Molecular Plant Breeding 2023, Vol.14, No.12, 1-5
http://genbreedpublisher.com/index.php/mpb

Research Report Open Access

Brief History of Plant Breeding (II): From Transplantation, Division, Cutting, Grafting to Primitive Domestication

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Molecular Plant Breeding, 2023, Vol.14, No.12 doi: 10.5376/mpb.2023.14.0012
Received: 31 May, 2023
Accepted: 05 Jun., 2023
Published: 12 Jun., 2023

Preferred citation for this article:
Fang J., 2023, Brief history of plant breeding (II): From transplantation, division, cutting, grafting to primitive domestication, Molecular Plant Breeding, 14(12): 1-5 (doi: 10.5376/mpb.2023.14.0012)

Abstract This article explores the early stages of plant breeding history, including the development and application of techniques such as transplantation, division, cutting, grafting, and primitive domestication. These techniques provided the foundation for plant propagation and improvement, promoting agricultural development and societal progress. Transplantation and division techniques enabled plants to grow in different environments and expanded the range of cultivation. Cutting and grafting techniques allowed plants to reproduce and maintain desirable traits, promoting variety diversification and improvement. This also marked the primitive domestication where wild plants gradually transitioned into cultivated plants, as humans began consciously selecting and cultivating superior plant varieties to adapt to human needs and environmental changes.
Keywords Plant breeding; Transplantation; Division; Cutting; Grafting; Primitive domestication

Throughout the long course of history, the relationship between humans and the natural environment has undergone profound changes. From the primitive nomadic lifestyle of avoiding harsh climatic conditions to the pastoral lifestyle of following water sources and grasslands, and eventually to settled living by utilizing abundant plant resources, human lifestyles and methods of obtaining food have gradually evolved. Settled living enabled humans to cultivate plants around their dwellings for their own consumption and for livestock. This change marked the transition of humans into an agrarian society.

However, human demand for food did not stop there. With population growth, relying solely on protection of crops in situ and shifting cultivation was no longer sufficient to meet the demand for plant-based food resources. As a result, humans began to expand the scale of shifting cultivation. In this process, humans gradually learned agricultural techniques such as whole plant transplantation, root division transplantation, branch cutting propagation, and grafting. These techniques greatly expanded the sources of "seeds" and allowed more plants to reproduce and spread.

These methods and techniques not only helped humans meet their food needs but also brought about changes in plants themselves. Through artificial selection and breeding, many plants gradually transitioned from the wild state to a domesticated state by humans. This may be considered as the earliest practice of plant propagation or breeding by humans. This stage can be referred to as the primitive breeding stage of humans, which marked the beginning of humans actively and consciously influencing and altering the evolutionary process of plants.

1 The Relationship between Early Humans and Plant Life

The transformation of early human lifestyles was a long and complex process. Initially, humans, like many animals, roamed the vast Earth, moving with the seasons and changing environments. They constantly changed their dwellings in pursuit of food and water sources and to avoid harsh weather conditions. However, with a deeper understanding of the environment and technological advancements, humans began transitioning from a nomadic lifestyle to settled living. They started to establish long-term settlements in one place to utilize the resources of the land, particularly plant resources.

As humans discovered that protecting and cultivating plants could yield more food, settled living further developed. They began practicing in-situ protection and shifting cultivation around their settlements. For example, they would leave behind seeds or tubers of favored plants in anticipation of their growth in the next growing season. Shifting cultivation involved relocating plants or parts of plants to new areas, allowing them to grow in a broader territory.

Settled living not only changed human lifestyles but also greatly altered the way plants were utilized. In primitive nomadic life, humans primarily gathered plants for food. In settled living, they actively engaged in planting and propagating plants to obtain more food. This required a deeper understanding of plants, such as their growth cycles and suitable environmental conditions. Moreover, through selective planting, humans introduced more desirable plant varieties to their settlements, such as high-yielding grains or flavorful fruits. This conscious utilization of plants can be seen as the earliest attempts at breeding by humans.

2 Emergence and Development of Transplantation, Division, Stem Cuttings, and Grafting Techniques

As the human population grew, the demand for food increased, and early humans attempted to expand the scale of shifting cultivation. They started to cultivate more plants in larger areas, particularly those that could provide a substantial amount of food, such as grains and legumes. However, relying solely on shifting cultivation made it challenging for humans to meet the growing food demand, prompting them to find new ways to increase plant yields.

In the face of food supply pressures, humans began exploring new planting techniques. They gradually learned techniques such as whole-plant transplantation, division, stem cuttings, and grafting, which were closely related to agriculture.

Transplantation is the most direct method of planting. Its significance lies in the ability to transfer plants from their original habitats to new environments, expanding the distribution range of plant species. For example, rice was first domesticated and cultivated in Asia, and through transplantation, rice cultivation expanded to various regions globally.

China is one of the earliest places to practice paddy field cultivation. Ancient Chinese farmers divided the paddy fields into small plots and planted rice in each plot. When the rice grew to a certain stage, they would transplant it to a well-watered area for better growth. This transplantation practice helped increase rice yield and quality. Ancient Chinese farmers typically sowed seeds in early spring and then transplanted well-grown vegetable seedlings to the fields when the weather warmed up. This method ensured vegetable growth and improved yield.

Division is an effective propagation method, particularly for plants that can generate new plants from their roots, such as strawberries and lavender. Through division, a large number of genetically identical plants can be obtained in a short period, greatly enhancing planting efficiency. Division provides humans with an efficient means of rapid plant propagation, expanding cultivation areas, and preserving and passing on rare plants. This method has been widely applied globally, significantly impacting agricultural production.

Lilies, an ancient flower, were propagated through division by the Babylonians as early as 3000 BCE, expanding their cultivation range. The Romans divided grapevines to obtain new grapevines. This division technique enabled the rapid expansion of the Roman grape cultivation industry. Ancient Indian farmers divided spice plants like ginger and turmeric to obtain more plant specimens. This method greatly increased spice production.

Stem cuttings involve cutting a portion of a plant's stem and inserting it into the soil or another growing medium to promote root growth and develop new plants. The primary purpose of stem cuttings is rapid plant propagation, maintaining the stability of genetic traits, and creating new plant varieties. For example, grape growers can ensure that new grapevines maintain consistent fruit quality with the mother plant through stem cuttings. Additionally, certain flowers like roses and chrysanthemums are commonly propagated through cuttings to maintain their specific colors and shapes.

Ancient Persians successfully propagated roses through stem cuttings. They inserted mature rose stems into the soil, and after a few weeks, the stems developed roots and began growing, creating new rose plants. Ancient Romans employed the technique of cuttings in fruit trees. They inserted stems or branches of apple, pear, and peach trees into the soil, creating new fruit tree varieties. Ancient Chinese farmers used stem cuttings to propagate bamboo by inserting bamboo stems into the soil, leading to the growth of new bamboo plants.

Grafting is a technique that joins two or more different plants together, typically by attaching a scion (a shoot or bud) from one plant onto the stem or branch of another plant known as the rootstock. The primary purpose of grafting is to combine the strengths of different plants, accelerate plant maturity and fruit production, and improve disease resistance and adaptability. For example, in grape cultivation, high-quality grape varieties are often grafted onto disease-resistant grape rootstocks, resulting in grapes with both excellent fruit quality and disease resistance. Another example is apple cultivation, where growers may graft apple varieties with exceptional taste onto rootstocks with robust vigor and adaptability, ensuring both fruit quality and enhanced plant growth.

According to historical records, ancient Babylonians had mastered the grafting technique in fruit trees. They grafted high-quality fruit tree varieties onto resilient rootstocks, resulting in new fruit tree varieties with high yields and superior fruit quality. Ancient Greeks grafted high-quality olive varieties onto rootstocks that could adapt to local soil and climate, leading to the production of premium olives. Ancient Chinese farmers used grafting techniques to graft superior fruit tree varieties onto rootstocks with strong disease resistance and broad adaptability, successfully improving many fruit tree varieties.

The emergence of these techniques allowed humans to expand their plant resources and significantly increase food production. Whole-plant transplantation and division enabled plants to grow in larger areas, boosting productivity in specific regions. Stem cuttings and grafting allowed humans to "create" new plant varieties. Through grafting, different plant species could be combined, resulting in plants with both desirable fruit quality and robust root systems. These techniques greatly enhanced the availability of food sources for humans and laid the foundation for the establishment of agricultural societies.

3 The Process and Impact of Plant Domestication

Primary breeding techniques such as transplantation, division, stem cuttings, and grafting have greatly facilitated the process of plant domestication. These techniques allow humans to consciously modify and utilize the genetic traits of plants, making them better suited to human needs. Through transplantation, humans can bring plants to new locations and enable their reproduction. Division, stem cuttings, and grafting enable the propagation and improvement of high-quality plant varieties, increasing food production, improving food quality, and enriching human food sources.

Plant domestication, particularly the domestication of food crops, has significantly contributed to the development of human societies. With stable and abundant food sources, humans began to settle and establish villages, leading to the formation of complex social organizational structures and civilizations. The domestication of plants also promoted the development of handicrafts and industries such as textiles, dyes, construction, and medicine.

Human activities not only alter the genetic characteristics of plants but also impact their distribution. For example, transplantation enables plants to spread to various regions worldwide. Furthermore, agricultural practices such as irrigation, fertilization, and weed control undertaken by humans have altered the natural environments of plants to some extent, influencing their evolutionary processes. Additionally, human selection and breeding of high-quality plant varieties have exerted directional evolutionary pressure on plant populations, driving the process of plant evolution.

4 Conclusion

Plant domestication represents a significant milestone in the long and rich history of humanity. From the nomadic lifestyle of early humans, who sought refuge from harsh climatic conditions, to the process of settling and utilizing plant resources for survival, humans have continuously modified and utilized the genetic traits of plants through primary breeding techniques such as transplantation, division, stem cuttings, and grafting, driving the domestication of plants and the development of agriculture.

The emergence and development of these primary breeding techniques have not only expanded the distribution range of plants and improved their adaptability but also increased crop yields and improved quality. Plant domestication has had a profound impact on human society and lifestyle, facilitating the formation of settled communities, the development of social organizations, and the rise of agriculture and handicrafts.

At the same time, human activities have also influenced the evolution and distribution of plants. Humans have introduced plants into new environments through techniques such as transplantation, division, stem cuttings, and grafting, altering the genetic characteristics of plants. Additionally, agricultural practices have modified the natural environments of plants, exerting an impact on their evolution.

Through the primitive selection and utilization of plants and the use of simple techniques, humans have directly driven the process of plant domestication. From initial selection to domestication breeding, this process demonstrates how humans have propelled the further development of agriculture by selectively choosing and improving desirable plant varieties.

Acknowledgements
At the completion of this article, I realized that I was unable to properly cite the references listed at the end of the text in the format required for academic papers, and I deeply regret this. Nevertheless, I would like to express my sincere gratitude to the authors of those references. Their research has provided valuable support and background for this article and has had a significant impact on my thoughts and inspiration. I hold great admiration for their work and am grateful for their contributions to the field of plant breeding. Their efforts have deepened our understanding of the history of plant breeding and provided us with invaluable knowledge.

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