ORGANIC WHEAT BREEDING: The Sustainable Solution for Future Bread

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ORGANIC WHEAT BREEDING:

Organic farming has gained significant popularity in recent years, with consumers increasingly demanding organic products. As a result, there is a growing need for plant varieties that are specifically adapted to organic farming practices. However, the mainstream breeding sector primarily focuses on developing varieties for conventional farming, this has led to a scarcity of varieties suitable for the organic sector. This has resulted in, organic wheat breeding programs to develop wheat varieties that meet the specific needs of organic farmers and food processors. Wheat is the 2nd most important staple food crop after rice consumed by 65% of the Indian population and consumption of it is expected to rise further due to changes in dietary preferences. Wheat yield increased in the 1960s, during the Green Revolution, after semi-dwarfing genes were incorporated that were resistant to lodging, early maturing, highly responsive to inorganic fertiliser application and resistant to various diseases for many decades.

The prime goal of organic wheat breeding is to create wheat cultivars that are resistant to pests and diseases, have high yields, and can thrive without the use of synthetic fertilizers, pesticides, or genetically modified organisms (GMOs). Wheat is a self-pollinating crop, and unlike many other plants, it requires little work to recover the mature seeds. Pure line breeding towards homozygous stands is the standard method for breeding wheat for organic systems.

Organic farmers rely on crop rotation, mechanical weed control, and natural fertilizers instead of synthetic chemicals. Organic farmers prioritize traits such as high baking quality, weed suppressiveness, and tolerance to harrowing, which are not adequately addressed by conventional plant breeders. Organic breeding programs aim to produce wheat varieties that are adapted to organic conditions, possess desired traits, and meet the quality standards of the organic sector. By incorporating organic farming practices into the breeding process, organic breeding programs can select for varieties that perform well in organic systems and meet the specific needs of organic farmers and food processors.

Fig 1: Wheat flourishing in organic conditions

TRAITS FOR SELECTION IN ORGANIC BREEDING PROGRAMS:

1. **Breeding for Disease Resistance-** It is essential in organic production systems because organic farming guidelines forbid the majority of chemical treatments. The most prevalent wheat diseases in organic agriculture have been reported to be bunts, smuts, septoria, and fusarium head blight. In organic systems, diseases like rusts and powdery mildew, which are regulated by nitrogen application, planting date, and crop density, are less significant

because they appear in the latter phases of crop growth (Kunts, 1983). In organic agriculture, resistant cultivars/lines should not only be resistant, but their morphological/ phenotypic characteristics should also ensure their resilience in the face of intense disease pressure.

2. **Nutritional Value-** The nutritional value of organic wheat is frequently influenced by various management techniques, mainly environment of soil. Grain micronutrient concentration can also be influenced by soil organic matter, pH, the bioavailability of soil minerals and other factors. Particularly wild species seem to be important genetic resources for characteristics linked to increased nutritional content

3. **Breeding for Early Maturity-** Early crop maturity allows early crop harvest and may also help wheat to avoid certain diseases, heat stress, and drought (Sleper and Poehlman 2006). Early maturing varieties will take significantly less time to complete their life more in organic systems. Vernalization (Vrn) response, photoperiod (Ppd) sensitive, and genes imparting earliness per se govern the growth and the numerous developmental phases of the wheat crop. These three gene systems, as well as their interactions with temperatures during the growth period (Gororo et al., 2001), are crucial for wheat's adaptability and yield potential in a variety of environments, including those with organic management practices.

4. **Weed Suppression and Competition-** Mechanical weed control is mostly followed in organic systems. Therefore, a key characteristic for cultivars employed in organic systems is the capacity to withstand damage and bounce back quickly after mechanical weed treatments (Murphy et al., 2008).

5. **Nitrogen-use Efficiency-** Optimising symbiosis with free-living soil microorganisms like Azospirillum or arbuscular mycorrhizal fungi is one method for developing nitrogen-efficient varieties from populations. Other methods include the ability to outcompete weeds for available nitrogen and the ability to maintain photosynthesis under nitrogen stress (Dawson et al., 2008).

BREEDING APPROACHES:

1. **Sources of genetic diversity-** The fundamental motive of plant breeding is creation and exploitation of genetic diversity. Breeders differentiate between the primary gene pool consisting of elite breeding lines, the secondary gene pool, including landraces or gene bank material, and the tertiary gene pool which consists of related species or wild relatives. For instance, it has been demonstrated that the secondary wheat gene pool can provide novel genetic variability for resistance to drought, high temperatures, salt, waterlogging, and soil micronutrient imbalances in synthetic hexaploid wheat, which is produced by crossing tetraploid wheat with Aegilops tauschi.

2. **Exploiting genetic variation within varieties-** Wheat is a self-pollinating species and homogeneity is a prerequisite for variety release, genetic variation within released wheat varieties is relatively low. The creation of composite cross populations is an

alternate strategy used by Phillips and Wolfe to maintain genetic diversity and evolutionary fitness within varieties. Composite cross populations are created by combining seed stocks with various evolutionary origins and traits, recombining these stocks through cross pollination, bulking F1 offspring, and then propagating the bulked offspring in a series of natural cropping situations. Composite cross populations can be used as a substitute for choosing superior pure lines.

3. **Mass Selection-** In this the plants with superior performance are selected under field conditions and their offspring are advanced, in bulk, to the next generation, is frequently used by plant breeders seeking superior genotypes suitable for organic cultivation (Acquaah, 2007). Plants in self-fertilizing crops like wheat are homozygous at essentially all loci, although heterogeneous at the population level (Allard, 1999).

4. **Bulk Selection-** Bulk selection permits natural selection to exert its effects on segregating populations in the field. To progress the lines, seed is bulked and a random fraction is planted the following generation. Superior lines can be separated and produced as progeny rows in later generations. To minimize the genetic drift, large population sizes must be generated.

5. **Participatory plant breeding-** Participatory plant breeding (PPB) projects were developed in developing nations to serve the needs of small-scale, low-input farmers in remote areas who were not the target market for commercial breeding firms. It includes breeders, farmers, and consumers as well as extension professionals, vendors, industry, and rural cooperatives in plant breeding research. This strategy received more attention in breeding programmes for organic farming systems due to the special need of farmers for varieties

suitable for organic farming and the fact that the small organic market was not always attractive to commercial plant breeders.

6. **Molecular marker selection-** Currently, the use of marker-assisted selection in commercial wheat breeding programmes is still limited and restricted to backcross breeding or the introgression of important genes from non-adapted material and pyramiding of resistance genes. But it is anticipated that the rapid development of new, affordable, high-throughput marker systems and significant advancements in association mapping will enable better coverage of the wheat genome and may improve the ability to identify QTL for oligogenically inherited traits of interest to organic and low-input systems.

THE PROCESS OF ORGANIC WHEAT BREEDING:

Organic wheat breeding is a meticulous and time-consuming process that involves several steps, including:

1. **Selection:** Breeders carefully choose the parent plants with desirable traits, such as disease resistance, high yield, and adaptability to organic farming practices.
2. **Crossing:** Breeders cross-pollinate the selected parent plants to create new combinations of genetic material.

3. **Evaluation:** The resulting progeny are grown under organic conditions and thoroughly evaluated. The plants with the desired traits are selected for further breeding.
4. **Repetition:** This process is repeated over several generations to develop stable and high-performing organic wheat varieties.

CHALLENGES IN ORGANIC WHEAT BREEDING:

There are several challenges that hinder the development of varieties suitable for organic farming. Seed legislation and company economics often limit the flexibility of conventional breeders to modify their breeding programs to prioritize traits desired by the organic sector. Additionally, the long breeding process, which takes a minimum of 10 years to bring a variety to market, further complicates the development of organic varieties. Organic wheat breeding comes with its own set of challenges. As synthetic pesticides and fertilizers are not used in organic farming, breeders need to find alternative ways to combat pests and nutrient deficiencies. Moreover, organic farms face diverse environmental conditions, which means breeders must develop varieties that can withstand various climates and soil types.

FUTURE DIRECTIONS IN ORGANIC WHEAT BREEDING:

As the demand for organic products continues to grow globally, the future of organic wheat breeding looks promising. With advancements in technology and increased research funding, breeders are able to harness the power of genetics to develop superior organic wheat varieties. To further enhance organic wheat breeding programs, future efforts should focus on addressing specific challenges and opportunities. Breeders should prioritize selection for high baking quality genotypes that tolerate organic weed management regimes. This requires a concerted initiative involving all stakeholders in the organic bread production chain, including farmers, breeders, millers, bakers, and consumers. Additionally, advancements in molecular breeding tools can contribute to the development of new organic wheat varieties. Marker Assisted Selection (MAS) can expedite breeding progress by allowing breeders to select for desired traits more efficiently. However, the extent to which molecular breeding tools have been utilized in organic breeding programs and their impact on conventional breeding programs is not well-documented, as this information is often kept confidential by seed companies. Organic wheat breeding programs play a crucial role in meeting the needs of organic farmers and food processors. Collaboration among stakeholders in the organic bread production chain is essential to overcome challenges and ensure the availability of varieties suitable for organic farming. The continued advancement of organic breeding programs will contribute to the growth and sustainability of the organic sector.

CONCLUSION

As organic farming gains momentum, organic wheat breeding will play an integral role in ensuring that farmers have access to high-quality, resilient, and productive wheat varieties. Growing market demand and interest in low-input agriculture for ecological reasons will undoubtedly accelerate attempts to produce organic wheat, which will present a difficult challenge for plant breeders wishing to contribute to this dynamic new system. Successful organic varieties require a different set of essential characteristics than those that are prioritised in conventional breeding programmes. For example, organic varieties have a greater need for weed suppression capacity and nitrogen-use efficiency. The introduction of traits that farmers urgently require in order to optimise their organic farming systems and increase yield stability will also benefit conventional production systems that seek to cut back on the use of agrochemical inputs while enhancing environmental impacts and long-term agricultural sustainability. The adoption of organic farming practices can benefit farmers, consumers, and the environment, and it is the way forward for India's agricultural sector. So, there is a need of hours to adopt this eco-friendly practice which will be with us in the long run without any negative impact on the ecosystem. Therefore, breeding for organic agriculture needs much more funding and attention.