

Agricultural Productivity Program for Southern Africa (APPSA)

CROP IMPROVEMENT ENHANCE AGRICULTURAL PRODUCTIVITY

By

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CONFERENCE**

27-29 November 2019, Johannesburg, South Africa

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Centre for Coordination of Agricultural Research and Development for Southern Africa



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PRESENTATION OUTLINE

- **INTRODUCTION**
- **GLOBAL HISTORY OF FOOD PRODUCTION**
- **DISCOVERY OF HYBRIDS**
- **SIGNIFICANCY OF CROP IMPROVEMENT**
- **CROP IMPROVEMENT EFFORTS - ZAMBIA**
- **NEED FOR TECHNOLOGY INCLUDING BIOTECHNOLOGY**
- **PREPAREDNESS TO CLIMATE CHANGE**
- **CASE FOR CROP IMPROVEMENT**
- **CONCLUDING REMARKS**

INTRODUCTION

- God picked Agriculture for enabling mans existence on earth.
- ✎ Traditionally, the immediate basic needs for a human being are food including water, shelter and clothing. Everything else is considered a luxury.
- ✎ If a human being goes without food for 24hrs will quarrel, one who goes without food for 48hrs will steal and one without food for 72hrs will fight.
- ✎ Food is therefore very important and may stand in between peace and anarchy.

Introduction

☞ God perhaps also recognized this that is why he singled out agriculture to be imparted to his creation so that ensured they were food secure.

☞ Up until today, it can be seen that, improvement in productivity in agriculture has the multiple impact of increasing production, reducing poverty, malnutrition and generating growth and in the process improving food availability and livelihoods.

Introduction

- ⌘ This presentation looks at how Crop Improvement contributes at enhancing Agricultural Productivity.
- ⌘ Plant science through plant breeding is main focus and what has come out of it.
- ⌘ Agronomy in this presentation is covered broadly in what is referred to as the environment.

Introduction

- ☞ ZARI one of the departments of Zambia's Agriculture Ministry has been drawn upon for illustrations.
- ☞ Otherwise all Plant Scientists, Plant Pathologists, Entomologists and Plant Breeders all contribute to the making of genotypes or varieties the same applies to other disciplines when it comes to Environment manipulation
- ☞ To understand the contribution we need to know how food was acquired and is being acquired now

GLOBAL HISTORY OF FOOD PRODUCTION

- ☞ Human beings were originally expected to subsist solely upon horticultural and animal foods.
- ☞ God told human beings to work on the land in order for them to produce food.
- ☞ History of human development also tells us that primitive man lived off the land, gathering and hunting.

Population vs Food Production

- ⌘ Primitive man also resorted to tilling land as wild food was not always sufficiently stable or plentiful to supply his needs.
- ⌘ The bible story and human history all converge on man tilling the land to produce food.
- ⌘ The essential features used to grow crops for food have remained almost unchanged and we are also using them.

Main Features of Crop Production

- ☞ Gathering and preserving the seed of the desired crop plants.
- ☞ Destroying other kinds of vegetation growing on the land
- ☞ Stirring the soil to form a seed bed.
- ☞ Planting the seed when the season and weather are right as shown by past experience.
- ☞ Destroying weeds.
- ☞ Protecting the crop from natural enemies.
- ☞ Gathering, processing and storing the products.
- ☞ Farm machines merely speed up the hand of man in doing these things or enable him to do the work better.

Main Features of Crop Production

- What man has been doing when growing crops has changed little as we continue on the same path that fits into the relationship;
- **Phenotype = Genotype x Environment**
- God provided the genotypes and man manipulated the environment and food was produced.
- The relationship was used to feed man on earth without interfering with genotypes used as seed.

The Malthusian Factor

- ☞ Thomas R. Malthus in 1798, was the first to realise the way food was produced inefficient and would result in population growth outstrip food supply.
- ☞ At that time food production increased linearly where as population increased geometrically i.e. exponentially.
- ☞ The check on population increase was the maximum limit set by food supply.
- ☞ Population was contained by food and also drastic actions like war, famine, pestilence and premature mortality.

Malthus Cross

- ☞ Later advances in knowledge and other measures far improved human welfare and this threatened food availability if the technologies for producing it did not change.
- ☞ On the ground, new lands, new technology and capital investments in irrigation became significant in producing food which supported human populations thereby delaying the Malthus cross but were still using same genotypes.

Delaying Malthus Cross

- ⌘ Food increase in the past was generally achieved by increasing cultivated land while using the same type of plants.
- ⌘ The technologies available in terms of machinery and environmental manipulations reached their upper limits hence became inadequate as social wellbeing improved and population increased.
- ⌘ The Malthus cross would have come to pass had it not been for the contributions of plant science in form of Crop Improvement.

Gregor Mendel

- ∞ The natural genotype performance limitation and the limited opportunities for opening new lands on which to grow the genotypes left no choice but to look at the genotype in the relationship
- ∞ This opportunity was provided by utilising the ideas of a man named Gregor Mendel proposed in 1865

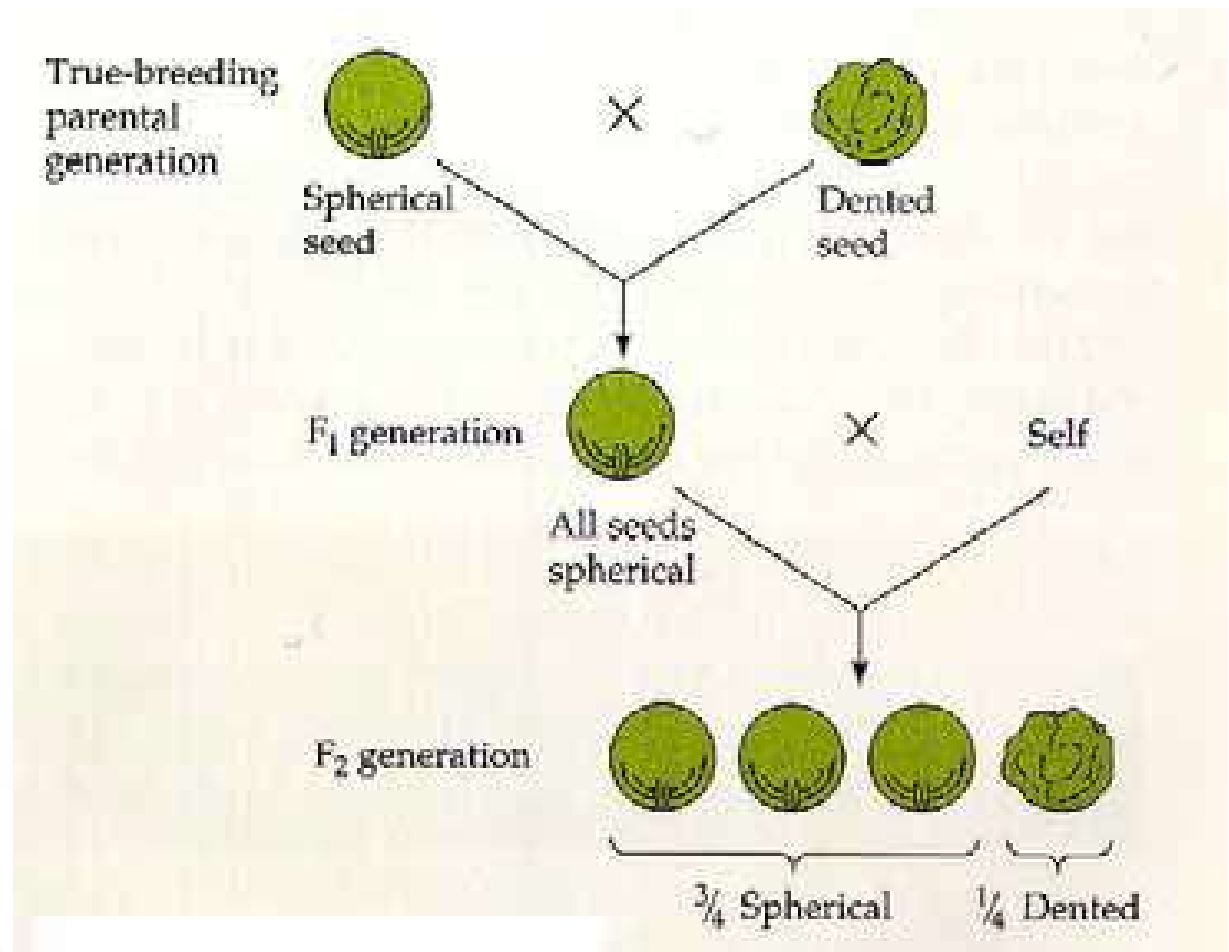
DISCOVERY OF HYBRIDS

- ☞ Gregor Mendel established that plant characteristics are controlled by hereditary factors or genes found in the DNA.
- ☞ The genes are expressed in an environment to produce a trait.
- ☞ This information was put to use and resulted into creating hybrids that revolutionized crop production

Effectiveness of hybrids

- ∞ In Hybrids, Hybrid vigour or heterosis is achieved only if the first generation or F_1 progenies is used as seed
- ∞ If the F_2 is used performance of the off spring may drop by as much as 30%.
- ∞ Hybrid vigour or heterosis is the foundation of modern hybrid crop production.

Gregor Mendel 1865 : Father of Genetics



Production of Hybrid Crops



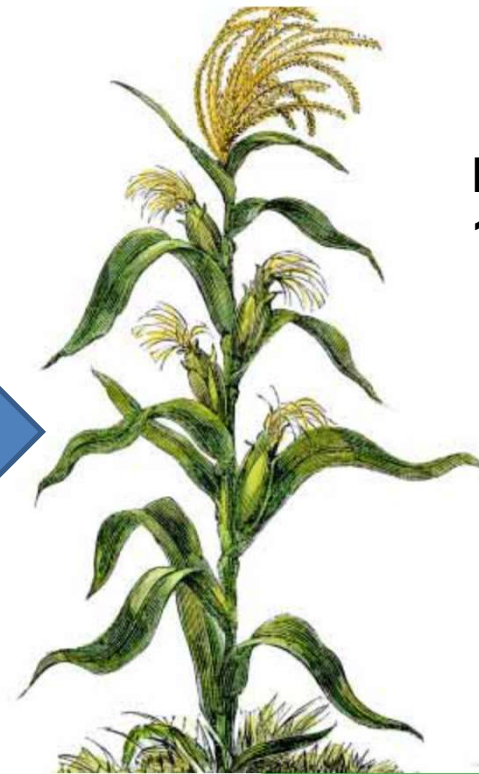
P1



P2



F
1



Hybrid Vigour



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Types of hybrids

- Crop Improvement takes place through: introduction, selection and hybridization to produce varieties.
- Greatest impact comes from hybrids and come as;
- Single cross hybrid $A \times B$ and is obtained by controlled pollination of inbred or pure line A by inbred line B.
- Double cross hybrid $(A \times B) \times (C \times D)$ and is a cross between 2 single cross hybrids.

Types of hybrids

- ∞ Three way cross hybrid (AxB) x C and is the result of a cross under controlled conditions between a single cross hybrid (AxB) used as female parent and a pure line C.
- ∞ Top cross is a cross between a population and an inbred line or between a population and a single cross hybrid.

Efficiency and cost of seed

☞ All factors being equal i.e same favourable environment best performance of varieties is in order of single cross, three way cross, double cross, top cross and Open Pollinated Variety (OPV).

☞ Cost of seed is in reverse order. The most expensive being single cross hybrid and cheapest is OPV.

☞ Variety stability is in reverse OPV, Top Cross

Types of hybrids

- ⌘ The development and use of hybrids is governed by many factors and one of the most important is inbred lines.
- ⌘ Inbred lines are very delicate and may take many years to develop and their products also take many years to be produced.
- ⌘ The difficulties encountered by plant breeders to identify and use ideal traits led to the discovery of other processes.
- ⌘ Conventional, Mutagenesis, Tissue Culture, Transgenesis

SIGNIFICANCY OF CROP IMPROVEMENT IN AGRICULTURE

- ☞ Plant Genetics is very important and is the stepping stone where plants are developed which respond favourably to other factors.
- ☞ Plant breeding made a major contribution to increased food by the application of genetics.
- ☞ Traits as contained in a variety is inadequate without other factors of production but they did make an impact

Impact of hybrid on yield

- ☞ Through the development of improved varieties, plant breeders in the US doubled maize yields between 1930 and 1966 and more than tripled 1930 yields by 1995.
- ☞ In other words, farmer average maize yields were increased from 1.6t/ha in 1930 to over 3t/ha in 1966 and to 9.5t/ha by 1995.
- ☞ Today average yields are far higher as farmers use of hybrids is 100%.

Proportional contribution

- ⌘ The analysis of the improved gains have shown that 50% of the yield increase is due to genetics the remainder due to agronomic practices:
- ⌘ Cultural practices 20%,
- ⌘ Fertilizers and herbicides 15%,
- ⌘ Mechanization 10%
- ⌘ Better methods of water conservation 5%.

Good Genotype under poor Environment

The genotype alone is useless without complimentary agronomic packages including pest and disease control.



Environmental manipulation



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CROP IMPROVEMENT EFFORTS - ZAMBIA

- ☞ Crops research in Zambia dates as far back as the 1920's.
- ☞ Maize introduced by 1900.
- ☞ 1912 to 1919 simple experiments carried.
- ☞ 1929 first Central Research station Mazabuka including at Fort Jameson (Chipata) and Abercorn (Mbala).
- ☞ 1950 Research Branch (ZARI) created from within Department of Agriculture
- ☞ Mt. Makulu which started functioning in 1951 opened in 1953.

Maize Improvement History - Zambia

- Maize improvement through breeding and using conventional methods started in 1962 varieties in use came from Zimbabwe mostly SR52
- In 1970 first hybrid released from the collection 63J as male that was crossed with SR52 to produce Zambia Hybrid 1 and named ZH1
- The hybrid was followed by the first Zambian OPV released from Hickory King and 17 inbred lines in 1973 and named Zambian Composite A or ZCA.

Maize Improvement History - Zambia

- 1980 ZAMSEED formed with exclusive rights to multiply and sale research developed and released varieties.
- ZAMSEED was only involved in marketing aspects of varieties not research
- 1983 SR52 purified and named MM752, 7 other hybrids released and 2 OPVs
- 1991 ZAMSEED Privatized and exclusive handling of ZARI varieties ended.

Maize Improvement History - Zambia

- By government policy all the varieties released up to about 1991 were all white.
- 1992 first yellow maize released as MM62.
- 2012 first Quality Protein Maize ProVitamin A maize or Orange maize released
- At present variety development and release takes place in both public institutions and seed companies.
- ZARI only develops varieties marketing is done by private sector

Maize Improvement History - Zambia

- ⌘ Efforts in crop improvement as per SCCI register shows 300 varieties up to September 2019 with 12 varieties registered in 2019 alone
- ⌘ All maize varieties released are rated to yield above 5t/ha some even touching 12t/ha or more
- ⌘ Release of varieties in other crops is also quite high
- ⌘ The average yields of maize however quite low
- ⌘ According to CFs the best yields were obtained in 2010/2011 season at 2.73t/ha from 1,355,764 ha

Maize Improvement History - Zambia

- ⌘ The other good season was 2015/2016 at 2.1t/ha from 1,364,977 ha
- ⌘ The 2017/2018 season was quite poor at 1.72t/ha from 1,392,546 ha
- ⌘ The average yields are just between 2t and 2.5t and rose from below 1t some time back
- ⌘ The average yields are for smallscale farmers
- ⌘ This is far below what farmers in USA were getting in the 60's before hybrids were fully refined

Maize Improvement History - Zambia

- ☞ If we look at the relationship we have been using genotypes are accounted for and suspect environmental manipulation as contributing to low average yields.
- ☞ These low yields are not in just Zambia but the region
- ☞ This may mean we are not communicating, how is it that we have consistently high yielding varieties but low average yields?
- ☞ Focus is needed on farmers
- ☞ This does not mean we break off from our activities in Crop Improvement it is actually time to refine our technologies by embracing Biotechnology

Need for Technology including Biotechnology

- ⌘ The changes in agriculture have taken place in countries where most agricultural research takes place and where fruits of research are taken up by farmers and industry at large.
- ⌘ Developed countries have embraced technology including biotechnology.
- ⌘ In most of our countries Biotechnology has been in most cases demonized perhaps due to poor introduction.

Need for Technology including Biotechnology

- ⌘ Biotechnology is just a tool that helps accelerate crop breeding programmes and does complement conventional breeding.
- ⌘ In all our countries many scientists working in different institutions have the skills to engage in biotechnology but policy as well as lack of specialized equipment to carry out research with limits them.
- ⌘ The truth about biotechnology and not necessarily GMO is that it is the future of agriculture.

PREPAREDNESS TO CLIMATE CHANGE

- With respect to biotech, current plant breeding already taking place, is devoted to enhancing yield stability especially maintenance of disease and pest resistance.
- It is however, important to establish capacity for biotechnology research on major crops to provide the technology for the future especially in view of -**CLIMATE CHANGE**.

Climate Change Preparedness

- Climate change effects are predicted to increase adverse weather conditions and increase incidence of disease and insect pests which will result in a lowering of crop yields.
- The effects of Climate Change are already being experienced.
- The way forward is to have crops adapted to changing climatic conditions.

Climate Change Preparedness

- ☞ Climate Change as the new threat to agriculture has been recognized and this threat cannot be addressed overnight except if work had been going on for some time.
- ☞ It is a fact that there is at least a 20 year lag between initiating strategic research and obtaining impact on farmer fields.
- ☞ The outputs of APPSA built on earlier work

Climate change preparedness

- ☞ If we are to be in time to overcome challenges of climate change preparedness should have started when it became apparent but is still not too late to start working on interventions directed at specific crops.
- ☞ This can only happen in situations where there is a strong breeding program that continuously develop and introduce superior, locally adapted hybrids and varieties which find their way into the production system.

Climate change preparedness

- Current projections indicate a rise in food consumption and the future inter annual variability of crop production is going to be uncertain due to the uncertainty of future climate and also extreme weather conditions predicted in climate change.
- Only heightened public and private investment in agriculture including research will help ensure future food supply.

CASE FOR CROP IMPROVEMENT

- ☞ Crop Improvement through the science of plant breeding has been singled out as being a major contributor to the continued improvement of food crops e.g.
- ☞ Developing new varieties that are high yielding,
- ☞ Resistant to pests and diseases,
- ☞ Resistant to extreme weather events such as drought or flood,
- ☞ Adapted to different environments and growing conditions and also of
- ☞ Crops of increased nutritional value

Case for Crop Improvement

- ☞ The number of released varieties in all crops is impressive.
- ☞ The average crop yields however, appears questionable i.e. deployment of technologies doubtful pointing to issues of Technology transfer.
- ☞ It would be unwise to stop further research but should include technology transfer in our efforts.
- ☞ APPSA has for the first time brought cross country scientists together in a practical way and have achieved commendable outputs.

Case Crop Improvement

- ☞ There is serious need to address average yields and the response to climate change in a focused way since these cut across countries.
- ☞ No one country is able to offer solutions except with cooperation with others.
- ☞ In Zambia, institutions like NSTC that has wider mandate over research should be embraced closely so that strategic research being undertaken in different Ministries may find useful application tomorrow.

CONCLUDING REMARKS

- ☞ Crop Improvement is a specialized activity that calls for special skills and facilities that are employed to discover and develop new technologies.
- ☞ Developed countries where agriculture is advanced have invested much in agricultural research in general.
- ☞ The picture seen in our countries is of excellent technologies but Technology Transfer appears limited there is need to find out what is happening at farm level

Concluding Remarks

- Farmers need technical know how to maximise use of resources including land.



Concluding Remarks

- ☞ We need to have faith in our scientists to deliver as demonstrated by what APPSA has achieved.
- ☞ CGIAR Centres have prospered because of the generous funds donors provide to them.
- ☞ These centres are not a substitute for National Research Institutions - they could be good at basic research since it is very expensive to undertake but national institutions need high caliber scientists as well to look for compatible technologies for their own countries.

Concluding Remarks

∞ The population will continue to increase and people will continue to look for quality products hence there is need for increased agricultural production and this can be achieved through improvements in current agricultural technologies.

Concluding Remarks

Although crop yield and quality can be improved by disease and pest control, fertilizer application and better cultural practices, such practices are costly and can be cheaply done through crop breeding including the use of biotechnology.

Concluding Remarks

- Consumers will continue to demand more diverse and higher quality diets and need foods that can be transported and stored.
- Natural foods contain what consumers want but these are not found in one plant but scattered all over expressed as traits.
- You need special type of people to find these and extract them and put them into a desired plant. So far through APPSA it has been demonstrated that we have such people in the region all we need is sustained Research.

Concluding Remarks

- Research is an economic activity because it requires the use of scarce resources but it provides something of value in return



∞ **END OF PRESENTATION**

∞ **THANK YOU**

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