Engineering 4 (2018) 431–432

Contents lists available at ScienceDirect

Engineering

journal homepage: www.elsevier.com/locate/eng

Editorial

Genetic Crop Improvement: A Guarantee for Sustainable Agricultural Production

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Crop production provides food, feed, and other nutrients that support our everyday lives. Cereal crops, which include wheat (*Triticum aestivum*), rice (*Oryza sativa*), maize (*Zea mays*), barley (*Hordeum vulgare*), millet (*Setaria* spp.), sorghum (*Sorghum bicolor*), rye (*Secale cereale*), oats (*Avena sativa*), and so forth, are the most important source of food for human consumption [1]. In 2017–2018, the global production of cereals was about 2613.5 million tonnes and the utilization was 2593.2 million tonnes; the utilization for food and feed accounted for 43.1% and 35.0%, respectively [2]. Although soybean (*Glycine max*), rapeseed (*Brassica napus*), sunflower (*Helianthus annuus*), and peanut (*Arachis hypogaea*) are traditionally the most important oil crops, it has been demonstrated that non-classic oilseed plants such as oil palm (*Elaeis guineensis*) have potential as new oil crops.

Science and technology can contribute significantly to food security. A new "Greener Revolution," which includes crop improvement, environmentally friendly approaches for crop protection, and efficient use of water and fertilizers, is needed [3]. The genetic improvement of crops promotes sustainable crop production; thus, the development of new crop cultivars constitutes a major objective in breeding programs. Genetic gains are the benefits from crop breeding. For example, wheat yield increased at a rate of 26 $kg{\cdot}hm^{-2}$ per annum during the period 1901–2014 in New South Wales, Australia [4], and increased by 57.5 $kg{\cdot}hm^{-2}$ per annum during the period 1950–2012 in the major wheat-producing regions of China [5]. However, crop yields are constantly challenged by different biotic and abiotic stresses [6,7], and this situation can be worsened by climate change. The occurrence of certain diseases has expanded. For example, *Fusarium* head blight in wheat, which was regarded as the most devastating fungal wheat disease in southern China, but which rarely occurred in northern China, has now spread to the north and become one of the most serious threats in the Huang-Huai River Basin Winter Wheat Zone, the largest wheat-producing regions of the country. The objectives of crop genetic improvement must be to solve these emerging problems in addition to maintaining yield and quality. New techniques in crop genetics and breeding, such as molecular breeding, genomics approaches, and gene editing, are being used to improve the efficiency of crop breeding.

The guest editor team is grateful to the Chinese Academy of Engineering (CAE) for organizing this special issue of *Engineering*. We also express our thanks to all the authors for their contributions and to all the reviewers and editors for their reviews and editorial works. This special issue includes seven review papers that address the current status of crop genetics and breeding.

Plant breeding has been revolutionized with the development of biotechnologies such as genomics and molecular breeding. However, the successful examples that have been achieved in multinational corporations cannot be imitated by small- or medium-scale breeding programs due to several significant constraints. The Consultative Group on International Agricultural Research (CGIAR) Excellence in Breeding Platform, which is part of the new CGIAR Portfolio 2017–2022 of Research Programs and Platforms, was developed for staple crop- and animal-breeding programs of the developing world, and gives small breeding operations around the world access to modern genotyping, bioinformatics, and phenotyping tools. It also provides a series of training programs in key areas of research need.

Enhancing genetic gain depends on both continuously increasing genetic potential and narrowing the gap between genetic potential and the actual yield that is achieved [8]; the latter is largely addressed by improving biotic and abiotic stress tolerance. The challenge of biotic stresses comes not only from airborne fungi such as *Blumeria graminis* f. sp. *tritici* (the causal agent of wheat powdery mildew), but also from a class of soil-borne pathogens that invade crop roots. Three review papers on this topic are provided in this special issue, with one addressing airborne and two addressing soil-borne diseases. Using powdery mildew resistance as an example, a group of scientists from Sichuan Agricultural University, China, demonstrate the potential of *Pm40* as an additional gene to replace the traditional *Pm21* for developing sustainable disease-resistant cultivars. As qualitatively inherited genes will lose their resistance after being used in agriculture over a period of time, it is important to identify new resistance genes in order to continuously provide resistance genes to replace ineffective genes. Regarding soil-borne diseases, Drs. Yan and

https://doi.org/10.1016/j.eng.2018.07.019
2095-8099/

Baidoo from North Dakota State University, USA, summarize the improvements that have been made in resistance to soybean cyst nematode (*Heterodera glycines*) through breeding. They provide an example of how the molecular biology of pathogens and related studies can be used to expedite conventional breeding programs. A group of scientists from the University of Alberta, Canada, review the occurrence and control measures of root rot, a soil-borne disease in field pea that is caused by *Aphanomyces euteiches*, and that presents a significant threat to Canadian field pea production.

Global climate change caused by greenhouse gas emissions has largely contributed to adverse changes in temperature and precipitation. One significant impact on crop production that is caused by global warming—drought stress—may result in a significant loss of yield for many crops. Developing crops that are adapted to the changing climate is an important task for crop geneticists and breeders. The paper contributed to this special issue by Dr. Nazim Ud Dowla and his colleagues from Australia reports on the adaption of wheat to drought stress by altering the key genes that control vernalization (*Vrn*), photoperiod (*Ppd*), and dwarfing (*Rht*) traits.

To meet the demands of the increasing global population while protecting natural environments, it is critical to develop high-yielding and environmentally friendly crops, including those with improved traits, new crop types, or new products. New crop species, types, and products can be created through the development of synthetic crop species or crops with significantly changed production modes, such as a change from annual to perennial [9]. Three review papers published in this special issue provide examples of such efforts in plant breeding. A paper by scientists from China and the United States reports on the development of perennial wheat, which has long been an objective of several breeding programs in different countries. This article summarizes the production and potential application of perennial wheat via crossing wheat with perennial wheatgrasses. A review provided by a joint group of scientists from China and the International Maize and Wheat Improvement Center (CIMMYT) summarizes the potential application of synthetic hexaploid wheat in wheat breeding. The newly developed synthetic wheat provides useful genetic resources that are needed for wheat improvement. A paper by a group of scientists from the Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia, reports on the genetic manipulation of non-classic oilseed plants to enhance their potential as a biofactory for the production of triacylglycerol as the dominant form of vegetable oil. The authors summarize current genetic engineering strategies to increase triacylglycerol accumulation in plants.

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