REPORT

OF

OAT ENHANCEMENT WORK SESSION

Madison, WI

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Purpose of Work Session

Large surpluses of such major crops as wheat, corn, and soybeans have prompted a renewed emphasis on the adaptation of "new" or alternate crops to acreage currently occuppied by surplus crops. Rather than "force fit" an exotic crop to fill such a need, it seems more logical to take advantage of genetic variability within an already adapted crop such as (specifically) oats to develop new types of the crop with expanded usefulness and value. Oats are not in surplus. In fact, up to 5 percent of the U.S. supply must now be imported.

The work session recognized, but did not address, the importance of adequately protecting the crop from disease, insect, and environmental stresses. Rather, the participants attempted to map both short- and long-term strategies by which to alter key yield and quality (including nutritional) traits, so as to increase oat value and demand.

Specific Objectives

The work session explored approaches to achieving the following:

- Protein - increase the quantity of oat protein produced (both per groat and per unit area of production).
- Lipids - improve the quantity, quality, and distribution of fatty acids in oat groats.
- Fiber - increase the quantity and distribution of soluble fiber (as indicated by ß-glucan measurement) in oat groats.
- Hull percent - reduce amount of hull while maintaining desirable groat quality.
- Yield - increase yield by improving production efficiency.
- Nutritional needs - develop broad database reflective of the nutritional value of oats.

Considerations

Key considerations that were raised and discussed, relative to each research objective, are as follows:

Protein

- Oat protein quality is already excellent, so selection for improved quality need not be of high priority.
- Reasonable breeding objectives would include groat proteins of 25-26 percent and 700+ pounds of protein per acre.
- High oat protein content may be of particular value in feed for young pigs and lactating dairy cattle and in specialty food products.

- Combinations of high oil and protein will be important for high energy animal feeds.
- New protein evaluation data (associated with yield) are needed for the oat germplasm collection.
- Studies are needed of nitrogen uptake, metabolism, and mobilization.
- Small sample size and nondestructive analysis techniques would encourage early generation screening of individual plants.
- Manipulation of regulator genes in the seed could reduce the tendency of plants to waste nitrogen previously absorbed but lost during ripening.
- Key locations for oat protein evaluation and enhancement research would include Madison, Ames, Aberdeen, and Raleigh.

Lipids

- The current range of variability is 2-15 percent.
- Oil content has shown no correlation with other characteristics.
- Immense variations exist in fatty acid composition of oat oil.
- Oat oil is high in polar lipids such as phospholipids and glycolipids.
- High oil (high energy) oats have significant potential for dairy and swine feeding--especially if the use of growth hormone gains approval.
- Oats could be a special (natural) source of antioxidant--useful for its food stabilization and anticarcinogenic properties.
- An oil content of 18 percent would probably be needed for oats to be considered an "oil crop."
- Genetic variability exists for lipases; Hammond (Iowa) suggests that zero level is possible.
- Lipoxygenases--the most heat stable of enzymes--are being studied at Minnesota.
- Enhancement of both the quantity and quality of oat lipids should be a high priority.

Fiber

- Not all dietary fiber is of equal benefit to human consumers. Soluble fiber such as that found in oats has been proven effective in lowering serum cholesterol levels, as well as in reducing the insulin requirements of some diabetics.
- ß-glucans are the best indicators of soluble fiber.

- The currently estimated range of ß-glucan in oats is 2-6 percent based upon a very small sample of available germplasm.
- Determining the exact range of ß-glucan residing in the oats germplasm collection must receive high priority.
- Large-scale production of low (approximately 2 percent) and high (approximately 5 percent) ß-glucan genotypes is needed for oat milling evaluations.
- Screening for ß-glucans is possible with:
  a. Image analysis - uses half-seed, but the equipment is expensive.
  b. ELISA - is cheaper than image analysis, but less accurate.
  c. Scanning fluorescent microscopy - uses the same principle as image analysis, since ß-glucans are in cell walls.
  d. NIR - may have potential.
- High ß-glucens are desirable for all oat uses, except in the feeding of very young animals.

Hull Percentage

- Hulls reduce the value of oats.
- Current hull-percentage measurement methods are imprecise.
- Test weight provides relatively little useful information.
- Image analysis may offer potential for more accurate measurement of hulls.
- Groat yield per unit area is an important determinent of oat value.
- Oat ideotypes are needed with either lower hull percentage (<23 percent) or hull-less trait.
- Research on hull-less oats is being conducted at Ottawa; University Park, Pennsylvania; Coker's (South Carolina); Mexico; Wales; and (possibly) U.S.S.R.

Yield

- Yield can be increased via recurrent selection (Minnesota).
- Since nighttime respiration rates influence yield, genetic variability for this trait should be measured.
- RFLP techniques can help confirm quantitative models (Aberdeen).

- Increases might be attained through extension of the growing season, although night temperatures are probably a limiting factor.

- The most important measurements of productivity are thought to be:

  a. groat yield per acre,

  b. protein yield per acre, and

  c. oil yield per acre (which greatly influences metabolizable energy).

Nutritional Factors

- Must identify various oat nutritional properties relative to composition of the entire groat; e.g., the impact of ß-glucans in relation to the lipids present.

- Need to conduct feeding tests utilizing oat genotypes with different levels of ß-glucans.

- Need to determine what property (perhaps the gum fraction) gives oats the reputation of being a cereal that "sticks to your ribs."

- Need to verify the presumption that ß-glucans do not inhibit trace mineral uptake.

- Need to investigate the potential for improving animal products by feeding oats; e.g., in Britain, increasing the amount of oats in winter feed for dairy cattle has been found to increase the proportion of monounsaturated fats in milk. Oats with high oil content would, presumably, be even more effective.

- Need to produce new oat-based foods for humans, large animals, and pets which are nutritionally balanced, without dilution or deletion of existing good qualities.

Research Strategies

The oat research community is relatively small, but it is competent and cohesive. Working largely with existing resources, this "consortium of consenting collaborators" has the potential to achieve significant progress toward both short-term and long-term objectives. The action items which follow represent the first steps in what must be a continuing process of planning, coordination, and cooperation.

Protein

- Give very high priority to the systematic evaluation of oat germplasm for protein, along with associated yield information (Madison, Aberdeen).

- Continue and/or accelerate efforts to increase the quantity of oat protein in productive agronomic types (Ames, Raleigh, others).

- Intensify investigations of nitrogen uptake, metabolism, and mobilization (may require grant support--possibly Lafayette and/or St. Paul).

- Address the need for updated assay equipment at Madison (location, area office, National Program Staff).

Lipids

- Increase lipid quantity and build adapted gene pools (Ames, Raleigh).

- Determine fatty acid composition, distribution, and associated genetic variability (Ames, Madison, Aberdeen).

- Conduct an antioxident survey within oat germplasm (Ames).

- Initiate lypoxygenase research (St. Paul).

- Increase seed of a high-oil type for testing by Quaker Oats (Ames).

- Address the need for new NIR at Madison for oil and protein analysis (location, area office, National Program Staff).

- Obtain assays commercially from Illinois.

Fiber

- Give very high priority to evaluating the oat germplasm collection for β-glucan (with fluorescent microscopy) (Albany, National Program Staff, Beltsville/Aberdeen).

- Evaluate with ELISA the elite set of germplasm selected by the Albany screening (Madison).

- Emphasize enhancement of β-glucan quantity in oats in other breeding programs (All).

Hull Percentage

- Continue breeding for hull-less varieties (Ottawa, University Park, Hartsville, others).

- Emphasize reduction of hull percentage in breeding and enhancement programs (All).

- Develop improved method(s) for small-scale analysis of hull percentage--possibly through image analysis (Manhattan, others).

Yield

- Nursery coordinators need to request and encourage reporting of (a) groat yield per acre, (b) protein yield per acre, and (c) oil yield per acre (Aberdeen, St. Paul, University Park).

- Develop RFLP mapping information that adequately reflects the genetic and physiologic factors limiting yield expression (Aberdeen).

- Generate the much-needed information to better understand photosynthetic efficiency and night respiration in oats (University Park, St. Paul, Madison, others).

Nutritional Factors

- Facilitate improved interface between existing nutrition research laboratories (Albany, Barrington, National Program Staff, others).

- Increase collaboration among nutrition and plant science research communities (National Program Staff, Albany, Madison, Barrington, others).

- Determine the structure of specific ß-glucans (Madison).

- Track the ß-glucan/cholesterol relationship (Barrington).

- Determine therapeutic threshold levels of oats in various diets (Albany).

- Provide continual feedback to plant scientists (Albany).

- Interact with animal nutritionists; e.g., Vaughn Spear (Ames) or Rosemary Newman (Bozeman), to interpret and communicate broad nutritional requirements to plant scientists (Albany).

- Investigate mechanisms responsible for beneficial physiologic effects associated with oat consumption (Albany).

Summary

This work session was a first step toward implementation of a cooperative research effort that has exciting potential--both in terms of increasing farm income and improving consumer health. The ideotypes described in the table represent difficult but probably achievable goals. Significant progress toward their achievement should be possible within a relatively short time utilizing currently available resources.

Table. Oat Ideotypes (potentially achievable ideals) for Specific Utilization Purposes

Potential Use	Ideotype							
					Yield			
	Prot. %	Oil %	β-glucan %	Groat %	bu/A	lbs. Groats/A	lbs. Prot./A	lbs. oil/A
Human food	24	7	10	79	180	4,550	1,092	318.5
Animal feed	20	14	4	100	140	4,480	896	627.2
Animal feed (starter)	24	14	2	100	140	4,480	1,075	627.2
Oil crop	18	18	4	79	180	4,550	819	819.0
Current potential	19	7	4	75	150	3,600	684	252.0