POLICY BRIEF

ENHANCING FOOD SECURITY IN KENYA THROUGH PREDICTIVE MAIZE BREEDING METHOD: A NEW WAY TO DEVELOP HIGH YIELDING MAIZE VARIETIES

Key Messages

- Development of high yielding maize varieties using the current methods takes about 15 – 20 years
- Predictive breeding, a new way to develop new crop varieties by utilising DNA and metabolites markers, reduces time of development of varieties to about 5 – 6 years
- This may reduce hybrid variety development costs thus making them easily accessible to low income smallholder farmers.
- Predictive breeding will enhance development of varieties that are resistant to drought, pests and diseases by identifying and incorporating excellent genes
- Predictive maize breeding approach leads to reduced cost of evaluating materials to be used in development of high yield maize varieties by more than 80%

Policy Recommendations

- Allocation of resources for implementation of predictive maize breeding in research centres and institutions.
- Increase awareness on the use of predictive breeding approach in maize improvement.
- The county governments in collaboration with research centres and institutions should map target areas that can benefit from predictive maize breeding.

Why is predictive maize breeding important for food security in Kenya?

Maize is the most extensively grown cereal crop in Kenya for staple food (Figure 1) accounting for more than 80 per cent of the population. Its average per capita consumption is 103 kg per person and accounts for 3 per cent of Kenya's GDP ([1]). However, despite increased production since 1961, its production has fluctuated substantially in recent years.

These may be attributed to climate change and high cost of hybrid seeds and other inputs. Despite the great efforts made to increase maize production, the demand has occasionally outweighed the supply, requiring importation of large quantities of maize grain (Figure 2). For example in 2018, maize production was estimated to be 4,000 1000 tonnes ([2]).

In January – February, 2018, approximately 77,500 tonnes of maize worth $31.2 million since were imported ([3]). Development of low input high yielding maize is the most viable option to increase maize production option as there is limited scope for expanding cultivated land. This can be achieved using predictive breeding method.

Figure 1: Various product made from maize (source internet)

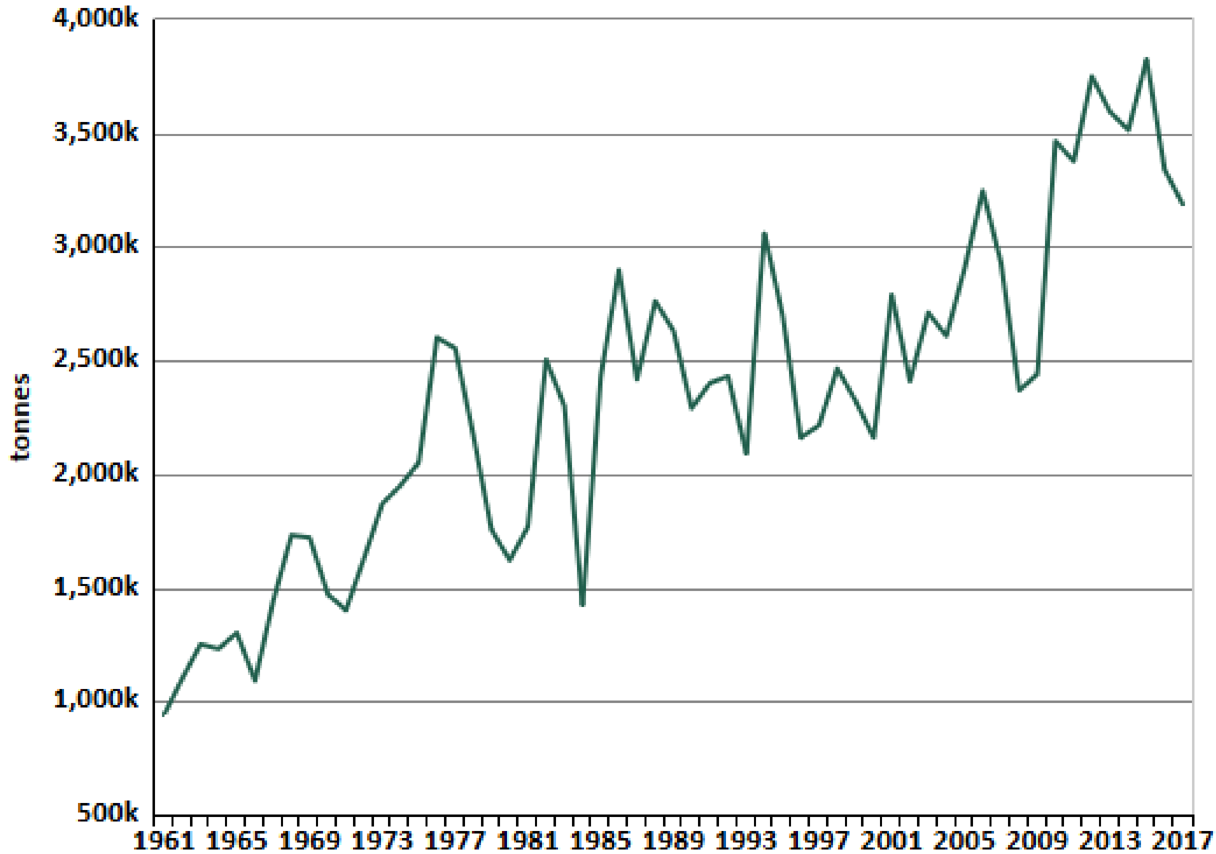

Figure 2: Kenya maize production. Source[2]

Current maize breeding approach

The major limitation in the current maize breeding approach is the very large number of potential hybrids resulting from a breeding program, that need to be evaluated before a variety can be released for commercial use by farmers. In addition, it takes long time to produce the parents that are used to produce these potential hybrids.

To produce the parents to be used in developing hybrid maize varieties, the maize materials used must be selfed for at least six seasons (taking about 6 years; Figure 3). Once the parents are produced they are combined in all possible ways to produce potential hybrids (Figure 4). These potential hybrids are then evaluated in the field to identify high yielding varieties that are then released to the farmers (a process that may take up to 15 years).

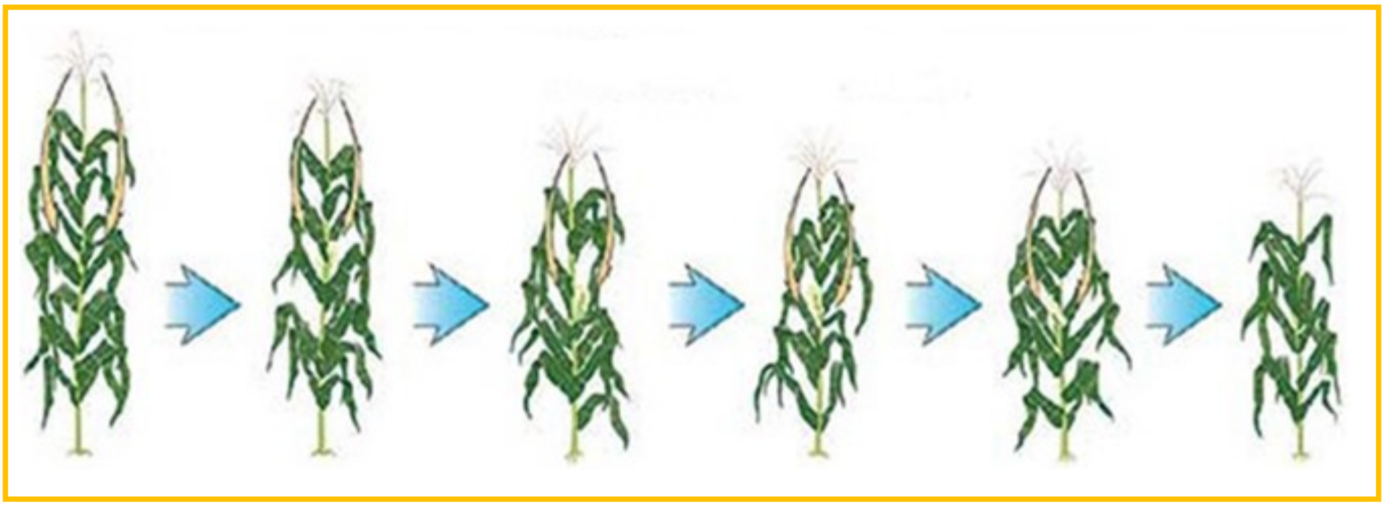

Figure 3: Developing inbred lines: requires six cycles or years of selfing.

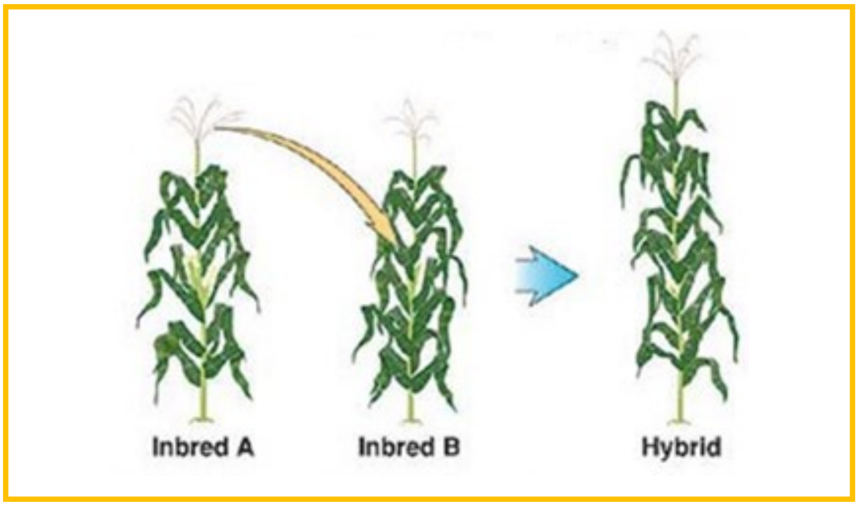

Figure 4: Development of hybrid varieties: done by crossing two or more parents (inbred lines).

The evaluation of the potential hybrids or varieties must be repeated in plots, seasons and location, thus requiring large pieces of land to grow the plants. Hence, evaluation is costly to maintain and data obtained may be unreliable due to environmental variation or applicable across different environment.

For example, if one has 200 parents (inbred lines), if combined in all possible ways, one will end up with 39800 potential hybrids (varieties). If one has 1000 parents, if combined in all possible ways there will be about 1 million potential hybrids (varieties).

This will require huge resources to identify high yielding varieties among them that can be released to the farmers. Hence, the major constraint in current maize breeding approach is the high number of potential hybrids that can be generated from even a few parents.

To screen such large numbers of hybrids requires huge resources in terms of land, human and finances. Moreover, the prediction accuracy is reduced when trials are made over large acreages. The implication is that identification of the high yielding varieties become difficulty, resulting in release of lower yielding maize varieties available to the farming community.

The consequences of this is food insecurity. Moreover, the approach requires that the maize plants be planted till maturity, which increase the time needed to release a high yielding maize variety (currently at 15 -20 years). This also leads to high costs of maize hybrid seed since cost is relative to time taken to develop a variety. The consequence of this is that the farmers are not able to buy the new maize hybrid seeds leading to food insecurity.

The technical rationale is to shorten the selfing cycles and develop a maize breeding approach that eliminate the need to evaluate large numbers of potential hybrids before releasing a new variety to the farmers. The new approach should also not require that the plant be grown to maturity to obtain part of the evaluation data. Hence the need to come up with new breeding approach that can reduce the number of years required to release a variety, eliminated the need of extensive for evaluation of huge potential maize hybrids and low cost of maize hybrid seeds. The predictive maize breeding approach will fit this criterion.

What is maize predictive breeding approach?

A new method, maize predictive breeding approach has been developed to solve the shortcomings of current maize breeding approaches. Maize predictive breeding method is a breeding method that uses biomarkers and molecular markers to predict the performance of hybrids from their parental lines (Figure 5 and 6).

The approaches allow for the use of 22 days old parental seedlings to predict the performance of their hybrid. Meaning that you do not need to make many crosses to come up will all possible combinations of hybrids, only best parents are combined thus reducing number of potential hybrid to as low as 10 potential varieties. Then these 10 hybrids can be evaluated in the field to identify the high yielding maize hybrids.

One only need a small greenhouse area (climate chamber) where all parental lines can be grown up to 22 days after sowing (Figure 5), extract their DNA (genetic markers) and metabolites (biomarkers). Then these biomarkers and genetic markers are used to predict the performance of the hybrids using prediction models (Figure 6). The implication is that you do not need large acreages for evaluation of potential hybrids saving on cost and time needed to come up with a high yielding maize hybrid variety. Moreover the prediction accuracy of best parental lines and hybrids is increased. Implying that better hybrids can be developed leading to food security.

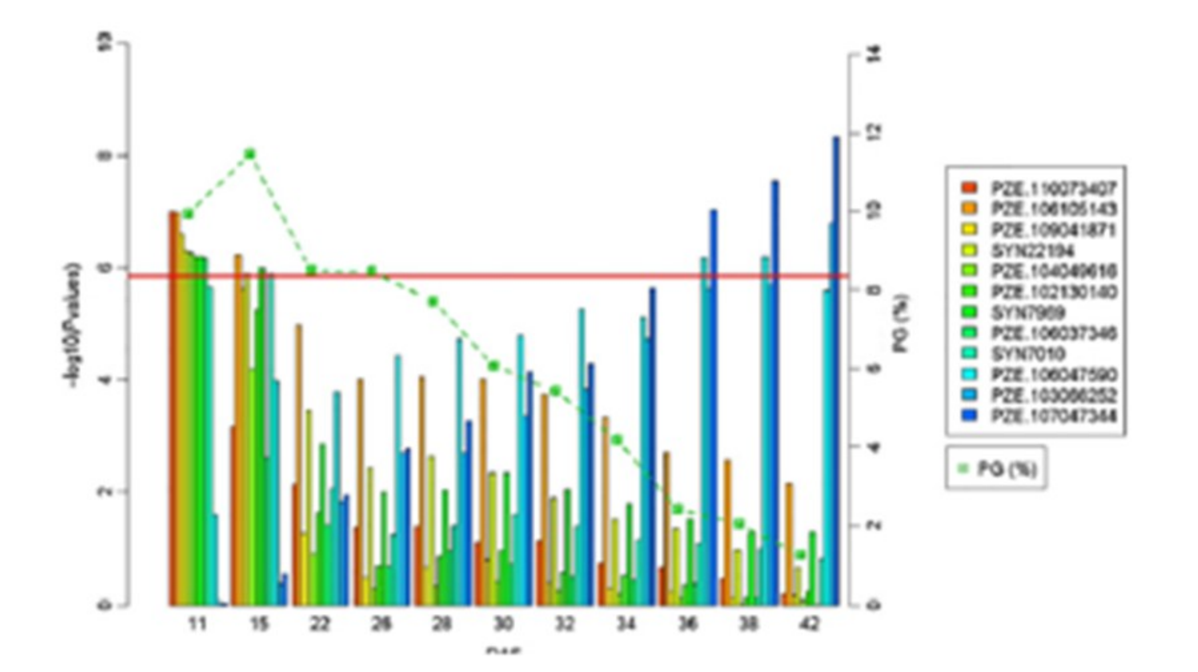

Figure 5:

Figure 5: Significant marker-trait association detected for accumulation of maize biomass at different growth stages using predictive breeding approach. This graph demonstrate that it is possible to select materials to be used in breeding programs as early as 22 days after sowing instead of waiting until maturity (approximately 5 – 8 months) as it is with current maize breeding methods. This will help to reduce time taken to develop new maize varieties.

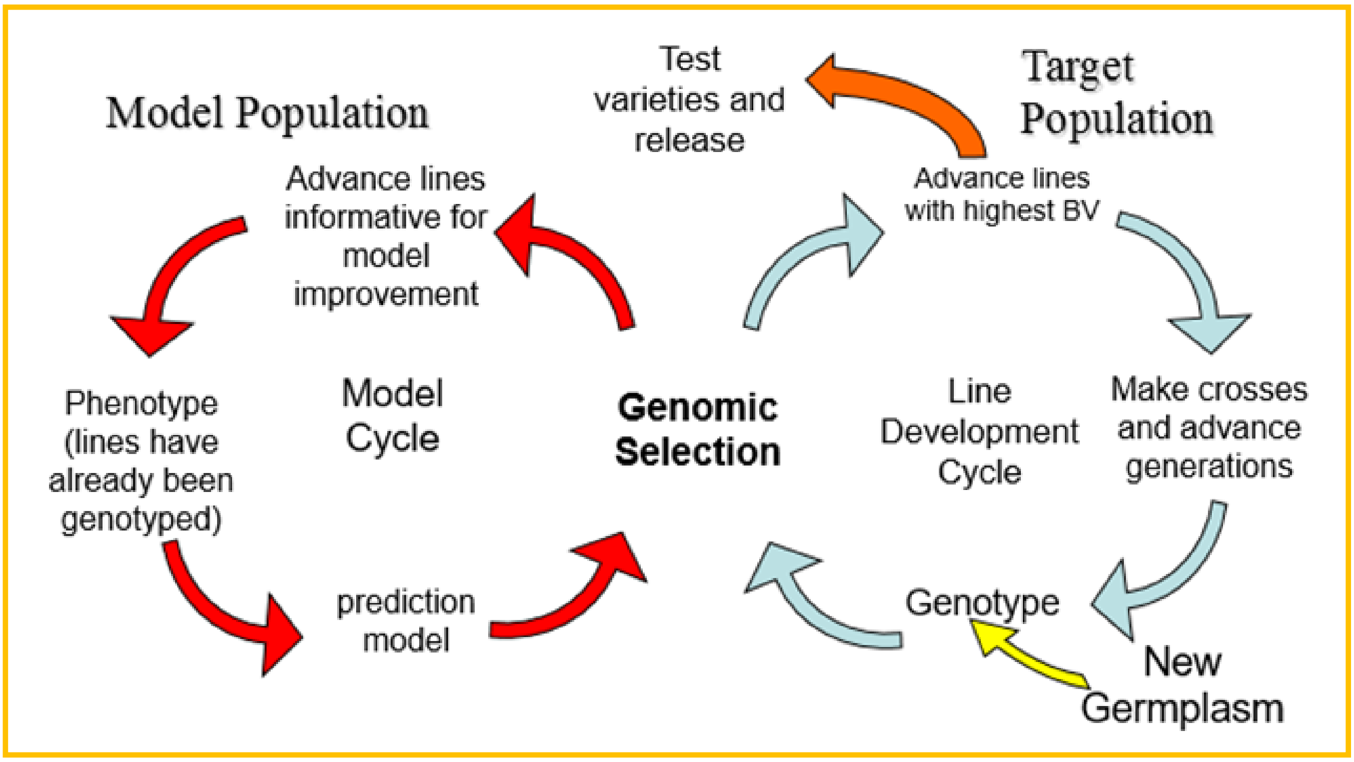

Figure 6: Genomic selection scheme as an aid to prediction breeding.

Importance of Predictive Breeding in Maize

The prediction models have been used effectively to predict many traits of interest ([4, 5]). Using DNA markers and metabolite markers the prediction accuracies have been found to range from 0.72 – 0.81 for different traits which is quite promising. Significant signals for biomass accumulation have been mapped that can explaining to a larger extend (12 - 32 % genetic variation found in materials used ([4, 5]).

These demonstrate that predictive models that can identify optimal set of predictors from the biomarkers and genetic markers will be an indispensable tools in future maize breeding efforts. The new maize variety developed is expect to be economical in terms of reduced input costs, since shortening of breeding cycle translate to reduced cost of hybrid seeds. In addition the reduced breeding cycle implies that new varieties will be rapidly developed and realised mitigating quickly any change in climate, thus ensuring food security (Figure 7).

Figure 7: High yielding maize varieties (Source internet)

References

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