HOME-SCALE GRAIN PRODUCTION

Mark Dempsey
Carolina Farm Stewardship Association
Organic Growers School Spring Conference – March 2020
INTRODUCTION

- Grain Crops
  - Cereals
  - Legumes
  - Pseudo-cereals
  - Oilseed crops

- Why grow on small scale?
  - Can grow staple foods
  - Family-scale
  - Retail high-end grains
  - Reduce animal feed costs
  - Match what you grow with what you eat
SCALE & EFFICIENCY

- Will never be efficient as:
  - Big grain growers (lbs/hr)
  - Vegetables ($/acre)

- But can:
  - Diversify your operation
  - Help meet nutritional needs
  - Help rethink food system
  - Reduce feed costs
  - Improve soil nutrient management
THE CROPS

- Cereals
- Legumes
- Pseudo-cereals
- Oilseed crops
CEREALS

- Corn
- Sorghum
- Small Grains
  - Wheat
  - Rye
  - Barley
  - Oats
  - “Ancient” wheats
- Rice
CEREALS

- Highest yields
- Tolerate wider soil water range
- Warm vs. cool season
  - Affects crop rotation
  - Affects yields:
    - Summer (corn+sorghum) > winter (small grains)
    - Fall-planted (“winter”) > spring-planted (“spring”)
  - Differ in nutrient requirements
    - Warm: Higher N / Lower K
    - Cool: Lower N / Higher K
## CEREALS

- **High N demand**
  - Corn: 130 lb/a (3 lb/1000 sq.ft)
  - Sorghum: 100 lb/a (2.3 lb/1000 sq.ft)
  - Small grains: 60 lb/a (1.4 lb/1000 sq.ft)

- **Lots of calories, but low nutritional value:**

<table>
<thead>
<tr>
<th></th>
<th>bu/a</th>
<th>lbs/1000sq.ft</th>
<th>% Protein</th>
<th>% Fat</th>
<th>% Carb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>160</td>
<td>205</td>
<td>10%</td>
<td>5%</td>
<td>82%</td>
</tr>
<tr>
<td>Sorghum</td>
<td>90</td>
<td>115</td>
<td>12%</td>
<td>4%</td>
<td>82%</td>
</tr>
<tr>
<td>Wheat, rye &amp; barley</td>
<td>60-90</td>
<td>80-125</td>
<td>11-14%</td>
<td>2%</td>
<td>84-86%</td>
</tr>
<tr>
<td>Oat</td>
<td>80</td>
<td>60</td>
<td>18%</td>
<td>7%</td>
<td>71%</td>
</tr>
</tbody>
</table>

- **Yields are high, they have culinary value, high energy feed for animals**
LEGUMES

- **Warm Season:**
  - Dry bean & other *Phaseolus* spp
  - Soybean
  - Cowpea, Adzuki & other *Vigna* spp
  - Peanut

- **Cool Season:**
  - Pea
  - Lentil
  - Chick-pea
LEGUMES

- Lower yields than cereals
- Narrower moisture tolerance range
  - More sensitive to wet than dry
- Warm vs. cool season
  - Affects crop rotation
  - Affects yields:
    - Summer (bean+cowpea) > winter (pea+lentil)
    - Fall-planted > spring-planted (potentially)
- Less winter-hardy than cereals
Development & growth habit:
- Naturally indeterminate / vining
- Vining bred out of many varieties
- “Vining” gradient:
  - 4 categories
### Lower soil nutrient needs than cereals
- **N-fixation**
- **Lower total P & K needs**
  - Higher P & K need per lb grain

### Higher nutrient content

<table>
<thead>
<tr>
<th></th>
<th>bu/a</th>
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<th>% Fat</th>
<th>% Carb</th>
</tr>
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<tbody>
<tr>
<td><strong>Cereal</strong></td>
<td></td>
<td></td>
<td></td>
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<td>60</td>
<td>18%</td>
<td>7%</td>
<td>71%</td>
</tr>
<tr>
<td><strong>Legume</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bean</td>
<td>35</td>
<td>55</td>
<td>22-24%</td>
<td>2%</td>
<td>68-70%</td>
</tr>
<tr>
<td>Soybean</td>
<td>55</td>
<td>75</td>
<td>33-40%</td>
<td>21%</td>
<td>32%</td>
</tr>
<tr>
<td>Pea</td>
<td>50</td>
<td>65</td>
<td>26%</td>
<td>1%</td>
<td>69%</td>
</tr>
<tr>
<td>Lentil</td>
<td>25</td>
<td>35</td>
<td>26%</td>
<td>1%</td>
<td>68%</td>
</tr>
</tbody>
</table>
PSEUDO-CEREALS

- Buckwheat
- Amaranth
- Quinoa
PSEUDO-CEREALS

- Lowest yields among grains
- Little breeding effort
  - Room for improvement
- Favorable nutrient profiles
  - Mod. high protein compared to cereals
  - Rich in micronutrients
- Growers be warned:
  - Easily become weedy
    - Thousands seeds/plant
    - Seed size & flower structure: harvest losses
PSEUDO-CEREALS

- Buckwheat
  - Excellent performance on poor soils
  - Prefers cool temps, but frost-tender
  - Indeterminate growth habit & day-length sensitive
    - Tricky harvest management: swathing strongly preferred
  - Sow-to-harvest time: 10-15 weeks
  - Fits in well after spring/summer crop
    - Planted mid-Aug. (mountains) to early Sept. (coast)
  - Great pollinator resource
  - Low nutrient requirements: 25/15/20 N-P-K per acre
OILSEED CROPS

- High oil content
- Not used as grains per se
  - But some crops double-duty
- Uses
  - Oil extraction
  - Animal feed (meal): high quality
  - Food
  - Processing: peanut butter, tahini
OILSEED CROPS

- **Legumes:**
  - Soybean
  - Peanut

- **Brassicas:**
  - Canola
  - Camelina

- **Asters:**
  - Sunflower
  - Safflower
OILSEED CROPS

- Other oilseeds:
  - Flax
  - Sesame
  - Okra
CROP ROTATION

- Cereal – Legume – Pseudo-cereal
- Alternate warm & cool season
- Double crop opportunity:
  - Buckwheat or other crop after winter wheat
  - Corn after winter pea/lentil
  - Beans after winter wheat
- Cover crops integrate well with grain crops
3 Crops
Low Intensity: "Give+Take"

Winter Wheat

Dry Bean

Soybean

Winter Cover Crop: Rye/Black Oat + Crimson Clover

Winter Pea

Winter-killer CC: Oats+Radish

Winter Pea

Winter Fallow

Okra

Buckwheat

Sunflower

Winter wheat

Corn

Dry Bean

Wheat

Soybean

Corn

Lentil

Chickpea

Mung

Adzuki

Cowpea

Buckwheat
4 Crops
Med. Intensity w/Buckwheat

Winter Wheat
Summer Fallow
Buckwheat
Sunflower
Okra
Winter-killed CC:
Oats+Radish
Winter Pea
Winter Lentil
Winter Pea

Winter Cover Crop:
Rye/Black Oats + Crimson Clover

Wheat
Buckwheat
Lentil
Cowpea
4 Crops Med. Intensity w/Okra

Year 1:
- Winter Wheat
- Winter Pea
- Winter Cover Crop: Rye/Black Oat + Crimson Clover
- Lentil

Year 2:
- Summer Fallow
- Summer Cover Crops
- Buckwheat
- Winter- Killed CC: Oats+Radish

Year 3:
- Corn
- Lentil
- Mung
- Sunflower

Wheat
Okra
Chickpea
Adzuki bean
PRODUCTIVITY

<table>
<thead>
<tr>
<th>Crop</th>
<th>High yield</th>
<th>Low yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn (160 bu/a)</td>
<td>150</td>
<td>20</td>
</tr>
<tr>
<td>Sorghum (90 bu/a)</td>
<td>125</td>
<td>10</td>
</tr>
<tr>
<td>Wheat (60 bu/a)</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>Oat (80 bu/a)</td>
<td>50</td>
<td>10</td>
</tr>
<tr>
<td>Bean (45 bu/a)</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>Soybean (55 bu/a)</td>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td>Pea (50 bu/a)</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Lentil (25 bu/a)</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>Buckwheat (20 bu/a)</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>

Lbs grain/1000 sq ft
**GROWING NUTRIENTS**

<table>
<thead>
<tr>
<th>Protein (lbs/acre)</th>
<th>Cereal</th>
<th>Legume</th>
<th>Animal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Corn</td>
<td>Sorghum</td>
<td>Wheat</td>
</tr>
<tr>
<td></td>
<td>Oat</td>
<td>Dry bean</td>
<td>Soybean</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pea</td>
<td>Lentil</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Buckwheat</td>
<td>Beef</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pork</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Chicken</td>
</tr>
</tbody>
</table>
GROWING NUTRIENTS

- 2500 sq ft. Extensive Rotation
- Corn – Bean – Wheat – Pea/Lentil (4-yr)
- 150-200 lbs total
- 30-40% of daily calories grown
- 33-42% of protein needs grown
- 1 person, 2500 cal/day, 100 g protein/day
- If target was protein “sovereignty”, would need 3600-4000 sq.ft. (total) per person
- *75% of protein needs met: 75% legume, 25% cereal
ANIMAL FEED

- Supplement purchased with homegrown
- Grow all feed for flock/herd
- Egg layer example:

**Graphs:**
- **Lbs grain / bird / year**
  - Multigrain Diet
  - Oat only (low yield)
  - Corn + Pea (high yield)

- **Sq ft / bird / year**
  - Multigrain Diet
  - Oat (low yield)
  - Corn + Pea (high yield)
## PLANTING: row & seed spacing

<table>
<thead>
<tr>
<th>Cereals</th>
<th>Date</th>
<th>Plants/acre</th>
<th>Row spacing</th>
<th>Seed spacing/density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>1 wk. b/f last frost</td>
<td>25k</td>
<td>24“ or 30”</td>
<td>10” or 8”</td>
</tr>
<tr>
<td>Sorghum</td>
<td>1 wk after last frost</td>
<td>100k</td>
<td>24“ or 30”</td>
<td>2.5” or 2”</td>
</tr>
<tr>
<td>Wheat</td>
<td>1st wk. Oct</td>
<td>1 million</td>
<td>6” (or broadcast)</td>
<td>1” (23 per sq.ft.)</td>
</tr>
<tr>
<td>Oat</td>
<td>1 wk. b/f wheat</td>
<td>1 million</td>
<td>6” (or broadcast)</td>
<td>1” (23 per sq.ft.)</td>
</tr>
<tr>
<td>Legumes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bean</td>
<td>last frost</td>
<td>50k-100k</td>
<td>24”</td>
<td>5” – 2.5”</td>
</tr>
<tr>
<td>Soybean</td>
<td>last frost</td>
<td>100k-200k</td>
<td>24”</td>
<td>2.5” – 1.25”</td>
</tr>
<tr>
<td>Pea</td>
<td>1st half Sept</td>
<td>300k</td>
<td>12” (or broadcast)</td>
<td>1.5”-2” (7 per sq.ft.)</td>
</tr>
<tr>
<td>Lentil</td>
<td>1st half Sept</td>
<td>500k</td>
<td>6” (or broadcast)</td>
<td>2” (12 per sq.ft.)</td>
</tr>
<tr>
<td>Pseudo-cereals</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buckwheat</td>
<td>Early Aug</td>
<td>200k</td>
<td>12” (or broadcast)</td>
<td>2.5” (5 per sq./ft.)</td>
</tr>
</tbody>
</table>
PLANTING: cover crop termination
PLANTING: cover crop termination
PLANTING: cover crop termination
PLANTING: equipment
**IN-CROP MANAGEMENT**

- Generally unirrigated
- Weed control via cultivation, hand-weeding or various mulches
- Fertility applied before planting or in-crop as needed (corn & wheat in particular)
- Insect & disease issues treated as they arrive
IN-CROP MANAGEMENT
IN-CROP MANAGEMENT
## PEST MANAGEMENT

<table>
<thead>
<tr>
<th>Cereal</th>
<th>Insect pest (control measures)</th>
<th>Disease (control measures)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>Euro corn borer (modern varieties)</td>
<td>Gray leaf spot (crop rotation)</td>
</tr>
<tr>
<td></td>
<td>Corn rootworm (crop rotation)</td>
<td>Corn leaf blight (crop rotation)</td>
</tr>
<tr>
<td></td>
<td>Black cutworm &amp; wireworm (tilleage)</td>
<td>Sorghum leaf blight</td>
</tr>
<tr>
<td>Sorghum</td>
<td>Midge</td>
<td>Sorghum leaf blight</td>
</tr>
<tr>
<td></td>
<td>Cornstalk borer</td>
<td>Leaf spot</td>
</tr>
<tr>
<td></td>
<td>Soil insects</td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>Hessian fly (plant after &quot;fly free&quot; date)</td>
<td>Powdery mildew (plant later in fall)</td>
</tr>
<tr>
<td></td>
<td>Aphid (plant later in fall)</td>
<td>Headscab / Fusarium head blight (difficult)</td>
</tr>
<tr>
<td>Oat</td>
<td>Cereal leaf beetle</td>
<td>Barley yellow dwarf (modern varieties)</td>
</tr>
<tr>
<td>Legume</td>
<td>Bean</td>
<td>Fusarium root rot</td>
</tr>
<tr>
<td></td>
<td>Mex bean beetle</td>
<td>Angular leaf spot / Bacterial brown spot</td>
</tr>
<tr>
<td></td>
<td>Jap beetle</td>
<td></td>
</tr>
<tr>
<td>Soybean</td>
<td>Corn maggot (wait to plant after tilling)</td>
<td>White mold (modern varieties)</td>
</tr>
<tr>
<td></td>
<td>Soybean aphid (modern varieties)</td>
<td>Septoria brown spot (wide row spacing)</td>
</tr>
<tr>
<td></td>
<td>Spider mite (modern varieties)</td>
<td>Downy mildew (wide row spacing)</td>
</tr>
<tr>
<td>Pea</td>
<td>Root rots: Pythium / Fusarium</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Foliar diseases: Ascochyta / Anthracnose / Stemphylium</td>
<td></td>
</tr>
<tr>
<td>Lentil</td>
<td>Leafhopper</td>
<td>Like pea, but also viruses</td>
</tr>
<tr>
<td></td>
<td>Tarnished bug</td>
<td></td>
</tr>
<tr>
<td>Pseudo-buckwheat</td>
<td>Aphid</td>
<td>Powdery mildew</td>
</tr>
<tr>
<td>cereal</td>
<td>Wireworm</td>
<td>Sclerotinia stem rot</td>
</tr>
</tbody>
</table>
Harvest when crop has died back & grain has dried down

Pick beans as pods turn brown

Buckwheat better swathed and threshed when plant is wet to avoid seed loss

All grain crops are higher quality before being weathered

Dryer is better for storage, but not all situations allow for very dry harvest
HARVEST: equipment

- Small grains & buckwheat:
  - Sickle, Scythe, electric trimmer, sicklebar mower
- Beans & sorghum:
  - Clippers for threshing whole plants/tops
- Hand pick corn ears or bean pods
- Small-scale combines ("plot combines")
- Walk-behind combines
- Reaper/binder combination w/ threshing machine
THRESHING
THRESHING

- By-hand
- Bag + beat-up
- Large tote + footwork
- Treadle thresher
- Homemade thersers
- Small-scale combines ("plot combines")
- Walk-behind combines
- Reaper/binder combination w/ threshing machine
CLEANING

- Screens & wind
STORAGE

- Bags, buckets, barrels & bins
- Dry before or in storage: Air and/or heat
- 55-60 lb (1 bu) = 9.3 gallons
  - 10 gallon barrel holds 1 bu + headspace
  - 5 gal bucket holds ~30 lb grain
- Storage pests can be treated
  - Freezing (0°F - 10°F) for 10 days
  - Heating (130°F) for 10 minutes
  - Diatomaceous earth & spinosad 90% effective
ANY QUESTIONS?