Case Study 6: Seed Production Research for New Crop Varieties in Africa

AGRA Theme 3: Quality Seed Production

Component: Seed production research for enhanced producibility of newly released improved crop varieties: Examples from the One CGIAR and Multi-National Companies (MNC).

Executive Summary:
A functional, stable, and successful African seed system will be characterized by rapid seed scale-up of deployed productive improved easy-to-produce varieties (especially hybrids). The varieties will be identified right from the breeding stage through seed production research as those with good seed production potential or producibility. Such hybrids will have good female parents with good agronomic characteristics, and high seed production potential; and males with good agronomic characteristics including pollen-shedding qualities. Seed production research at the seed company will be mainly to ensure that seed parents will perform well under the target seed production environments.

Context:
In most cases, upon commercial release, the breeder of a certain variety passes its parentals onto the Early Generation Seed (EGS) producing entity which in turn forwards the variety to the seed company for the ultimate certified seed production by the seed grower. The correct way to produce seeds of the variety in the target environment must be forwarded together with the seed. Information on parental inbred line and single-cross seed yield under different environments and flowering synchrony between parents are important for successful seed production (Worku et al., 2016).

The International Maize and wheat Improvement Center (CIMMYT) was desirous to assist seed companies that license hybrid maize to optimize seed production to avail good quantity of quality seeds to farmers while achieving favorable business. Seed production technology was, therefore, developed, and tested, and results for specific hybrids were availed together with appropriate pilot information. The specific seed companies receiving the hybrids are then taught how to conduct seed production research since they are responsible to adjust the recommendations under their conditions. Seed production research is, therefore, initially conducted by the breeder and thereafter by the seed company ideally in the target seed production environments.

Challenges and Objectives:
Seed production is an important step in a functioning seed system. Often variety development, EGS seed production, pre-basic seed production, basic seed production, and certified seed are all done in different environments. The different progenitors may, however, be affected by the growing environment. Ideally, breeding, seed production, and grain production should be done in the same environment, but it's logically difficult. Since hybrids have different parents that are mostly inbred, they are more prone to issues of difficult seed production (MacRobert et al., 2014). The best hybrid may sometimes not be the best in seed production. The seed production potential of a hybrid is referred to as hybrid producibility. It was observed that once seed companies obtained maize hybrids from outside their breeding programs, and, especially, through licensing from CIMMYT and other institutions, it took a long time for them to maximize seed production for the various seed classes (breeder, pre-basic, basic, and certified seed). The delay was accompanied by seed crop failures largely due to poor synchronization of female and male parents, and poor performance of one or both inbred parents.

Seed production research (SPR) was, therefore, started for each new hybrid to find the conditions that produce more seeds of the best quality in the less acreage. This was premised on the fact that agronomical practices and environmental conditions in the hybrid seed production fields have a great impact on profitability.
The aim of the seed production research is, therefore, to elaborate crop production protocols by conducting experimentation to study how to use the parents at their best for optimal seed production. All the heterogeneous information of agronomical testing is compared and analyzed, and the production protocol sheets are prepared.

Interventions:
CIMMYT started seed production research primarily to identify the high potential yielding but also highly producible maize hybrid for licensing to seed companies. The seed company must then conduct trials to see how to best produce the seed at a commercial level. Seeds production research is, thereafter, an important type of research for a seed company, as it conducts the study of exactly how to produce specific types of seed to maximize volume and quality at harvest time. Particular attention should be paid to nicking periods, the pattern of male and female rows, and border rows to ensure isolation, plant population, and crop management practices. An important component of production research is maintaining accurate production records so that production techniques can be either replicated or improved in subsequent years.
Seed production research approaches involve two kinds of experimentation: 1) Study each parental line separately to describe its *per se* performance and agronomical characteristics; and 2) Study parental lines planted together to determine the optimal conditions for seed production.
At the breeder level, inbred lines are tested across locations to avoid failure in seed production fields. Seed production research is conducted at all maize growing ecologies in ESA i.e., dry mid-altitude, sub-humid mid-alt, and upper mid-alt). Breeders screen inbred lines developed through both DH technology and pedigree for yield potential and good agronomic traits at an early stage (Chassaigne-Ricciulli et al., 2020). Commercial breeders then conduct preliminary seed production research for the producibility of Stage III hybrids. Further seed production research continues for parents of regional trial hybrids at 3-4 locations. Descriptor data generation and testing of parents of hybrids allocated to seed companies and those in NPTs are done at 5-7 locations. Trials are planted under optimum moisture conditions and organized separately for single cross and inbred line parents, but the two trials are planted adjacent in the same field, same day, and time at each location, and receive the same management and data collection procedures throughout the season.
Seed production research targets generating the following important information required by seed producers for successful production of hybrid seeds:

1. Areas of adaptation of both female and male parents
2. Female parent potential seed yield
3. Nicking (planting split and pollination)
4. Female parent agronomics (height, standability, disease reactions (leaf diseases, ear rot, etc.), silk emergence, ease of tassel for removal, etc.
5. Female seed characteristics (size, shape)
6. Male pollen production (duration, quantity, and tassel characteristics)
7. Male agronomics (Height, standability disease reactions (leaf diseases), and insect pests.
8. Planting patterns (female: male row ratios)

The utility of the SPR data was improved by making the scores quantitative through the preparation of a scoring system (out of 100) using these the female and male parent characteristics that any hybrid may be evaluated for seed production potential.
Other aspects of SPR include molecular testing at certain intervals for the identity and quality of parental inbred lines which should be a continuous process. Screening inbred lines for tolerance to locally available herbicides are advisable to give recommendations for seed companies.

Results:
SPR did at different stages of hybrids development assists in eliminating hybrids with seed production problems before release. SPR also assists to generate the information required for seed production of new hybrids. Newer maize hybrids are expected to be easily producible thus ensuring a good quantity of affordable seeds for farmers.
The information generated from SPR will enhance the use of CIMMYT's tropical mid-latitude parental germplasm by breeders working in both private and public breeding programs for developing and deploying high-yielding maize hybrids for the benefit of small-scale farmers in SSA (Worku et al., 2016).

Supporting Visuals or Quotes:

> *Seed production research helps research for development breeding institutions to rapidly deploy easy-to-produce hybrids and facilitates seed companies to achieve rapid seed scale-up* - Watson Chivasa, 2022

Future Plans:
Though seed production research is more critical for hybrid maize seed production, its benefits in ensuring the timely successful production of large quantities of seed at optimum costs will benefit all crops. Adoption of regular conduct of SPR for new varieties and new seed production environments is essential for functional effective and efficient seed systems in Africa.

Call to Action (CTA)/Key takeaways:

- CESSA to include capacity building through training for SME seed companies.
- The seed production research process could be improved and well documented for ease of its application for OPVs, self–pollinated crops and vegetatively propagated crops.

References

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MacRobert, J.F., Setimela, P.S., Gethi, J., Worku, M. 2014. Maize Hybrid Seed Production Manual; International Maize and Wheat Improvement Center (CIMMYT): Mexico City, Mexico, pp. 1–26.

Worku, M, Makumbi, D., Beyene, Y., Das, B., Mugo, S., Pixley, K., Banziger, M., Owino, F., Olsen, M., Asea, G., and Prasanna, BM. 2016. Grain yield performance and flowering synchrony of CIMMYT's tropical maize (*Zea mays* L.) parental inbred lines and single crosses. Euphytica 211:395–409 DOI 10.1007/s10681-016-1758-3.