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Breeding for Quality Traits and its Contribution for the Improvement of Field Crops

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Abstract

Plant breeding started thousands of years ago when People initiated selection of crops to obtain vital beneficial characteristics from their wild types during domestication. Ensuring healthy diets for an expected global population of nearly 10 billion people in 2050, while at the same time improving the world those people live in, will require sweeping changes to farming and how we produce food, according to a new report. Among them breeding for quality traits has main share. Increased crop production without increasing the amount of land used for crop production is the key to feeding world population. The amount of crop harvests needs to be increased from year to year both in quality and quantity.In conventional plant breeding technique the rate of yield increment is insufficient to cope with the increased food demand caused by a rapidly growing world population and genetic gains of quantitative traits have not been effective as they are largely affected by genotype by environment (G × E) interaction. One possible way of solving food scarcity problems is to develop improved plant varieties rapidly. Therefore to make breeding programs more effective and efficient other branches of biology (modern breeding tools) are being integrated into it. Since both conventional and modern plant breeding is essential in crop plant improvement for quality traits; here we highlighted some the role of plant breeding in quality trait improvement.

Introduction

The world population is rapidly increasing and expected to be 10 billion by 2050 (www.un.org/development/desa/en/news/population/world,2017). More agricultural output is required to ensure human nutrition and health in light of the world's fast population expansion.This enforces plant breeders to introduce newand improved crop plants in to their breeding programs following their target environment. Since the early 1900s, plant breeding has played a fundamental role in ensuring food security and safety and has had a profound impact on food production all over the world [1]. In recent years, however, problems related to food quality and quantity globally have arisen as a consequence of the excessive food requirement for the rapidly increasing human population. Plant breeding can be used to develop plants with desired traits [2]. Genetic improvement of crop plants is a key to increase yield, develop varieties for stress tolerance and quality trait improvement. Among them breeding for quality trait improvement is the main component that contributes to nutritional and food security. Quality differs from crop to crop and refers to fitness of the economic plant product in relation to its end use. In general, crop quality is determined

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by external and internal traits. The external qualityattributes include physical and aesthetic characteristics, such as size, color, texture, andfragrance. In contrast, the internal quality factors include nutrients (like protein, starch, lipids etc.) and bioactive compounds (such as carotenoids, lycopene, aminobutyric acid, flavonoid and so on).

Various strategies have been successfully applied to improve various crop traits, including conventional crossing breeding, chemical and radiation mediated mutation breeding, molecular marker-assisted breeding and genetic engineering breeding [3]. However, the conventional plant breeding processes is time consuming and laborious, especially for polyploidy crop breeding [4]. In modern plant breeding, Genome Editing (GE) technology which modifies plant genomes in a precise and predictable way is showing distinct advantages in crop breeding. Crop improvement using both conventional and modern breeding technique has contributed significantly. Among the various target traits for crop improvement, crop quality is one of the highest objectives. Since the development of new crop varieties goes with the preference of the consumers; quality improvement of crop plant has risen and being done by researchers and breeders over the past few years. Here, we summarized some of the contribution of plant breeding for quality traits improvement on different crop plants.

Quality breeding

People of different age groups (Children of pre-school age, adolescent women and reproductive women) are suffering from micronutrient deficiency health related conditions (Bouis *et al*, 2020). Nutrient deficiency problem can be solved through producing and providing nutrient rich foods sources. This can be achieved through quality breeding. Quality of produce is an important objective in plant breeding. Applying breeding technique in quality traits improvement is called quality breeding. Quality is the fitness of products for its use whereas quality traits are traits that define some aspect of product quality in crop plants. The quality characters vary from crop to crop. For instance grain size, color, milling and baking quality in wheat. Cooking quality in rice, malting quality in barley, colour and size of fruits, nutritive and keeping quality in vegetables, protein content in pulses, oil content in oilseeds, fibre length, strength and fineness in cotton. Quality traits can be classified into organoleptic, nutritional, morphological, biological and others. Different quality traits like pro-vitamin A and minerals (Fe, Zn, Ca, and Mg) wich are deficient in human diet affects the cognitive development, reduces disease resistance in children and the mothers survival at childbirth [5]. Children in different parts of the world suffer from stunting and underweight due to malnutrition wich results in reduced mental development [6].

Objectives in breeding crop plants for quality traits

Breeding for quality traits depends on the preferences of the end users or consumer needs and stalk holders [7]. Some of the objectives in crop plant improvement for quality traits improvement by exploitation of genetic variability are the following.

- ❖ Genetic manipulation of biosynthesis of chemical components in edible crop plants.
- ❖ Improving crop physical appearance for the economic crop plant parts through the modification of color, shape and size.
- ❖ Prolonging shelf life by improving crop texture quality.
- ❖ Improving palatability of crop plants-like flavor, eating and cooking quality.
- ❖ Improving for nutrient elements and micronutrients like increasing carotenoid content, protein content, improving for fatty acid composition and reduction of anti-quality factor.

Breeding methods in improving crop plants for quality traits

Plant breeding is a process in which; specific heritable changes are induced in plants through human efforts and breeding methods for quality traits is not differ from breeding for other quantitative traits [8].

Conventional breeding in improving crop plants for quality traits

The general approach of conventional breeding is to combine certain traits from two parents into one off spring. It is selective breeding methodology when plants are selected for their superior performance on selected traits without violating the law of inheritance. The required traits obtained from closely related plants and incorporated into new cultivars using hybridization technique [9].Then selection based on phenotype is done to identify the most important genotype and the selected candidates are evaluated and then released as new varieties. The advantage of conventional plant breeding is that you don't need to know which gene variations influence which traits and its disadvantages are that it can take a lot of time (often many years) and effort, and it may not produce the desired result.

Modern plant breeding techniques in improving crop plants for quality traits.

The world is expected to grow by 25% geometrically, yet food supplies both in quality and quantity is still limited [10]. Traditional or conventional breeding methods will not be sufficient to meet the demands of future generations, hence, breeders and cultivators are constantly under pressure to improve crop production and develop new varieties of crops that are of higher quality and yield higher yields that should be of superior quality in every respect, including nutritional value, disease resistance, and climatic changes. Despite the fact that it is necessary to use both conventional and contemporary breeding techniques to feed the growing global population.Modern plant breeding consists of genomics, phenomics and enviromics [11]. Among the modern breeding tools genomic selection, marker assisted selection, transgenic technology, High Throughput Phenotyping (HTP) and gene editing through CRISPR/Cas9, TALEN, and ZFN are some of the important and widely used in crop plant improvement for various quality traits.

Marker assisted selection: If you know which gene(s) underlie the trait you want to introduce into your crop, you can use marker-assisted breeding (also called molecular breeding).

Transgenic technology: Is much more precise than either traditional or marker-assisted breeding. It can be used to insert just the gene that you're interested in while leaving all of the rest of the plant's genes intact. However, it does require a thorough up-front understanding of the gene that is being transferred, as well as testing of the product to ensure that it is functioning as intended.

Genome editing: mostly done through CRISPR/Cas9, TALEN, and ZFN. It is a technique for rewriting individual letters of an organism's DNA code. It is the most precise of all the crop improvement methods. Moreover, after a plant's sequence is rewritten, it is indistinguishable from a plant that has been modified through traditional breeding—because the technique leaves behind no foreign DNA.

Contribution of plant breeding for quality trait improvement in crop plants

A-gliadin in the gluten protein of wheat wich can cause some celial and non-celial disease in human was reduced using CRISPR/cas 9 by knocking out α-gliadin genes [12]. According to Zhang *et al*. (2018) the total wheat protein content and grain weight were improved using CRISPR/Cas 9 by knocking out genes that encode Ubiquoting ligase that regulates the cell number of spikelet hulls. Very long chain fatty acid wich is undesirable for consumption and industrial use in camelina sativa was reduced by deactivating agene wich encodes for fatty acid elongase1 using CRISPR/Cas 9 [13]. This method can also be used in rapeseed, Ethiopian mustard and Soyabean in developing higher content of Oleic acid and lower contents of linoleic acid and erucic. Ripening and shelf life problem due to their perishability in horticultural crop can also be resolved by gene editing [14].

Different horticultural crops were benefited from newly emerging discipline called phonemics [15]. Non- bitter allele fixed in water melon by genome sequencing [16]. Cucumber was characterized and improved for fruit bitterness by large scale phenotyping and genetic mapping [17]. Brassica species were also characterized for carotenoids, ascorbic acid, phenolics and glucosinlate through genetic and metabolomic analysis. Integrated approaches of biochemical, biological and molecular methods were also used in improving tomato for nutritional quality through the exogenous application of 5-Aminolevunilic acid and Melatonin [18]. Legume crops like soybean, fababean and lupine which are adapted to different environmental condition and rich sources of protein are challenged from the accumulation of pyrimidine glucosides, vicine and convinewhich cause hemolytic anemia (favism) in individuals deficient in glucose6-phosphate dehydrogenase. To alleviate this problem low vicine and convicine fababean varieties were developed [19]. Lupine an important legume crop which has high protein levels do also have ant nutritional factors called alkaloids that produced in different tissue and transported to seeds. Blocking the transport of toxic alkaloids to the seeds by different breeding techniques like transport engineering can help in producing non-toxic protein rich lupinevarieties [20].

Another attractive source of protein is oil rapeseed with a balanced amino acid grown for oil and protein but not for feed due to anti nutritional factors, heavy metals and toxic metabolites Malahal *et al*. (2003) reported the breeding effort that resulted in improved rapeseed for antinutritional factors resulted in low glucosinolate content.A transgenic approach was also used in improving crop plants for micronutrient quality. The level of different micronutrients, minerals and vitamins were increased in different crop plants through transgenic approach. Rice plant was improved for provitamin A (β-Carotene) [21]. Whereas rapeseed, flax, tomato, soya bean, maize, rapeseed and lattuce were improved for vitamin-E-content by the over expression of individual genes or the biosynthetic pathway [22]. Plant varieties with EPA and DHA were also developed using modern breeding tools. Camelina sativa an oil crop of brass icaceae family was improved for omega-3-PUFAS production by the introduction of genes coding for proteins necessary for EPA and DHA synthesis from marine micro organisms through transgenic approach [23]. EPHA and DHA are fatty acids produced in wild and farmed fishes but not in plants.

It is also possible to improve lupin for alkaloid, cassava for cynogenic glycosides and rapeseed and brassica carinata and rapeseed by increasing their degradation, targeting their biosynthesis and reducing their transport in to the edible plant parts. Provitamin A- rich orange- sweet potato, orange maize and yellow cassava were also developed using conventional plant breeding approach [24].

Conclusion

The science of plant breeding has been contribute for improving the nutritional quality of produce by incorporating quality traits in to breeding program and developing crop varieties rich in essential micronutrient, vitamins and proteins. Preserving and conserving genetic diversity of local landraces, wild relatives and traditional crop varieties that posses unique quality traits and utilizing them in breeding programs is vital to improve crop plants for different quality traits. Farmers' livelihoods can be enhanced by improving crop plants for desired traits and empowering farmers by providing them with access to new technologies like crop varieties and information about their appropriate use. Both traditional and modern plant breeding tools can help us to empower farmers and enhancing their livelihoods.

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