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Wheat Breeding: Satisfying Farmers and Millers

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Prairie strong, worldwide

INTRODUCTION

- Wheat is the oldest cereal to be cultivated, allowing mankind to settle and develop agricultural practices and the start of civilization
- This occurred some 10,000 years ago in the fertile crescent, present day Iraq
- For the majority of time since then improvements in wheat production and food quality were totally random – achieved through natural selection.

INTRODUCTION

- Scientific wheat breeding has only been around for about the last 100 years.
- Through this process, scientists are able to select naturally desirable traits and combine them into new plants that are better than the parents from which they came
- It can take 8 to 12 years for a new, unique plant to be developed, involving hundreds of crosses and selections to get those traits in the desired combination

ABSTRACT

- Breeding wheat to develop new varieties is a question of balance.
  - The new variety must satisfy farmers so they will grow it profitably.
  - It must also provide essential functional properties that will satisfy millers and end users such as bakeries, pasta manufacturers, noodle factories and others.
  - The more requirements that a breeder must bring in, the more difficult to develop a variety that will please both farmers and end users.

ABSTRACT

- Wheat is a very complex grain and has the widest range of food applications of any of the major cereals grown today.
- Countries that are wheat producers have introduced various systems to ensure that variety development meets the needs of farmers including good agronomics and disease resistance.

ABSTRACT

- Those that are also wheat exporters have developed various degrees of sophistication to assure good functional properties for their global customers.
- This presentation will discuss evaluation and registration programs needed to ensure that new wheat varieties are best positioned to provide the balance so that farmers, millers, processors and consumers are satisfied.

Three areas that wheat breeders must consider

1: Agronomic concerns:

Ensure the variety will provide good yield per hectare, adequate maturity time to meet the seasonal variations as well as a number of other considerations such as ability to withstand frost, drought, and excessive rain at harvest.

Three areas that wheat breeders must consider

2: Diseases and pests:

With a growing concern for improved food safety and desire for a reduction in herbicide and pesticide residues, breeders try and introduce natural resistance to a wide range of factors that can attack and deteriorate a healthy plant.

Three areas that wheat breeders must consider

3: Quality requirements:

Wheat is a very complex grain and has the widest range of food applications of any of the major cereals grown. Breeders must develop wheat with good milling and processing quality so that processors are willing to buy it and perhaps pay a premium for the product.

Agronomic concerns:

- Most of the wheat globally are **Winter** types – seeded in the autumn, harvested in mid- to late summer
  - seeding August to October in the north (EU, North America, etc)
  - seeding March to May in the south (Argentina, Australia, etc)
- **Spring** wheat is grown in northern EU, Russia/Kazakhstan, North America – seed in the spring, harvest in the fall
  - seeding April – June, harvest August to October
- Agronomic breeding also deals with soil type, acidity, salinity, tillage models, fertilizers, weed controls, moisture patterns

Agronomic targets:

- **YIELD** – kg/ha
  - more tonnes per hectare = better profitability for the farmer
- **Maturity** - # of days from seeding to maturity
  - this can be critical for spring wheat crops where frost in the spring or fall can be a concern – CWRS = 85 to 105 days
- **Plant height** – cm
  - if the plant is too tall (typically > 110 cm) then:
    - there is a greater chance for the plant to blow over in the wind (lodging)
    - more energy + nutrients going into the straw, less into the kernel
    - more “trash” (straw) to get rid of

Agronomic targets:

- **Winter survival** – for winter wheats – the percentage of seeded plants that are not able to survive the winter dormancy period
- **Sprout damage** – the ability of the kernels to resist wet weather at harvest without starting the germination (sprouting) process
  - measured visually and also by Falling Number
- Quality targets also of interest to agronomists:
  - **Test weight** – kg/hl - higher test weight tends to indicate a greater flour yield – customers will often have a minimum test weight requirement
  - **Protein** - % - a measure of the protein, functional component of wheat, typical range of 9% to 17% (dry basis)

Agronomic targets:

- **Protein Transfer Efficiency** – Most millers and end users equate protein content with higher quality and better value. Therefore breeders want to develop plants that are more efficient in transferring the inputs of energy, ground nutrients and water usage into a high level of protein. This is an important objective in an effort to reduce the requirement for expensive nitrogen, potassium and phosphorous fertilizers.

Disease and Pest Resistance

- **Diseases**
  - these will vary significantly depending on the geography
  - leaf and stem rusts are a major concern – Ug99
  - fusarium (and DON levels)
  - smut and bunt, root rot, mildew, septoria, ergot, etc
- **Pests**
  - insects that attack the wheat kernel
    - orange blossom midge, aphids, grasshoppers,
  - insects that attack the whole plant
    - sawfly, borers, leaf beetles, grasshoppers
- Impact of diseases and pests can be mild (slight loss of yield) to a total devastation of the complete field crop.

Quality Objectives

- Wheat quality objectives will range from very basic to very sophisticated
- Wheat exporters tend to need more sophisticated quality targets and segregation in order to attract buyers and get the best price
- Basic quality requirements will include:
  - test weight
  - protein (or wet gluten measurement)
  - measure of dough strength – e.g. sedimentation
  - fundamental product evaluation – bread quality

Quality Objectives

- **Wheat quality**
  - Protein - % - measured dry basis or on a moisture basis
  - Test Weight – kg/hl
  - Kernel Weight – mg or grams per 1000 kenels
  - Hardness – psi,
  - Vitreous Kernels - %
  - Wheat ash - %
  - Falling Number – seconds

Quality Objectives

- **Milling quality**
  - Flour Yield - % - typically measured using a laboratory flour mill, measured on clean wheat or constant ash basis
  - Milling (flour) yield must be related to other flour quality factors such as ash or colour in order to judge flour purity

Quality Objectives

- **Flour quality**
  - Protein - % - typically measured at 14% moisture basis
    - Protein loss – wheat protein to flour protein loss (straight grade)
  - Wet Gluten - % - simple test, can be measured manually
  - Moisture Content – %
  - Ash - % - measure of milling purity
  - Colour – different systems – KentJones/Satake, Minolta, Agtron
  - Amylograph peak viscosity (or RVA viscosity)
  - Starch Damage – different systems – Megazyme, Chopin

Quality Objectives

- **Rheological tests**
  - FARINOGRAPH – measures water absorption, mixing time, mixing tolerance and dough ‘strength’ (development & stability)
  - MIXOGRAPH - measures water absorption, mixing peak, gluten strength
  - EXTENSOGRAPH – measures the balance between dough resistance and extensibility
  - ALVEOGRAPH – CONSISTOGRAPH - measures the balance between dough resistance and extensibility

Quality Objectives

- **Performance tests**
  - BAKING – style of bread produced will depend on market expectations, generally require standardized formula and methods – pan bread, sandwich bread, hearth bread
  - PASTA – for durum wheats - evaluate color, speckiness, texture (eating quality)
  - NOODLES – similar as above – color (discoloration), specks, texture
  - BISCUIT – height (thickness), spread

Cooperative testing

- New breeder test lines need to be compared to established standards (check varieties)
- Prior to registration, breeder lines should be grown in numerous locations over at least three years
  - need to test for various environmental regions – e.g. soil type
  - need to test for different disease and pest pressure
  - need to test through different seasons – e.g. hot, dry, cold, wet
- Must keep meticulous records on the agronomic and disease + pest reaction for each test line in each of these regions

Cooperative testing

QUALITY TESTING

- Samples need to be tested for quality attributes against the standard varieties
- Samples from different regions can be tested separately or combined into composites
- Quality evaluation laboratory needs to use consistent test methods, calibrated instruments and equipment and trained personnel

Cooperative testing

CULTIVAR EVALUATION

- Expert panels should be established for each of the disciplines being evaluated – agronomy, disease, quality
- Panels should be as consistent and independent as possible
- Evaluation criteria and rating systems need to be clear and relevant and should be updated as necessary
- Breeders need feedback to know what their targets are

Variety Support and Registration

- A formal process is necessary to bring approved varieties into the production system
- Government or industry-driven registration systems are often used – they should be formalized and structured
- Plant breeders need protection of their intellectual property investment and payment (royalties)

Seed Multiplication

- From breeder seed level to wide commercial availability can take two or three growing seasons to multiply the quantity of seed
- It is import that variety (genetic) purity be maintained to assure good seed performance
- Seed certification and registration system needs government control or a strong industry association to assure purity

Commercial Production

- Farmers need a good supply of pure, well performing seed
- Farmers need good information on the attributes of the variety and how it will fit with the particular growing region
- Commercial production needs to be kept segregated so the quality attributes put into the seed can get to the end user
- Farmers need to be paid for the value of the seed they are growing

A Balanced System

- Key components – a review
  - Breeders need to understand the pest, disease and agronomic variability of the region the seed will be planted
  - Quality objectives from the end-user (baker, miller, noodle maker) need to be transmitted to the breeder so these attributes can be introduced into new varieties
  - Farmers need to keep their seed pure and product segregated so there is consistency of expected performance

A Balanced System

- Key components – a review
  - Regulations and controls need to be fair, effective and in the right place
  - Farmers need to get the value back for what they produce so they can do it again, year after year
  - A good, balanced breeding development and production system will benefit the total value chain


thank you