Current Situation of Introduction and Use of African Crop Germplasm Resources and Recommendations

Zili DING, Minghua YAO, Chunhai JIAO*

Hubei Academy of Agricultural Sciences, Wuhan 430064, China

Abstract Africa is the origin center of many crops. It is rich in original ecological resources, especially special resources which are excellent materials for breeding research. With acceleration of commercial seeds in agriculture of African countries, some original ecological resources are disappearing. Through experience of introduction of African varieties in recent years, it analyzed current situation of introduction and use of African crop germplasm resources. Finally, it came up with recommendations for rescuing and taking full advantage of excellent African resources, solving difficult problem restricting crop breeding, enriching China's crop germplasm bank, and improving China's and African crop breeding level and innovation ability.

Key words Africa, Crop germplasm, Introduction, Recommendations

With economic globalization and constant improvement of South-South Cooperation mechanism, the economic and commercial exchange between China and African countries is constantly strengthening, the Forum on China-Africa Cooperation established in October, 2000 further provides excellent opportunity and motive force for cooperation of China and African countries. Policy documents of China for Africa stated that Sino-African agricultural cooperation should focus on agricultural planting, enhance cooperation of agricultural technologies, actively undertake introduction and exhibition of crop germplasm resources, as well as training of agricultural practical technique. Exploration, storage and innovation of germplasm resources are listed into priority fields of agricultural sci-tech development in *National Mid- and Long-term Plan for Science and Technology Development* (2006 -2020). *Opinions of the State Council on Accelerating the Development of the Modern Crop Seed Industry* approved on February 22, 2011 clearly called for consolidating crop seed industry resources, strengthening policy support and input, rapidly improving sci-tech innovation ability of China's crop seed industry, and comprehensively improving development of China's crop seed industry. Implementing "go global" strategy for agriculture and ensuring national food security are fundamental objectives of agricultural development in the new period. Africa has abundant original ecological crop germplasm resources that have important function for improvement of crop varieties. Introducing and using excellent African germplasm resources are of great significance for enriching China's crop germplasm resource bank, improving China's crop breeding level and innovation ability, and improving China's international competitive power of crop varieties and technologies.

Received: November 16, 2014 Accepted: February 5, 2015

Supported by International Sci-tech Cooperation Program of Ministry of Science and Technology of China (2011DFB31620).

* Corresponding author. E-mail: 274184394@qq.com

1 Current situation of African crop germplasm resources

Africa is one of the 12 important crop origin centers. At present, there are still numerous wild species and crop wild relatives, and abundant original ecological resources, especially excellent and unique resources. Crop wild relatives have such specific traits as high yield, disease resistance and stress resistance[1]. Besides, they have rich genetic diversity and have become major sources of new genes for modern crop breeding.

1.1 Complex and changeable terrain and climate cultivate rich crop resources The distinct feature of African terrain is plateau continent with average altitude of 750 m[2]. Africa extends across southern and northern hemispheres. The equator crosses middle parts of Africa. The distribution of its climate, hydrology, vegetation and soil is closely connected with its plateau terrain. It basically takes on symmetrical distribution: the tropical rain forest zone, tropical savanna zone, tropical steppe zone, tropical desert zone, and subtropical forest zone (Mediterranean plant zone)[3]. High altitude terrain brings African agricultural system with unique characteristics[4] and numerous original ecological crop resources. In addition to low commercial level of agricultural production, low crop yield, and low efficiency, crop germplasm not only keeps rich types, but also has specific traits such as barren resistance, high temperature resistance, drought resistance, and disease resistance. Therefore, Africa has huge potential of development and use of crop germplasm resources.

1.1.1 Grain. Main grain crops in Africa include rice, corn and wheat. Africa has rich rice germplasm resources, is origin center of African wild rice and Oryza glaberrima Steud. There are 14917 varieties of rice germplasm resources. African rice varieties have higher ability of disease and insect pest resistance, saline and alkaline resistance, drought resistance, flood resistance and barren resistance than Asian rice varieties. Besides, African rice varieties have high affinity to indica rice and japonica rice and high hybrid affinity to Asian rice varieties. In these resources, there are

large ear rice varieties with average number of grain above 200; there are also super large ear rice varieties with average grain weight up to 40 g; there are long grain rice varieties with length of rice grain up to 1.1 cm; there are rice varieties able to resist rice blast, bacterial blight and brown planthopper; some varieties are immune to leafhopper, ordinary dwarf disease and yellow dwarf disease; some varieties are drought, weed, saline and high temperature resistant.

1.1.2 Cotton. Cotton is one of the most important industrial crops in Africa. The planting area is wide from south latitude 30° to Mediterranean coast and from East Africa to Atlantic coast of the West Africa. It covers nearly all African Continent except desert areas. Egyptian long staple cotton features long cotton linter, smooth and tough. The yield of Egyptian long staple cotton accounts for about 40% of the total global yield. According to varieties, Egyptian long staple cotton mainly includes GIZA 45, GIZA 86, GIZA 70, GIZA 89 and GIZA 90. GIZA 70 has the highest yield, accounting for 75%, and GIZA86 accounts for 10% approximately. In the exported cotton, the long staple cotton takes up 68% and extra long staple takes up 32%. GIZA 86 long staple cotton and GIZA 70 extra long staple are most favored in international market, accounting for 44% and 20% of total export volume respectively. GIZA 70 is mainstream product at market and is a major type imported by Chinese enterprises. West Africa and Central Africa are major cotton producing areas. Nigeria has 6 major cotton varieties used for commercialized production, namely, SAMCOT8, ASMCOT9, SAMCOT10, SAMCOT11, SAMCOT12 and SAMCOT13. Especially in the condition of natural climate, many African cotton varieties are resisting high temperature, drought, and waterlogging.

1.1.3 Vegetable. Vegetable is essential industrial crop in 6 agricultural regions of Africa and also major production base of European organic vegetable. Common vegetables include tomato, onion, potato, wild cabbage, eggplant, hot pepper, melon. Vegetable products account for the first four largest agricultural products exported by Africa. Africa is origin center of many types of vegetables, has numerous ecological melon and vegetable resources. These crop resources have higher disease resistance and high temperature resistance in local climatic condition. Especially now, there are numerous wild species and crop wild relatives. Vegetable production in Africa is mainly original ecological vegetable having high quality, low yield and high resistance. It is badly necessary to cultivate high quality, high yield and high disease resistance varieties.

1.1.4 Beans. Africa is rich in bean germplasm resources, near 20000 bean varieties with high genetic diversity. It is the origin center of many varieties of beans. For example, Ethiopia is origin center of pea and secondary origin center of broad bean; Nigeria is diversity center of cowpea. In Ibadan of Nigeria, there are 12000 cowpea germplasm resources. Africa is origin center of many bean varieties. The bean resource is abundant, especially disease-resistant and stress tolerant resources.

1.2 Low agricultural production efficiency brings rich crop resources Farmland in Africa is relatively scattered, most crop production is mainly decentralized small peasant operation. Such farming method is simple and primitive, mainly relying on hoes and shovels without agricultural machinery. Sowing method adopts broadcast sowing without field management; it is greatly short of agricultural machinery, sowing, planting and harvesting depend on manual labor[5]. Besides, it lacks agricultural infrastructure. Many African countries do not have water conservancy, road, electricity and warehousing storage facilities support for farmland. Crops often suffer great drop in yield. Basically, they live at the mercy of the forces of nature. Agricultural production mode is backward and agricultural machinery level is low[6]. In addition, scientific and cultural quality of African people is relatively low. Many peasants are illiterate or semiliterate. They lack knowledge about new varieties and technologies of agricultural production and they lack basic knowledge and skill of agricultural production due to no traditional agro-farming civilization.

1.3 The hybridization and commercialization of agricultural products are low and peasant family varieties are major parts of production For a long term, most African countries pay little attention to agriculture. In recent years, economic conditions of African countries are constantly improving, but due to heavy burden of debt, agricultural input only accounts for 8 – 10% of total investment, even lower than 5% in some countries[7]. In addition to little attention to agricultural management and training of technical personnel, agricultural sci-tech level of African countries is still relatively low. Most African countries have not started commercialized breeding and traditional varieties of peasant families are still used in production. Such situation keeps excellent variety resources and original ecological features. Agricultural developed countries, such as American-European countries, have not entered African agricultural market, so some excellent variety resources are temporarily kept.

2 Current situation of use of crop germplasm resources in China

2.1 Innovation of crop germplasm resources Rich biological germplasm resources are material foundation for survival of human beings and are closely connected with survival and development of human beings[8]. China has numerous biological germplasm resources and abundant wild plants and animals. There are more than 3000 varieties of higher plants in China, only second to Brazil and Colombia. In the world, about 1200 – 1500 varieties of plants are cultivated[9], while in China, only 840 varieties of plants are cultivated, accounting for 56 – 70% of the total world cultivation number, involving 1251 cultivation species and 3 308 wild relative plants[10-12]. According to statistics, Chinese plant genetic breeding technicians collected and made a catalogue of 180 plants, 420000 varieties of germplasm resources, made development and utilization of them, and selected 6300 crop varieties[13]. For example, scientists bred the miracle Mexican wheat using Jap-

anese wheat dwarfing gene; Scientists of International Rice Research Institute (IRRI) cultivated IR8 and IR series rice varieties using Chinese dwarfing gene of Dee-geo-woo-gen, starting well-known green revolution; large area of extension of hybrid rice is an example of considerable increase of rice yield using sterile cell feature of wild rice. These examples show that rich germplasm resources are material foundation for breeding new varieties.

Since the 1970s, China has introduced about 100000 various crop seeds and seedlings from more than 90 countries, regions and international agricultural organizations. A good many excellent foreign germplasm resources are used for large field production, for parent materials, or being tamed for cultivation. They play a decisive role in China's agricultural development. According to statistics, about 75 rice varieties introduced from foreign countries are planted with area more than 667 hectare separately; China introduced long-grained non-glutinous rice IR8 from IRRI, the planting area has reached 0.9 million hectare; China introduced japonica rice No. 58 from Japan and the planting area reached 3.7 million hectare, and it has been developed to 55 new rice varieties. By now, japonica rice varieties planted in China are still mainly introduced from foreign countries. Great breakthrough in Three-line Indica Hybrid Rice Combinations is the use of Taiyin No. 1, IR24, IR661 and IR26 rice restorer lines. At present, all restorer lines popularized in China adopt foreign varieties directly or indirectly. The excellent hybrid rice combination Shanyou No. 63 was planted as large as 5.3 million hectare.

About 80 wheat varieties introduced from foreign countries are directly used in China. Using these varieties, China has cultivated near 400 new excellent varieties. Introduction and direct use of Mexican wheat greatly promote increase of wheat yield in Xinjiang and Yunnan and greatly improved early maturity and disease resistance of winter wheat in Shanxi and Hebei. Most founder parents of wheat breeding in China are introduced from foreign countries. About 80% improved wheat varieties of China have foreign blood lineage. Some wheat varieties of Henan Province also contain materials introduced from abroad.

2.2 Loss of crop germplasm resources Due to sharp growth of population and unreasonable resource development activities, as well as environmental pollution and ecological damage, China has serious loss of diversity of germplasm resources. Some researches indicate that about 200 plant varieties are extinct and about 5000 plants are on the brink of extinction[14]. In 1949, China planted about 10000 wheat varieties and most were local varieties; by 1970, only about 1000 varieties were planted; by now, only about 100 are planted and only several local varieties are planted; wild rice and wild bean habitat and population number of China have reduced about 70 – 90%; a lot of wild varieties collected in the beginning of the 1980s are difficult to find at present[15-16]. Now, 354 plant varieties of China have been formally included into the List of National Endangered Plants[17].

3 Necessity for strengthening introduction of African crop germplasm resources

3.1 Using excellent African crop germplasm resources to explore and breed new resources and speed up breeding of excellent crop varieties China has rich crop resources, but resource gene is narrow, the homogeneity is high, there are few breakthrough varieties, and resource innovation ability is weak. All of these restrict crop breeding, and it is thus difficult to form world varieties. At present, large trans-national companies, such as Monsanto, Syngenta and BASF, nearly produce all vegetable varieties. And foreign seeds have comprehensively covered China's bean, corn, wheat and flour fields. In recent years, China strengthened collection of foreign resources and cooperative researches, but most are countries in Southeast Asia, the cooperation with African counties is little. However, with acceleration of cooperation with African countries in agricultural science and technology, some African original ecological resources are losing. Therefore, solving the bottleneck of varieties in stress resistance and high quality breeding has great realistic significance for realizing great-leap-forward development of China and Africa crop breeding in stress resistance, high quality and high efficiency.

3.2 Using excellent African germplasm resources to cultivate new multi-resistant and high yield crops With global environmental pollution, damage of ecological environment, and changes of climatic conditions, plant diseases and insect pests of crops are deteriorating. Using African disease-resisting gene resources to breed new crop varieties is a fundamental method to solve plant diseases and insect pests. At the same time, breeding and popularization of nutritive and high efficient crop varieties will greatly reduce application of fertilizer and alleviate pressure of agricultural product demands on weak soil ecological environment. In recent years, excessive use of chemical pesticide and fertilizer leads to serious pollution of farmland. Besides, Henan and Anhui provinces are in short of fresh water resources. Drought and lack of water have become major factor restricting agricultural and economic development. Thus, cultivating drought resistant varieties is an effective approach for solving shortage of water resource.

4 Recommendations for strengthening Sino-African agricultural cooperation

4.1 Strengthening rescue introduction of African crop resources African countries are rich in original ecological resources. Peasant family varieties are major varieties, and most varieties are excellent ones. Before these resources become extinct, it is recommended to strengthen rescue introduction of these crop resources and cooperation with African countries. It is urgent to increase yield of African crops planted in China through introducing and directly popularizing excellent crop varieties and germplasm resources. China has a long history of introducing foreign germplasm resources. At present, about a half of 840 crop varieties are introduced from abroad[18]. In Africa, more than 50 countries have abundant crop germplasm resources, so China can introduce many varieties of crops. Therefore, it is recommended to in-

corporate exchange and introduction of African germplasm resources into Sino-African agricultural exchange and cooperation scope. Through survey and analysis, it is recommended to collect various plant germplasm resources, to provide reference for China making exchange of germplasm resources and further improving crops, forage grass, vegetable, livestock, and poultry, *etc.* It is recommended to include introduction and exchange of germplasm resources into Sino-African agricultural cooperation scope.

4.2 Making pertinent introduction of African resources and realizing best use of introduced varieties Five provinces of central China are hot in summer and have frequent rainstorms, similar to rainy season of African countries. It is badly needed to cultivate high stress resistant and high quality varieties to solve problems such as bad harvest and weak growth. Therefore, in line with practical situations and long-term demands of agricultural production in five central provinces of China, it is recommended to collect excellent crop germplasm resources from African countries with similar summer climate, make innovative use of those resources, improve current crop varieties of five central provinces, and strengthen demonstrative extension and application of improved crops. This is the necessity for China innovating crop resources, and also the necessity for African countries ensuring grain security. Through introducing excellent germplasm resources and setting up international sci-tech cooperation and exchange platform, it is expected to open up new channels for agricultural sci-tech exchange and cooperation, and cultivate agricultural scientific research teams with international competitive power, so as to boost international influence of China in agricultural scientific researches.

References

[1] ZHANG FD, GUO YQ, YU LQ, *et al*. Evaluation and screening of resistance to barnyardgrass in germplasm of wild rice(*Oryza sativa*) and African cultivar [J]. Acta Agronomica Sinica, 2004, 30(11):1140 – 1144. (in Chinese).
[2] YANG QS, HAN J, DING SB. World geography [M]. Beijing: Higher Education Press,2004: 296 – 318. (in Chinese).
[3] SU SR. African geographical process[M]. Beijing: The Commercial Press, 1983: 10 – 35. (in Chinese).
[4] Jared Diamond. Guns, germs, and steel: The fates of human societies[M]. Shanghai: Shanghai Translation Publishing House, 2000:43 – 45. (in Chinese).
[5] XIN L. Study on African agriculture——Taking the case of Angola [J]. World Tropical Agriculture Information, 2007(7): 1 – 3. (in Chinese).
[6] LI WG, ZENG YD. Agricultural cooperation and development prospects between China and Zambia [J]. World Agriculture, 2006(11): 40 – 42. (in Chinese).
[7] AN CY. Reflections on the promotion of Sino – African cooperation in tapping Africa's land resources[J]. West Asia and Africa,1999(5): 61 – 66. (in Chinese).
[8] Yani Wu, Wenke Wang, Shuchun Meng. Study on present status of plant germplasm resources conservation and countermeasures [J]. Agricultural Science & Technology, 2013, 14(5): 732 – 737.
[9] WANG ZM, KANG B, DENG SH, *et al*. The improvement effect of backcross to cross progenies between cultivated soybean(*G. mas*) and semi-wild soybean(*G. gracilis*)[J]. Journal of Jilin Agricultural University, 1996, 18(4) : 12 – 17. (in Chinese).
[10] LI WB, WANG JL, YANG QK. Inheritance of quantitative characters in the self-cross and backcross populations of *Glycine mas* × *G. soja hybrids* [J]. Soybean Science, 1990, (2): 89 – 102. (in Chinese).
[11] ZHANG F, GAO XB, GAO YM, *et al*. Improving seedling cold tolerance of japonica rice by using the "hidden diversity" in indica rice germplasm in a backcross breeding program [J]. Acta Agronomica Sinica, 2007, 33(10): 1618 – 1624. (in Chinese).
[12] ZHANG BS. Crop breeding [M]. Beijing: China Agricultural Science and Technology Press, 1996: 40 – 41. (in Chinese).
[13] SHI J, LIU YB. Analysis on the present situation and development trend of Chinese seed industry [J]. Agricultural Science&Technology and Equipment, 2013(4): 79 – 80. (in Chinese).
[14] WANG JG. A general introduction to resource and environment[M]. Beijing: China Agricultural University Press, 2002: 86 – 104. (in Chinese).
[15] LI KD. Progress, problems and countermeasures of in situ conservation of wild rice in Guangxi[J]. Journal of Plant Genetic Resources, 2008, 9(2): 230 – 233. (in Chinese).
[16] LI XH, WANG KJ, LI FS. Analysis on the current status of annual wild soybean distributed in part of China [J]. Journal of Plant Genetic Resources, 2005, 6(3): 319 – 322. (in Chinese).
[17] LOU XZ, LIU XM, WANG SM, *et al*. Survey of world plant genetic resources [J]. China Seeds, 1996(4):1 – 6. (in Chinese).
[18] JIANG HP. Thinking on cooperation of agriculture between China and Africa and suggestions on related policy [J]. Management of Agriculture Science and Technology, 2008,27(6): 5 – 7. (in Chinese).

(From page 64)

rice and corn generally increases by 10% in the context of summer drought in the whole province, indicating that there are significant strengths of light and temperature climatic resources. Therefore, it is necessary to rationally develop and use climate resources for scientific distribution of agricultural industries, actively develop water – saving irrigation techniques, efficiently use water resources to meet crop's water needs during summer drought, and transform the weaknesses of drought into the strengths of climate resources for the development of specialized agriculture. Good light and heat conditions may be more conducive to agricultural production.

References

[1] ZHOU XP, CHEN JW, XIAO X. Review of assessment method of grain comprehensive productive capacity in China [J]. Shandong Social Science, 2006(12):123 – 125. (in Chinese).
[2] GU DY, LIU JG, YANG ZQ, *et al*. Reviews on crop productivity potential researches [J]. Agricultural Research in the Arid Areas,2007,25(5):89 – 94. (in Chinese).
[3] LI SA, JU H, CHI BL. Reviews on crop potential productivity researches [J]. Chinese Journal of Agrometeorology,2005,26(2):106 – 111. (in Chinese).
[4] LIU B, YANG GH, ZHANG LP. Analysis and evaluation on of agricultural resources the production potential in south Xinjiang area——Taking the Alar irrigated area for example [J]. Journal of Arid Land Resources and Environment, 2006,20(3):139 – 143. (in Chinese).
[5] JIANG ZW, WU XP, HUA L, *et al*. Long-period quantitative simulation and evaluation of summer maize potential productivity in Luoyang dryland [J]. Acta Ecologica Sinica, 2009,29(1):315 – 324. (in Chinese).
[6] FAO. Report on the agro-ecological zones project[R]. Rome: World Soil Resources Report , 1978, 1(48):1 – 20.
[7] WANG BS, MA XG, FENG M, *et al*. Study on the Countermeasures of Drought Control and Disaster Release Based on Human Land Relationship – – A Case Study in Yunnan Province[J]. Agricultural Science & Technology, 2015,16 (1): 25 – 30.