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Crops breeding future: Effective tools towards promising advances

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ABSTRACT

Plants have become recently a concern of major priority in scientific research projects, particularly crops, which could influence directly human beings health. That is why crop breeding is highly interesting, and it is urgently required to achieve more advances in this field. In this paper we put a spotlight on the importance of plants breeding as a key to find out effective solutions for certain problems encountered in agriculture and those threatening human health, and we illustrate some examples of promising tools and novel approaches, which will most probably help to achieve new advances in this field towards less costly, more wholesome and safer crops, especially those that are staple foods in many countries, such as rice and wheat. We underline also some challenges and orientations for a fruitful research in developing plant breeding.

KEYWORDS

Crop breeding;
Molecular biology;
Crop tolerance;
Crop resistance;
Plant domestication.

OVERVIEW

The future of crops breeding represents a major concern for the global food security. Herein, concepts come out as important parameters, including the future methods for crops breeding and crop variety in both botanic and genetic contexts. Plant breeding consists on modifying plant properties in order to obtain crops that fit what is required by human beings, mainly in agriculture field agriculture. The future advances in this field depend mainly on the methodologies chosen to carry out the relevant plants modifications and development.

Plant breeding is becoming more and more important, because it has great applications in many fields, such as agriculture. In modern agriculture, a great problem has been the plant diseases, and this leads to the application of pesticides, which have undesirable effects on both human health and environment, hence the importance of the effectiveness of plant breeding, especially disease-resistance breeding to develop resistant cultivars, and to avoid the drawbacks of pesticides utilization[1]. In fact, several illustrations provide orienting examples about the approaches the scientific community aspires to follow for crops breeding in the future. Yet, genetic approaches remain the main key in this field, and the study of the genes and the possible exploitations of the relevant findings might make further advances.

PROMISING TOOLS FOR CROPS BREEDING IMPROVEMENT

Modern plant domestication programmes start with the identification of key genes in crops breeding[2]. This implicates the application of advanced tools and novel approaches, such as genomic DNA enrichment using sequence capture microarrays[3], which would allow a more precise identification of the divers genomic sequences. Moreover, the new intragenic approach to genetic engineering eliminates unwanted features and activates dormant traits, which improves existing varieties, and this approach is highly promising since it was introduced as the first method that avoids the transfer of unknown or foreign DNA, hence its relative safety[4].

Moreover, the combination of complementary methods might further assist these methodologies, and indeed, divers theories that converge on this issue have been pointed recently. For example, the assessment of the quality of quantitative trait loci parameters in association with gene mapping processes could benefit from the cross-validation[5], and the dissection of the genetic and physiological basis of complex traits present in wild germplasm is worth exploiting for wheat breeding as illustration[6].

These advances have led to new theories and potential applications in crops breeding, such as marker-assisted selection in breeding wheat varieties with high yield[7]. In addition, we find it also important to mention herein the androgenesis, which is useful for plant breeding since it significantly reduces breeding cycle times[8], and this could provide more yield within a short period of time. Moreover, improving crop resistance and tolerance to different phenomena has been a challenging problem in agriculture, for instance, drought, which limits crops production and yield[9], thus the need for both genetic engineering and breeding of drought-resistant crops[10], and we mention here the example of identifying targets for improved drought-tolerance of the Miscanthus bioenergy crop[11]. Importantly, other examples of improving crop tolerance and its applications clarify further this concept. The breeding of salt-tolerant glycophytic crops has been discussed[12], and for crosstalk between stress responses, calcium-dependent protein kinases have been investigated for their involvement in three abiotic stress signaling pathways[13]. All these examples could provide starting data to further develop stress resistance in crops.

On the other hand, plant breeding could also play an important role to increase or decrease the concentration of quantitatively desirable or undesirable trace elements, such as cadmium[14]. Selection programs have been established and developed for a low-cadmium content for many crops, including those representing staple food in many countries, such as durum wheat, and this is very important since it helps to reduce the risk of movement of cadmium into the human diet[14], especially if these advances would apply for all interestingly targeted trace element and focus more on crops that represent staple foods.

Furthermore, there are other newly emerging illustrations for the use of informatics and statistics tools. For instance, connecting basic research and crop breeding can be achieved by databases, like systematic consolidation of Arabidopsis and other botanical resources, that can contribute towards the improvement of important crop breeds[15] by creating bridges between the different databases and the related molecular approaches.

Based on the variability of genotype, phenotype and the related properties within plants, which represent the crop diversity, the development of novel methods and approaches in plant breeding will surely influence the approach and concept of how the future crop variety would be. We would have improved regeneration and transformation protocols for divers crops, such as the three strawberry cultivars[16]. Importantly, other fields related to plant usage would also benefit from the development in plant breeding field, since plants represent primary materials for numerous applications, including natural medicines, such as traditional Chinese herbal medicines[17-20] and chemical applications[21,22].

CHALLENGES AND EXPECTATIONS

Although the great advances reached in this field, many challenges remain, and this may constitute pivotal inflection points towards further development and progress in this field. In the following passages we put a spotlight on some of the encountered challenges.

Plant breeding has an important role in increasing the yields and producing ameliorated cultivars, and germplasm banks have helped the preservation of biodiversity, but although this development, there still some challenges like legal protection of intellectual property and reduced germplasm sharing, which would have limit in effect on biodiversity creation[23].

For a long time nutritional quality of vegetables, which is affected by several steps in the food chain, has not been thoroughly investigated, since the effects of these different steps are usually studied separately[24]. That is why it has been proposed recently to make a combination of food technology and plant breeding through using food technological parameters as breeding traits in order to identify genetic loci associated with food processing[24], and mechanistic studies of glucosinolate losses during cooking have been conducted in this regard[24].

Another problem that is worth mentioning is the potential unsafe quantitative ingestion of naturally occurring secondary metabolites of food plants, and some of them, such as glycoalkaloids in potatoes and phytohemaglutinin in red kidney beans, have been causally associated with acute human toxicity if they were ingested through not properly processed or prepared foods[25]. Crops breeding might be very useful in developing crop cultivars low in such inherent toxicants[25], however, it has also to be able to make a balance between increasing the production of plant secondary metabolites with beneficial effects, and suppressing of those with harmful effects.

Furthermore, although genetically modified plants have been widely exploited, there still some limits to challenge, and this lately triggered the evolution of targeted mutagenesis and DNA insertion techniques based on tailor-made site-directed nucleases, which might allow to overcome struggles encountered in this field, but there still a need to find out effective solutions for the problems facing commercial plants breeding, such as certain technical limitations and significant uncertainties on tailor-made site-directed nucleases regulatory status[26].

Another challenge is the urgent need for further investigations to develop ozone-resistant crop cultivars in order to avoid high-ozone environment undesirable impact on agricultural yield[27]. Thus, the importance of focusing on the development of plant breeding methods that moderate plants resistance to ozone, and indeed, some investigations have been conducted recently in this regard on winter wheat cultivars[27].

It is also urgent to make more in-deep investigations for a clearer understanding of plant-microbe interactions mechanisms, such approaches would helpfully lead to more effective development of disease-resistant crop cultivars through the integration of plant breeding and plant pathology[1].

The development of new plants breeding techniques would remain difficult to realize as long as the regulatory approaches for groups of plants breeding techniques vary between different countries[28]. Hence, it is of vital importance that different countries collaborate in this field to avoid lack of global consistency, disharmony in regulatory approaches and asynchronous development in this field[28]. Otherwise, it would be difficult to avoid this global development disharmony slowing effect on the wheel of plant breeding development, for which an urgent progress is highly required, especially for crops that are staple foods such as rice, which represent almost daily main part of meals for millions of resource-poor farmers[29], who are themselves the main workforce for agriculture. We finally emphasize on the great importance of focusing more deeply on plant breeding development, taking into consideration all the relevant parameters in order to achieve fruitful advances.

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