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Florida Small Farms and Alternative Enterprises Conference

An Intro to Plant Breeding
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An Intro to Plant Breeding

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Tomatoes cause under-arm odour

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ARTICLE INFO

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ABSTRACT

Under arm odour [axillary odour AO, bromidrosis] is a deeply unpleasant problem that can affect a person’s self confidence and esteem and reduce social interaction. It is generally managed by good hygiene along with antiperspirants and deodorants, but the axillary apocrine glands may need surgical removal in severe cases of odour.

The odour comes from microbial conversion of the apocrine secretions into short chain fatty acids like isovaleric acid and volatile sulphur compounds like 3-sulphanylhexan-1-ol. These can be detected at a few parts per billion to parts per trillion by the human nose so an unhygienic state is soon apparent. Recently genetics have been found to play an important role too as people with the AA variant of the ATP-binding cassette (ABC) transporter gene, ABCC11, do not secrete preodour substrates for bacterial conversion, while those with GA or GG variants do.

Hygiene and genetics are an incomplete explanation though. Because the longitudinal ALSPAC study found that there is a mismatch between patients’ secretory status, as determined by genetics, and their use of deodorants. This suggests that other metabolic pathways or compounds contribute to the odour. In this paper I propose that under arm odour is commonly caused by terpenes excreted via the axillary apocrine glands. I also show that these come from terpene and carotenoid-rich dietary sources including lycopene, tomatoes, orange peel and the glandular trichomes of tomato plants. These observations suggest that the axillary apocrine glands are a prominent excretory route for terpenes. Considering the quantities eaten, tomatoes are likely to be the main source of dietary terpenes, and under arm odour in turn. This study also shows that lycopene is probably metabolised by β-carotene 9 10 monoxygenase which cleaves β-carotene eccentrically at the 9 10 or 9’10’ position of the chain. Direct evidence of lycopene metabolism by β-carotene 9 10 monoxygenase has hitherto been lacking.

The study of terpene and carotenoid metabolism can be greatly advanced by analysing the content of axillary gland excretions.

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Why Breed Plants?

- Increased yield
- Increased reliability
- Expansion of crops to new areas
- Improved quality
- Adaptation to mechanization
- Aesthetic value
The Art and Science of Plant Breeding

• The Art-
  Skills in observation: identifying novel plants with unique value

• The Science-
  Developed as knowledge advanced in classical genetics and related plant sciences
Plant Domestication

• Began about 10,000 years ago

• Where?

• Why?
  – Permanent civilizations
  – Crop cultivation
  – Fewer people providing food
  – Societal progression (travel, trade, communication, advances in tool production, etc.)
Plant Domestication

• Traits under selection:
  – Seed retention (non-shattering)
  – Seed dormancy
  – Increased fruit/seed size
  – Concentration of fruit set
  – Plant architecture
  – Reproductive strategy
  – Uniform maturity
  – Secondary metabolites
The Art and Science of Plant Breeding

Gregor Mendel

Source: http://jlcpensees.wordpress.com/category/genetics-and-random-mutations/
Principles in Breeding

• Science founded on:
  1. Gene – unit of heredity
  2. Hybridization – tool for genetic manipulation
  3. Understanding of rules of genetic behavior

• Sources of variation
  – Genetic
  – Environment
  – Genetic * Environment
Principles in Breeding

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• Qualitative vs. Quantitative
Inbreeding
Breeding Strategies

- Dependent primarily on pollination method:
  - Self-pollinated
  - Cross-pollinated
    - Mechanisms to promote:
      - Self incompatibility
      - Male sterility
      - Monoecy
      - Dioecy
  - Inbreeding depression?
- Reproduction method
  - Sexual (seed)
  - Asexual

Table 1. List of common self-pollinating and cross-pollinating crops

<table>
<thead>
<tr>
<th>Self-pollinating</th>
<th>Cross-pollinating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td>Alfalfa</td>
</tr>
<tr>
<td>Common bean</td>
<td>Banana</td>
</tr>
<tr>
<td>Cotton</td>
<td>Carrot</td>
</tr>
<tr>
<td>Eggplant</td>
<td>Cassava</td>
</tr>
<tr>
<td>Lettuce</td>
<td>Cucumber</td>
</tr>
<tr>
<td>Oat</td>
<td>Maize</td>
</tr>
<tr>
<td>Pea</td>
<td>Onion</td>
</tr>
<tr>
<td>Peach</td>
<td>Potato</td>
</tr>
<tr>
<td>Peanut</td>
<td>Rye</td>
</tr>
<tr>
<td>Pepper</td>
<td>Sugar beet</td>
</tr>
<tr>
<td>Rice</td>
<td>Sunflower</td>
</tr>
<tr>
<td>Soybean</td>
<td>Sweetpotato</td>
</tr>
<tr>
<td>Tomato</td>
<td>Watermelon</td>
</tr>
</tbody>
</table>
Breeding Strategies

- Bulking
- Single-seed-descent
- Pedigree-selection
- (Backcrossing)
- Recurrent selection
- Mass selection
- Hybrid breeding
Why hybrids?

- Heterosis (hybrid vigor)
- Proprietary protection
- Trait complementation
  - Essential for some traits
Tools in Breeding

~3000 – 8000 BC  Crop domestication
1865 (1900) AD  Gregor Medel
Early 1900’s  Hybrid corn
1930  Plant Patent Act
1937  Colchicine
1940’s  First use of male sterility
1950’s  Radiation; tissue culture
1953  Watson and Crick
1960’s  Breeding programs at Land Grants
1970  Plant Variety Protection Act
1970  Norman Borlaug, “Green Revolution”
1980’s  Expansion of private industry breeding
1990’s  Beginning of transgenics
2000’s  Genome sequencing
2010’s  Genome editing
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Mutation Breeding

• Keys
  – Supplement/tool
  – Most mutations are deleterious
  – Some extravagant claims
  – To increase genetic variability
  – A major force in evolutionary theory

• An example
  – ‘Mitcham’ cv. mint
  – Susceptible to *Verticillium* wilt
  – 1955 – irradiation of >100,000 stolons
  – → more than 6 million plants
  – Selection of 7 highly R clones
  – 1971 – ‘Todd’s Mitcham’ Peppermint
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Tools in Breeding

• Markers
  – Types
    • Morphological
    • Biochemical
    • Cytological
    • Molecular
  – To assist selection
    • Earlier selection
    • Reduce expense
    • Improve accuracy
    • Complex genetics
Tools in Breeding

• Markers
  – To assist selection
    • Earlier selection
    • Reduce expense
    • Improve accuracy
    • Complex genetics
A Few Success Stories

- **Hybrid corn**
- 1970 Norman Borlaug - Semi-dwarf wheat
- T.T. Change - Semi-dwarf rice (>40% inc)
- Emil Wolfe – *sh2* gene; ‘Florida StaySweet’
- 1960’s – Heinz & UF collaboration for tomato fruit firmness
- Jack Hannah – mechanically harvestable processing tomato
- Seedless banana
- Seedless watermelon
- Sweeter carrots
- “Spineless” Okra
- “Stringless” string beans
- Low-chill blueberries and peaches
- GE Herbicide resistance
- GE Insect resistance
- GE Virus resistance
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- GE Virus resistance
Seedless Watermelon

• Kihara
  – Began work in 1939
  – Hybrids available in 1951

Source: http://www.macroevolution.net/mitosis-versus-meiosis.html
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- Seedless banana
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- Sweeter carrots
- “Spineless” Okra (‘Clemson Spineless’ 1939)
- “Stringless” string beans (Calvin Keeney, 1894)
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- GE Herbicide resistance
- GE Insect resistance
- GE Virus resistance
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Intellectual Property Rights for New Varieties of Plants and Germplasm

- Plant patent
- Plant variety protection (PVP) certificates
- Utility patents
- Plant breeder’s rights
Intellectual Property Protection for Plant Varieties

- USA
  - Plant patent
    - Administered by United States Patent and Trademark Office (USPTO)
    - Granted to novel, distinct, and non-obvious plant varieties which are asexually reproduced
      - E.g. blueberry, strawberry, gerbera, vegetatively propagated turfgrass
    - Excludes sexually reproduced plants and tuber-propagated plants
Intellectual Property Protection for Plant Varieties

- USA
  - Plant patent
    - “Whoever invents or discovers and asexually reproduces any distinct and new variety of plant, including cultivated sports, mutants, hybrids, and newly found seedlings, other than a tuber propagated plant or a plant found in an uncultivated state, may obtain a patent therefore…”
Intellectual Property Protection for Plant Varieties

- **USA**
  - Plant patent
  - Grant lasts for 20 years from the date of filing application
  - Allow the inventor or assignee to exclude others from asexually reproducing the plant, and from using, offering for sale, or selling the plant so reproduced, or any of its parts, throughout the US, or from importing the plant so reproduced, or any parts thereof, into the US.
Intellectual Property Protection for Plant Varieties

- USA
  - Plant Variety Protection Certificate (PVP)
    - Plant Variety Protection Act of 1970
    - Enacted to encourage the development of novel varieties of sexually reproduced plants and to make them available to the public, providing protection available to those who breed, develop, or discover them, and thereby promoting progress in agriculture in the public interest.
Intellectual Property Protection for Plant Varieties

- USA
  - Plant Variety Protection Certificate (PVP)
    - Administered by the United States Department of Agriculture (USDA)
    - Granted to novel, distinct, uniform, and stable varieties which are sexually reproduced
      - E.g. peanut, oats, bahiagrass, wheat, tomato
Intellectual Property Protection for Plant Varieties

- USA
  - Plant Variety Protection Certificate (PVP)
    - Grant lasts 20 years from the certificate’s date of issue
    - Allows the certificate holder to exclude others from selling or marketing the variety, offering it for sale, delivering it, shipping it, consigning it, exchanging it, reproducing or multiplying it, or importing/exporting it, or using a variety for the production (not...
Intellectual Property Protection for Plant Varieties

- **USA**
  - Plant Variety Protection Certificate (PVP)
    - Exemptions
      - Right to Save Seed (Farmer Saved Seed Exemption)
        - It is not an infringement for a farmer to save seed it produces from seed obtained, or descended from seed obtained, by authority of the owner of the variety for seeding purposes.
      - The farmer can use such saved seed in the production of a crop for use on his/her farm.
Intellectual Property Protection for Plant Varieties

- USA
  - Plant Variety Protection Certificate (PVP)
    - Exemptions
      - Research Exemption
        - It is not an infringement to use and reproduce a protected variety for plant breeding or other bona fide research.
Intellectual Property Protection for Plant Varieties

- USA
  - Utility Patents
    - Administered by USPTO
    - Granted for a new and useful process, machine, article of manufacture, or composition of matter, or any new and useful improvement thereof.
      - E.g.: High oleic peanuts and peanut products
Intellectual Property Protection for Plant Varieties

- **USA**
  - **Utility Patents**
    - Grant is 20 years from the date of application filing (same as plant patents)
    - Diamond v. Chakrabarty – 1980
      - Chakrabarty (General Electric) developed bacterium capable of breaking down crude oil
      - GE filed a patent application
      - Application rejected by USPTO
      - Appealed by GE
Intellectual Property Protection for Plant Varieties

- USA
  - Utility Patents
    - Diamond v. Chakrabarty – 1980
      - Board of Patent Appeals agreed with original decision
      - US Court of Customs and Patent Appeals overturned the case in Chakrabarty’s favor
        - “The fact that micro-organisms are alive is without legal significance for the purposes of the patent law”
      - Diamond (USPTO Commissioner) appealed to the US Supreme Court
Intellectual Property Protection for Plant Varieties

- USA
  - Utility Patents
    - Diamond v. Chakrabarty – 1980
      - Supreme Court ruled 5-4 in favor of Chakrabarty
      - Held that living, man-made organisms are patentable subject matter as a “manufacture” or “composition of matter”
    - Dissent said that Plant Patent Act of 1930 and PVP Act of 1970 would not have been created if Congress already had a means for protection of living organisms (plants).
Intellectual Property Protection for Plant Varieties

- USA
  - Utility Patents
    - JEM Ag Supply v. Pioneer Hi-Bred International, Inc.
      - Pioneer protected plants under PVP and utility patent
      - Maintained a license that:
        - Prohibited seed (or progeny thereof) for propagation or seed multiplication purposes (Farmer Saved Seed Exemption)
        - Prohibited seed to be used in the development of a hybrid or different variety (Research Exemption)
Intellectual Property Protection for Plant Varieties

- USA
  - Utility Patents
    - JEM Ag Supply v. Pioneer Hi-Bred International, Inc.
      - Can utility patents be issued for plants or are the only options plant patent or PVP?
      - Utility patent requires the invention to be new, useful, and non-obvious.
      - Inventor must also describe the plant with sufficient specificity to enable others to make and use the invention after the patent expires
      - Public seed deposit
Intellectual Property Protection for Plant Varieties

- USA
  - Utility Patents
    - JEM Ag Supply v. Pioneer Hi-Bred International, Inc.
      - PVP does not require applicant to show usefulness or non-obviousness (only D, U, S).
      - PVP requires seed deposit, but this is not public until the PVP expires.
      - The Supreme Court ruled that multiple forms of IP can be used to protect new plant varieties.
Intellectual Property Protection for Plant Varieties

- USA
  - Trademarks
    - Administered by USPTO
    - Don’t protect varieties – only marks used in combination with certain goods or services to identify such goods and services as unique and distinguishable.
      - E.g.:
Intellectual Property Protection for Plant Varieties

- International
  - Plant Breeder’s Rights
    - International Union for the Protection of New Varieties of Plants (UPOV)
      - Established in 1961 to encourage the development of new varieties of plants for the benefit of society
      - 70 signatory countries to the UPOV convention
Intellectual Property Protection for Plant Varieties

- International
  - Plant Breeder’s Rights
    - Each foreign country administers its own legislation
    - Provides PVP-like protection to new varieties of plants
    - Includes D-U-S evaluation
Intellectual Property Protection for Plant Varieties

- International
  - If international protections are not sought, plant varieties become part of the public domain in foreign territories.
  - A variety can be protected under U.S. plant patent or PVP and licensed domestically, but this protection only governs the use and commercialization of such variety in the U.S.
Intellectual Property Protection for Plant Varieties

- International
  - It is not cost effective to file plant breeders rights in all territories – only file where there is potential for commercialization of such variety within the territory
  - Through international protection and licensing, royalties can be returned to support local breeding programs
Thank You!

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