KRISHI ARTICLES
E - PUBLICATION
https://krishiarticles.com/
Volume 1
Issue 2
October, 2026
ISSN: 2839-5794
Popular Article
Article ID: KA-2026-10

Genomic Selection: Accelerating the Future of Crop Improvement

Ankita Mishra, Shalvi Aishwarya Verma* and **Digbijaya Swain**

Department of Plant Breeding and Genetics, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

**Corresponding author: shalvi.verma9823@gmail.com*

Abstract

The growing need for higher agricultural productivity under the impact of climate change, resource scarcity and changing environments calls for faster and more efficient crop improvement methods. Genomic selection (GS) is a type of breeding which employs the knowledge about the genome to predict the breeding value of an individual based on molecular markers and genomic estimated breeding value (GEBV). With the help of GS, breeding cycles become faster and phenotyping becomes more efficient because no extensive phenotyping is needed in order to select individuals with high breeding value. In addition, it allows selecting individuals with the most desirable properties, such as yield, drought tolerance, nutrient-use efficiency and quality. In some cases, GS can be used to create climate-adaptive crops by combining the information about genome and multi-environmental phenotypes. Nevertheless, the success of GS is largely dependent on such factors as the quality of training population, accuracy of phenotypes, marker density, prediction models, genetic relatedness and genotype × environment interactions. GS is not meant to substitute for conventional plant breeding, but it helps to supplement other technologies such as marker assisted selection, speed breeding, doubled haploid breeding and genome editing.

Introduction

The task of feeding an expanding population within the context of climate change, depletion of natural resources and competition for agricultural lands is one of the biggest challenges in modern-day agriculture. New crop varieties should not only be more productive but also more resilient to changes in climate, efficient in nutrient use and adaptive to new environments. The development of a new crop variety via traditional methods of breeding takes a very long time. Genomic

Cite this article as:
Mishra, A., Verma, S. A., & Swain, D. (2026). Genomic selection: Accelerating the future of crop improvement. Krishi Articles, 1(2), 18–22.

selection is becoming a new, highly effective way to speed up this process. Rather than wait until a plant grows and choose it based on its performance, genomic selection involves the use of the information encoded in its genome in order to assess its future breeding value. Conventional plant breeding mainly involves phenotypic selection. Thousands of plants are grown and phenotypes such as yield, maturity, height, disease resistance, drought resistance or quality, among others, are evaluated and the best individuals are selected for further breeding. This technique has been very successful and forms the core of modern crop improvement. But there are many valuable traits that are governed by hundreds and sometimes even thousands of genes with small contributions from each. Such complex traits are grain yield, drought resistance, nutrient use efficiency and a number of quality traits. Their manifestation is also greatly affected by the environment. Plants that show excellent performance in certain locations or at certain seasons may not show the same performance under other conditions. Genomic selection takes a wider approach using genome-wide molecular markers to assess the genetic value of breeding individuals.

How Does Genomic Selection Work?

It is a specialized form of marker-assisted selection (MAS), in which information from genotype data on marker alleles covering the entire genome forms the basis of selection. This technique uses the information collected from genome-wide DNA and phenotype data of the plants to predict the breeding value of the plants. To begin with, a training population needs to be formed. The training population involves a representative set of plants and their important traits such as grain yield, plant height, maturity, drought tolerance, disease resistance or nutrient-use efficiency are evaluated. In addition, genotyping of the individuals is carried out through the use of many molecular markers found in the entire genome. The most commonly used molecular marker is Single Nucleotide Polymorphism markers (SNP). With the help of the information collected from the training population, a statistical prediction model is developed. The model will understand how genome-wide marker information predicts the overall performance of the plants. There are different statistical approaches that can be used depending on the breeding objective and type of data available to form the prediction model.

Once the prediction model is developed, a new set of breeding individuals will be genotyped using the same set of SNPs at an young stage without going through the field evaluations and their genomic data from all over the genome will be incorporated in the prediction model which will generate an output called genomic estimated breeding value (GEBV) for each individual. The

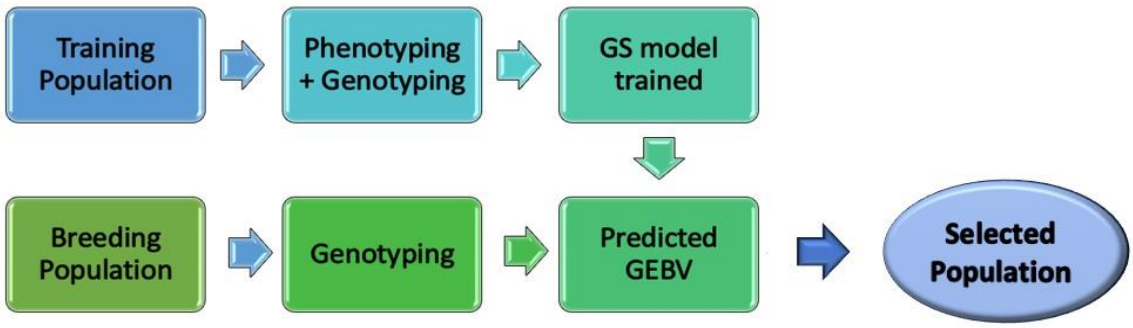


Figure 1: Schematic diagram representing workflow of genomic selection

plants in the population will be ranked in the descending order of their GEBV output. The individuals having high GEBVs will be selected as potential parents or further advanced.

Genomic selection is not an approach that will do away with the role of the traditional plant breeder. Genomic selection would only extend and enhance the role of traditional and marker-assisted selection. Knowledge of the breeder is required when selecting parents, breeding designs, objectives and validating the performance of plants that have been predicted. The breeder of the future may very well find himself or herself working at the interface of field biology, genomics, statistics, computing and artificial intelligence. As data on genomics, phenotypes and the environment become more readily available, breeding may become even more data driven.

One of the main benefits of using genomic selection technology is that it is possible to select plants at an earlier stage of their development. As a result, breeders do not have to grow and evaluate all plants since the process can be based on genomic information. It is important to note that genomic selection does not mean that there is no need for phenotyping anymore. The use of reliable phenotypic information is critical for developing the prediction model and field evaluation is required to check the results of breeding lines selection. In other words, GS is a decision-support technology based on molecular data, phenotypic evaluation, and prediction modelling.

Genomic Selection versus Marker-Assisted Selection

There is some similarity between genomic selection and marker-assisted selection (MAS). However, there are certain differences between these two techniques. The use of MAS typically involves several markers that are linked to certain genes or major QTLs. Genomic selection utilizes the data obtained from markers that are spread across the whole genome. As against MAS where one may ask whether or not the plant has this particular gene, in GS, the question that arises is how good this plant is as a potential parent/breeding line based on the information about the entire genome.

Advantages of genomic selection

1. **Faster breeding cycles:** By picking up promising individuals early on, GS can shorten the duration between generations. More generations of selection within a period may increase the speed of genetic gains.

2. **Complex trait selection:** Information across the whole genome can account for multiple regions and thus become useful for breeding for yield, drought resistance and nutrient uptake efficiency.

3. **Early selection:** Seedlings can be genotyped and ordered according to their breeding value. Less successful individuals can be weeded out early and the best ones selected.

4. **Phenotyping made easier:** Phenotyping is still necessary, but GS can assist breeders in making phenotyping more efficient through reducing the number of individuals to phenotype.

5. **More rational use of breeding materials:** Breeding programs produce numerous varieties. GS offers a tool for selecting individuals for further work.

Genomic Selection for Climate-Resilient Agriculture

Climate change is increasing the need for crop varieties that can maintain productivity under

drought, heat, flooding, salinity and nutrient stresses. In many cases, such characteristics are quite complex and significantly influenced by environment. Using genomic selection allows breeders to integrate the use of the whole genome information along with the information obtained from different environments. For instance, the prediction model based on the analysis of yield and drought resistance data from different regions can be used to select new high-performing breeds under water stress. Hence, GS can become an integral part of climate-smart breeding.

Applications in Major Crops

Genomic selection has applications in different crop plants such as rice, wheat, maize, barley and soybeans. In rice, breeders have been developing rice plants that are high-yielding, good quality, mature fast and are resistant to drought, salinity, submergence, heat and diseases. It may be difficult to test all members of large populations. Here, GS technology can be used to select the best members for testing. This technology can be used to complement other modern breeding techniques like marker-assisted selection, speed breeding, doubled haploid technology and gene editing. Instead of making these techniques redundant, GS technology can complement them.

Challenges and Limitations

GS is a strong tool, but it is not the perfect remedy either. Its efficiency hinges on such factors as the composition of the training population, accuracy of the phenotype assessment, information about the markers, prediction models and the genetic distance between the training and target populations. High level of technology, capacity to handle voluminous amount of data and professional skills of people working with such technologies are required.

Genotype by environment interaction is another problem to be solved in breeding through genomic selection. A particular genotype can behave differently in different environments; therefore, testing at multiple locations and knowledge about the environment still matter.

Perhaps the most crucial aspect of GS is that it does not reduce the importance of field-testing. It can be used as a decision-making tool.

Future prospects

Agriculture must now produce more output using less input, while adapting to an ever-changing climatic environment. Classical breeding methods will still be a vital part of the process, but genomic technology will help make the process more efficient. The future of plant breeding is dependent on the application of CRISPR gene editing, speed breeding and genomic selection. Artificial Intelligence, drones, UAV, high throughput phenotyping and weather will allow for efficient and accurate selection. More complex GS models that factor in inbreeding depression and epistasis may help enhance the prediction accuracy of the process, resulting in more productive and resilient crops. Genomic selection has changed the concept of breeding from choosing plants based on their observed characteristics to predicting the genetics of plants based on their genome.

As genotyping becomes cheaper, phenotyping becomes more accurate and computing power more advanced, GS is likely to be used in crop breeding more often. The endgame, however, is not the production of ever larger quantities of genomics data. It is the use of genetics in more rapid and informed breeding decisions. From seed to sequence and from sequence to improved variety, genomic selection is making breeding more efficient.

References

Bhanu, A. N., Vaibhav, B., Yasin, M., & Singh, S. (2026). Climate-Resilient Crop Improvement Through AI Technologies. *Crop Improvement with Artificial Intelligence: Methods and Applications*, 263-305.

Debnath, S., Devi, K., & Meetei, N. T. (2025). Genome Wide Selection for Accelerating the Efficiency of Molecular Breeding for Crop Improvement. In *Plant Breeding Technology: Future Trends and Challenges* (pp. 84-104). GB: CABI.

Manoj, M., Malarvizhi, M., Singh, S. S., Aiswarya, K., Thirumurugan, T., Sivaranjini, A., ... & Anand, A. V. (2026). Digital Plant Phenomics: Next-Generation Plant Phenotyping Based on Artificial Intelligence. In *AI in Plant Science and Precision Agriculture* (pp. 72-94). CRC Press.

Mapari, A. R., & Mehandi, S. (2024). Enhancing crop resilience: Advances and challenges in marker-assisted selection for disease resistance. *J. Adv. Biol. Biotechnol*, *27*(7), 569-580.

Saxena, R., Kumar, M., Tomar, R. S., Yadav, N., Kaur, N., Puri, P., ... & Yadav, A. N. (2026). Genome editing: A new age technology for sustainable agriculture and developing abiotic stress resilience in crops. *Journal of Applied Biology & Biotechnology (JABB)*, *14*(2), 12.

Wang, Y., Tang, Q., Pu, L., Zhang, H., & Li, X. (2022). CRISPR-Cas technology opens a new era for the creation of novel maize germplasms. *Frontiers in Plant Science*, *13*, 1049803.