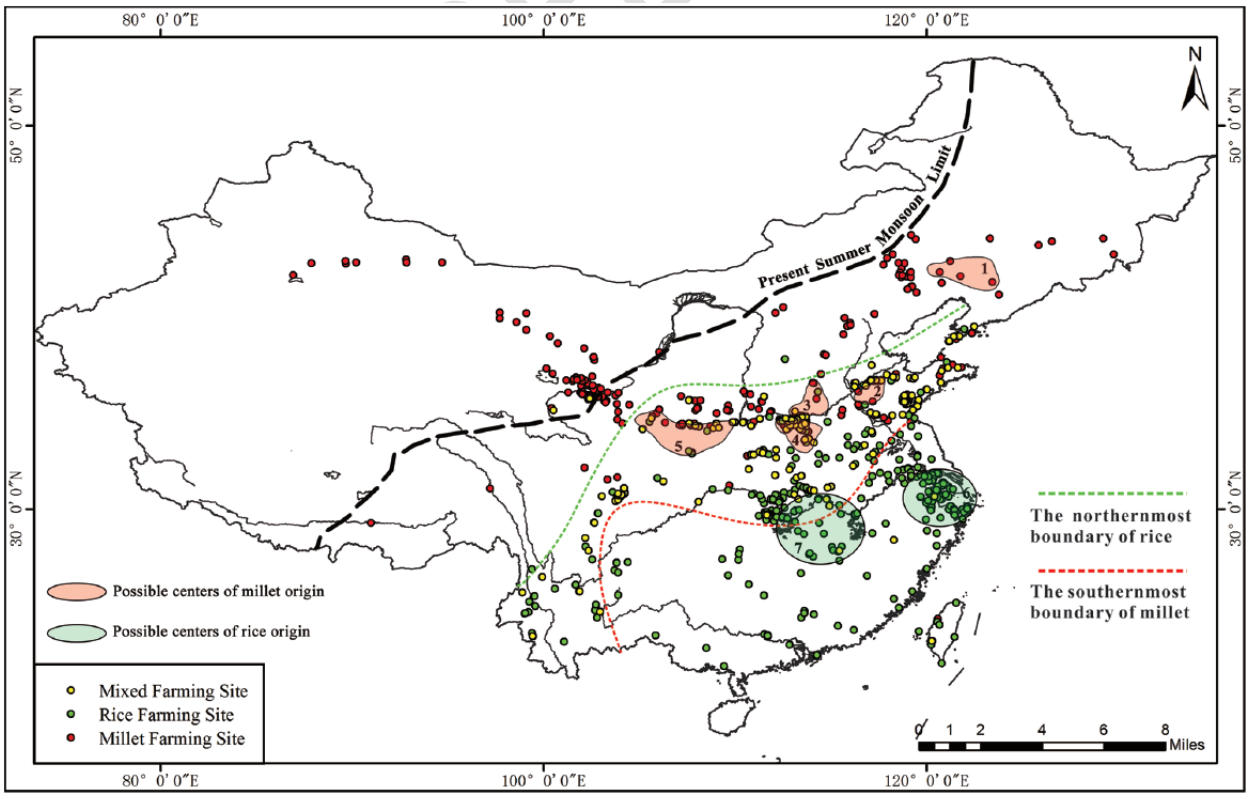

**Fig. 1 The boundaries, origins, and distribution of rice, millet, and mixed farming [49]**

## Dispersal of millets and rice

The millets and rice, both of these crops have been denominate in the sense of domestication and cultivation. The ancient archaeobotanical record also confirmed that both millets and rice have been noted as the crops, which spread out from their origins to nearby and farfetched areas. As it is true that the origin and dispersal of agriculture presented a steady economic base for the establishment of both ancient people and civilization [50, 51]. The extensively discussed language-farming spreading hypothesis prevail that augmented inhabitants within early farming societies lead to a mass departure in search of new land for agriculture and resultantly many languages also scattered [52]. Therefore, the vitality of the farmers with the language families increased towards wide range regions. The spreading of millets also occurred from China to Taiwan and, rice was dispersed from the South China toward other areas (Yangtze Basin) to South Asia as well as other territories. Both the crops have been observed as dispersing crops within and outside the boundaries of China. It is also evident that millets dispersed from Gansu toward Qinghai and then south to Sichuan [53]. The spreading of millets also perceived from Tibetan Plateau and rice from the Yangtze basin to Guangdong and Fujian in 2500 B.C [54]. The dispersal of millets to Korean in the Middle Chulmun period, and also out of northeast China to the southeastern side of Siberia, a moment away from beyond Jilin and Heilongjiang [55], is considered to be the vital one. The spreading of rice from southern part of China toward South Asia with the language speaking of Austroasiatic and Austronesian is also considered as valuable [56]. This rice dispersal toward South Asia is also precious because the Indus Valley Civilization regions, particularly, Pakistan and India got clear-cut influence from China regarding rice agriculture [57]. The Chinese legends confirm that there had been the activities of trade between China and India in the ancient era through the rice was spread from China to India. The trade activities of China with Northern Pakistan, Kashmir also portray the cultural exchange, which resultantly shows the facts of similarities in the tools for harvesting. The existence of the stone knives for harvesting in Kashmir is also recorded in China, which portrays the diffusion in the field of technology as well. In the Late Harappan period, at the site of Pirak in Pakistan, such harvesting tools also observed [58]. Interestingly, the archaeological researches also prove that Ganges Valley and lower Yangtze River are the centers of early rice agriculture. Above all, the wild progenitors (*Oryza rufipogon* and Oryza *nivara*) of Asian rice can be seen as native to Southeast and South Asia moving from a southern part of Chinese. It is also obvious that after 5000 cal. BP, the millets dispersed toward Eurasia and specifically According to [59], broomcorn millet become visible in Europe after 3600 cal. BP and it is proved with the resources of the archaeobotanical record. As far as its dispersal toward Taiwan, the routes of southeast China has been noted through, which millets entered into Taiwan and its entrance into Thailand is Yunnan and possibly Guangxi province of southwestern China through which the millets also entered there.

## Prehistoric development of rice, millets, and mixed farming

The agriculture in ancient China proposes the significance the cultivation of millets in the northern parts and rice in the southern part as well as the formation of mixed farming with the results of exchange of millets and rice from south to north. On the contrary side, there are some ambiguities to prove exact origin and evolution regarding mixed farming agriculture in China. The supporting arguments about mixed farming can be suggested as the movement of human, environmental conditions or cultural contacts among ancient people. Some of the clues suggest that the millet and rice cultivated in separate

regions and conditions and then both contacted during their progression, which ultimately formed mixed farming during the Neolithic period in China [60]. Some scholars suggested the regions and boundaries of the millets, rice, and mixed farming agriculture. However, it is proved that almost all the sites related to mixed farming are situated between Yangtze and Yellow River. According to [48], A gigantic sector of mixed farming is observed in Neolithic China, which suggested the boundaries and important sites in this context. The site of Gaolizhai in Dalian (northmost–eastmost), the site of Shifodong in Gengma (southmost–westmost) and some other sites like Jiaoridang and Haimenkou have been concluded as the earliest regions or origins of mixed farming. Systematically, the interaction between rice and millets depict the progression of mixed farming in the regions of Central Plains and Haidai around 8000 BP. In a deep sense, the millets emerged in North China and then dispersed toward other regions. Both foxtail millet and broomcorn millets dominated each other in different times and cultures. During the Peiligang culture (9000–7000 BP), the broomcorn millet was a chief crop, in later stages, the foxtail millet became dominant in the culture of Longshan (5000–4000 BP). In the Neolithic China, both millet and rice have been noted as the chief crops, which dominated many regions from the Yangtze to Yellow Rivers. Whether millet emerged in North China but its dispersal toward other regions makes it a valuable crop that detains countless region in China. The same case with the early rice, having the ancient origins in Yangtze River, Huai River, and Lower Hanshui River, it developed and captured many of the areas and became dominant crop too. The dispersal of rice within China and neighboring countries formulates this crop valuable and significant in the Prehistoric Era. In early farming societies [61, 62], which represent the Neolithic Era, both millet and rice portray the early agriculture through which the ancient Chinese Civilization has been attributed.



**Exchange route between millet and rice farming**

The early cultivation of millet and rice in China separately and in dualistic portrays the ancient human with the agricultural activities and its functions. In this regard, the geographical analysis can be a good hand to depict the ancient routes and dispersal of millet and rice through which the mixed farming came to a form. Analyzing this judgment, there has been a point some routes such as east, west, central, and common route. As far as the eastern route is observed, this route is pointed in the eastern alluvial plain between the regions of Haidai and Jiangzhe along the coastline of the Yellow Sea. On the other side, the west route or passage lies between the region of Ganqing and the Chengdu Plain [63]. Here mostly, the millet is found on almost all the sites, which are situated on the Sichuan Basin. Here, some ancient sites with the attribute of mixed farming have also existed like Guiyuanqiao and Baodun. The central route is positioned between the Hanshui Valley and Central Plains that is considered the combined route as well. Here, the vital site is Baligang that is situated in the Nanyang Basin. Interestingly, through Nanyang Basin, this central route is valuable because the dispersal of rice from northwards started here and the dispersal of and millet from southwards. There is also a common route or corridor until the Longshan culture. This route represents some sites with millets as well as rice. Through this route, the Longshan culture is Liangzhu represented well with the archaeobotanical record of archaeological sites with the reference of millet and rice agriculture.

**Conclusion**

According to above discussion, rice, millet, and mixed farming have been drawn with the specification of origin and evolution. With the help of archaeobotanical data of the mentioned sites, the retrospective

analysis formed. Geographically, the earliest mixed farming emerged in the Central Plains and the region of Haidai around 8000 BP. The discussion about specified routes or corridors depict the key features of rice and millets agriculture as well as their integration. With this, the highlighted centers of rice and millets portray the valuable place in the ancient history of Chinese agriculture through which the development of above-mentioned crops can also be focused on in further researches. The available archaeobotanical records also suggest the three reasons for the structure of mixed farming such as the human migration, environment, cultural exchange or communication, and demographic expansions that can be expected to have dispersed the major language families as well. This writing evaluates the interaction between rice and millets with the momentous arguments. Some important features of this manuscript depict the evidence that rice was brought into farming within the these delineated regions between 6500 and 5500 B.C. These regions are; centers of early rice like the Lower Yangtze, the Middle Yangtze, Lower Huaihe River, Lower Hanshui and Upper Huai River Basin, same the origins and centers of the millet are Cishan, southern Hebei, Peiligang, northern Henan, Houli culture sites, West Shandong, Xinglongwa, Manchuria, and Dadiwan culture, and Gansu. Finally, the dispersal of millet and rice with the identification of trajectories provides the precision conditions as well as the dominance of millet and rice in Neolithic China. Some of the ambiguities in time span and the transition in ancient agriculture can also be resolved regarding rice, millet, and mixed farming in further archaeobotanical researches.



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