Physiological Studies of Small Grains

Dr. Robert G. McDaniel
Plant Physiologist

Agriculture starts with the seed. In a large number of instances, across an array of seeded crops, the overriding limitation to greater production efficiency and higher yields is the quality, vigor and genetic potential of planting seed. Poor seed resistance to environmental stresses at planting time, poor germination and emergence under field conditions due to salinity or plant pathogen stresses; and low vigor seed lots, all may contribute to unexpectedly poor yields. Increasing costs of nearly all agricultural inputs, including more expensive planting seed, affirm the importance of research to improve genetic potential and quality of planting seed.

As part of the seed physiology program in the department of Plant Sciences, we have been investigating factors which contribute to the seed quality of small grains, specifically barley and wheat, for several years. We believe identification of superior quality seed, along with a fuller understanding of the factors contributing to the production of high quality seed are essential. Efforts to improve the genetic potential of seed will contribute to basic understanding of seed, and should serve to enhance our capability of capitalizing on the initial advantages of high quality planting seed throughout the growing season.

One analogy for seed is that of a storage battery. A seed contains a finite amount of "stored energy" in the form of sugars and other carbon compounds, which must provide sufficient "fuel" for the embryo to emerge. Until the leaves of the emerging seedling begin to carry on photosynthesis, this stored energy is the sole power source for the embryo. Environmental stresses; cold, salt or disease, or any combination of these, cause the seedling to require more energy for emergence: just as the storage battery in a car has to provide more energy to start the car in very cold weather. Inferior seed usually contains less stored energy, or is less efficient in utilizing this energy for rapid germination. It is to our advantage then, to identify seed sources which have the greatest energy reserves, as one can surmise these seed lots will exhibit superior growth potential across an array of environments.

We have measured the capability of seed of different barley and wheat cultivars to utilize stored energy for germination. Seed potential has been evaluated by measurement of seedling mitochondrial activity. Mitochondria, the powerhouses of plant cells, have been found to be closely associated with seed quality in a number of crops. The rate and efficiency with which these cellular powerhouses "turn over" energy in the developing embryo directly reflects the vigor of that seedling.

In this work we have evaluated the relative importance of fertility and irrigation, as two factors of significance in production of high quality seed. Of special interest has been the identification of cultivars which are more efficient nitrogen users. In the face of increasing fertilizer costs, reflecting the dependence of the Haber process on petro-chemicals, identification and selection of small grain cultivars which produce equivalent grain yields with less applied nitrogen than present varieties should be valuable. Table 1 presents a comparison of yield response across applied nitrogen levels for two barley cultivars. Barley cultivars were produced in Montana, and yield data were made available through the courtesy of Gene Hockett, at the Montana Experiment Station.

Table 1. Effect of applied nitrogen on yield and mitochondrial efficiency of two barley cultivars. (Three field reps; two lab reps.)

Applied Ammonium Nitrate (lb/A):		0	30	60	90	120
Shabet:	(1) Yield (grams/plot)	46.60	66.90	76.00	78.50	76.00
	(2) Mitochondrial efficiency	1.98	2.08	1.99	2.15	2.07
Betzes:	(1) Yield (grams/plot)	41.90	63.60	69.70	75.80	76.60
	(2) Mitochondrial efficiency	1.94	2.00	2.12	2.12	2.06

These data illustrate both the different response trend of the varieties to applied fertility, and also the potential utility of laboratory seedling vigor tests to establish seed quality. Shabet exhibits an optimum response to 90 lb/A rates of applied nitrogen, while yield of Betzes is still increasing at the 120 lb rate. Equivalent grain production of Shabet can thus be achieved at lower applied nitrogen levels, enabling potentially lower input costs per unit grain produced. Interestingly, the trend of seedling mitochondrial efficiency follows that for grain yield, one indication that optimizing productivity in small grains also results in high quality seed production. In this preliminary experiment, grain yield and mitochondrial efficiency of seed produced are significantly positively associated ($r = +0.73^*$).

This relationship suggests that, when the seed produced in these field trials are planted, the seed produced under optimum environments, eg. the highest yielding plots, will have the potential of outperforming other seed in the subsequent season. Table 2 illustrates the results of an experiment designed to substantiate this possible "carry over" effect on seed quality. Seed and yield data furnished courtesy of Dave Mason, North American Plant Breeders, Brookston, Indiana.

Table 2. Effect of seed production location on seed vigor (mitochondrial efficiency) and grain yield of three barley cultivars.

Location of Seed Production	Mitochondrial Efficiency	Grain yield, Two year means (lb/A)
Regina, Canada	2.21 a	2503 a
Fargo, North Dakota	2.25 ab	2531 a
Lethbridge, Canada	2.45 bc	2387 a
Lethbridge, Canada (irrigated)	2.54 c	2819 b

Vertical means not followed by the same letter are significantly different at the 5% protection level.

Variability in fertility response and dramatic fluctuation in yields of barley and wheat varieties tested from a number of sources indicated that accurate laboratory experiments would be predicated on closely controlled field conditions, and environments favorable to optimum cultivar performance. A series of studies using two wheat cultivars grown under carefully controlled nitrogen and irrigation levels at Mesa, Arizona, and supplied through the courtesy of Rex Thompson, Arizona Agricultural Experiment Station, is in progress. Preliminary results indicate significant effects of irrigation on seed quality components. Results of these and further studies are expected to provide a firm basis for maximizing high quality planting seed production for Arizona.

Supported by a grant from the American Seed Research Foundation.

WEED CONTROL IN WHEAT - SEPTEMBER 1978

By
Stanley Heathman, Extension Weed Specialist, Tucson
Don Howell, Extension Agent, Agriculture, Yuma
Sam Stedman, Extension Agent, Agriculture, Casa Grande
Charles Farr, Extension Agent, Agriculture, Phoenix

Trade names used in the publication are for identification only and do not imply endorsement of products named or criticism of similar products not mentioned.

Canarygrass and wild oat have become important grass weeds in Arizona's small grain fields. These weeds grow taller than the crop and produce many seeds which shatter and fall to the soil before and during harvest. This report is a summary of 3 years experience by the authors in the control of weeds in small grains.

Cultural Practices

If the grower uses good cultural practices, problems from wild oat and canarygrass should be minimized. The following practices will reduce weed problems:

1. Plant in moisture, through a dry mulch. Canarygrass will not emerge until the first postemergence irrigation. Some wild oat will emerge with wheat and barley.

2. If you plant on beds and furrow irrigate, plant the furrows as well as on top of the bed. You need crop competition in the furrows or weeds will grow there.

3. Barley is more weed competative than is wheat.

4. Crop rotation - Do not plant small grains in the same field year after year. Wild oat populations can increase to over 100 per sq. ft. and canarygrass to over 1000 per sq. ft. in 3 years of continuous small grains.