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Digitalizing Plant Breeding: Using Big Data to Improve Plant Breeding Programmes

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Introduction

Plant breeders have effectively incorporated the most recent scientific and technological advancements to boost crop output and quality along this extensive journey alongside humans. Since the completion of the human genome sequencing two decades ago, genomic tools and sequencing technology have developed significantly. By incorporating these developments, we have been able to reduce costs and/or speed up the plant breeding process. The success of the labor-intensive sciences of plant breeding is essential to addressing the global concerns of ensuring the security of food and water for the world's expanding population. Agricultural scientists are implementing recent advances in sensor technology, remote sensing, robotics and autonomy, "big data analytics", and genomics for high-throughput phenoltyping, precision agriculture, and crop-scouting platforms. The advent of digital agriculture brought forth by these technical advances should substantially improve the abilities of plant breeders. With the growing amount of genomic data and digitalized biological data available today, interdisciplinary approaches utilising cutting-edge technologies may result in a new paradigm for plant breeding.

Big Data: Its nature and significance

Big data refers to the enormous, difficult-to-manage volumes of data that exist every day in both structured and unstructured forms. It refers to data that is too big, moving too quickly, or complex to process using conventional techniques (Figure 1). Big data keeps a lot of information on hand and is accessible for a very long time (Shakoor et al., 2019).

What makes big data so crucial?

Big data is important since it allows for large-scale usage of data rather than just focusing on how much data you have. By analysing data from any source, it is possible to expedite resource management, increase operational effectiveness, optimise product

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development, create new chances for income and growth, and facilitate wise decision-making. Big data is helping to meet the demand for food, optimise the use of pesticides, control farm equipment, solve supply chain issues, anticipate yields, predict climate conditions, and enable weather forecasting by satellites and other devices on the ground and in the air. The installed machinery and sensors assist in analysing various soil types and soil fertility levels to forecast the consumption of fertilisers and seeds. By integrating information such as weather patterns, soil types, and market opportunities, plant breeders may maximise resource utilisation and boost crop yield.

The significance of big data in agriculture:

Among other things, big data made the technological revolution currently taking place in the agricultural industry feasible. Big data collection and analysis can assist stop a global food catastrophe in addition to increasing farm output on an individual level. This is significant since there is an increasing need to produce more food on less land. Policymakers and business executives use technical advancements like big data, IoT, analytics, and cloud computing to help them achieve this goal (Kamilaris et al., 2017).

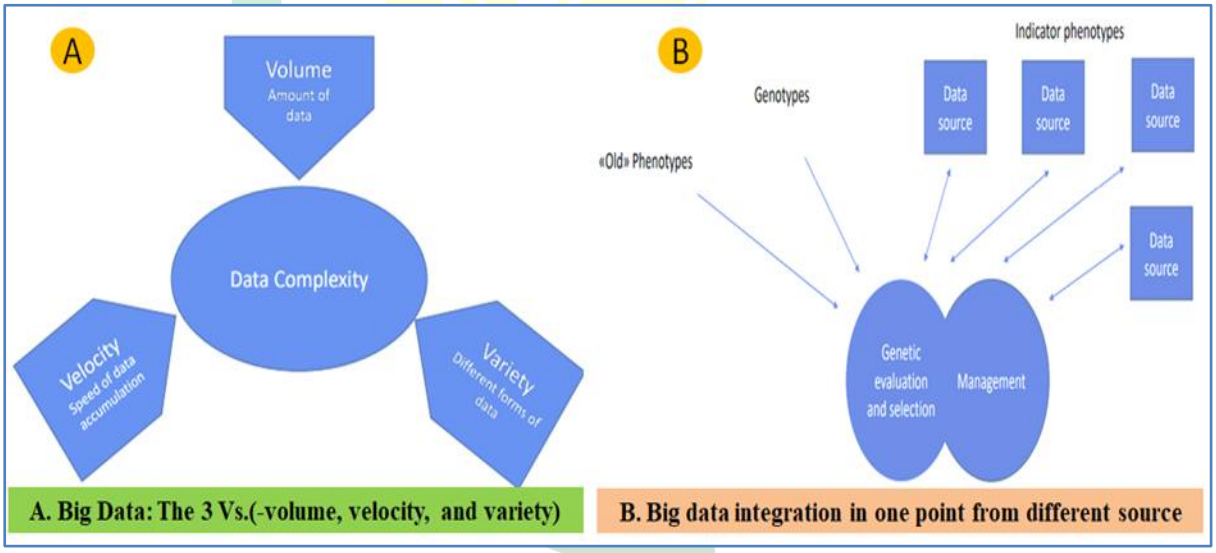

Figure 1: A Big data is high-volume, high-velocity and/or high variety information assets that demand cost-effective, innovative forms of information processing that enable enhanced insight, decision making, and process automation.

B. By big data assessing platforms or pipelines we can assess all data at a time by gathering from different sources without reduction in original data; it is simplistic and efficient way to plant breeders and agronomist for managing the crop data.

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Big Data: Practical utility in plant breeding

Plant breeding could be revolutionised by combining phenomic and genomic data. Field-based single plant phenotyping within the first generations has been an understudied aspect of the best integration of these two fields. Plant breeders may be able to select and advance populations during early generations thanks to high-throughput examination of individual plants, which could speed up genetic progress and improve the use of breeding resources. In plant breeding the amount of data are increasing exponentially, this for many reasons. Not only thousands of candidate verities are tested every season they are also characterized in greater detail incorporating more phenotyping information from different sources. In addition large-scale data are generated with molecular markers. Professional breeders see themselves confronted with large data sets (Sun et al., 2013; Howard, 2019).

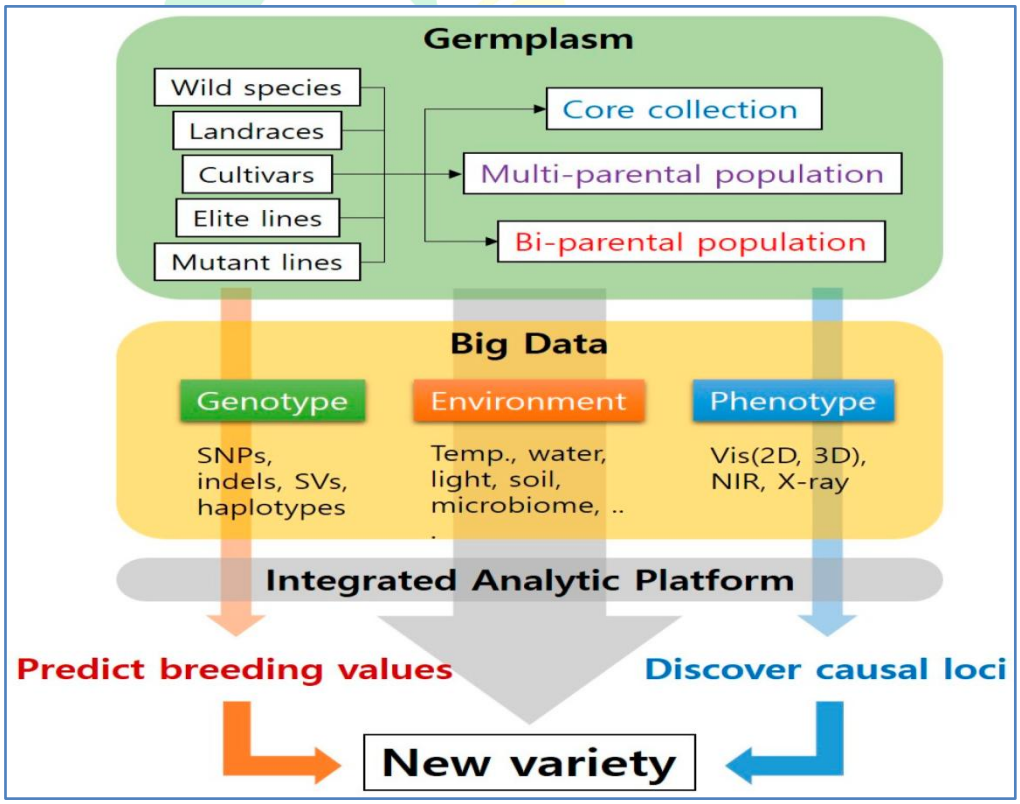

Figure 2. Flowchart of plant breeding in the era of assessing genotypes, phenotypes, and environmentalbig data to develop a new crop variety and enhance genetic gain overall.

Big data ecosystems for plant breeding must be developed for this improved genome-to-phenome prediction (Figure 2). Data that has to be modelled and condensed for decision-making purposes while the clock is ticking how can they handle this..?. To address this issues

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experts from biometrics to develop software pipeline combining data and models to obtain relevant information for the breeders (Figure 2).The biometrics pipeline contains features related to designs and analysis of phenotyping experiments, the transmission of alleles from parents to offspring and coupling of phenotypes and genotypes in QTLs mapping and GWAS models as well as genomic prediction models. So, biometrics pipeline helped us with this challenge by proving tools to know more about the crossing parents so we know how segregation goes into the population and it is very important to develop the best crossing parents and eventually select the best verities by combine all those selected traits/gene in one variety.. We will be able to precisely identify casual loci and forecast breeding values thanks to a variety of germplasm, massive data from genomes, phenomes, and environments, and integrative analysis. This will eventually help us make quicker and more informed judgments on breeding and management procedures were shown in figure 2(Kim et al., 2020).

Prospects and the conclusion

We are now able to quickly and cheaply analyse enormous amounts of genetic data from individual plant specimens thanks to the remarkable advancements in breeding technologies. To maintain the security of the food we consume every day, plant breeders have effectively adopted these improvements and created various varieties with higher yield and better quality. The current pace of genetic gain is insufficient to meet the expected food demands, even when using advanced breeding methods and platforms. Therefore, plant breeders must discover a more efficient way to improve genetic gain and create climate change-resistant types. According to the article's summary, genomic prediction, predictive breeding, and big data from genomes and phenomes are all potential ways to speed up the rate of genetic gain. To take advantage of new genetic advantages, it is also crucial to continuously produce genomic big data encompassing multi-omics data and to evaluate the multi-dimensional data.

References

Howard, J.T., 2019. The use of Big Data in a modern swine breeding program now and in the future.

Kamilaris, A., Kartakoullis, A. and Prenafeta-Boldú, F.X., 2017. A review on the practice of big data analysis in agriculture. *Computers and Electronics in Agriculture*, *143*, pp.23-37.

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Kim, K.D., Kang, Y. and Kim, C., 2020. Application of genomic big data in plant breeding: Past, present, and future. *Plants*, *9*(11), p.1454.

Shakoor, N., Northrup, D., Murray, S. and Mockler, T.C., 2019. Big data driven agriculture: big data analytics in plant breeding, genomics, and the use of remote sensing technologies to advance crop productivity. *The Plant Phenome Journal*, *2*(1), pp.1-8.

Sun, Z., Zheng, F. and Yin, S., 2013. Perspectives of research and application of Big Data on smart agriculture. *Journal of Agricultural Science and Technology (Beijing)*, *15*(6), pp.63-71.