ENVIRONMENTAL EFFECTS ON SEED PRODUCTION AND QUALITY

James C. Delouche 1/

Good Climatic Areas

Environmental factors have a great influence on the development and quality of seed. The specialized seed production areas in the U.S. and in other countries have developed because of the favorableness of the environment for seed production.

A major portion of the seed of temperate climate forage and lawn/turf grasses is produced in the Pacific Northwest. Climate and other components of the environment are very favorable in the Pacific Northwest for production of grass seed. The most important factor is a dry summer season. This factor combined with mild winters, ample rainfall during the winter/spring growing season, and a variety of soil types contributes to high yields, excellent harvesting conditions, and high seed quality. The kinds of seeds produced in the Pacific Northwest can be produced in other areas of the country - and were in former times - but the risks are many and severe. Very often the seed crop reaches the harvesting stage in good shape, only to be essentially lost because of a period of bad weather.

The arid irrigated areas in California, Idaho, Arizona and other western states are important producers and suppliers of vegetable, ornamental, and forage legume seed. Low humidity, minimal rainfall, bright sunny weather, favorable temperatures, and good soils are all ideal for production of high yields of high quality seed, provided, of course, the moisture requirements can be met through irrigation. The risks associated with production of vegetable, ornamental and forage legume seed in non-arid areas are essentially absent in arid, irrigated zones.

The favorableness of the environment in the seed production areas cited has long been recognized. Seed production has developed into highly specialized and professional types of "farming" and agri-business. Research and extension activities have evolved to support the continuation and improvement of specialized seed production in these areas.

The case of cottonseed is a very recent example of a shift in seed production from relatively unfavorable, high risk areas, to a more favorable area with fewer risks. Until the late 1970s, most of the

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1/ Dr. Delouche is with the STL, MSU.
cottonseed used for planting the crop in the Southeast was produced in the area. Seed quality was (and is) highly variable because of variable climatic conditions during the harvest period. Seed produced in Arizona, on the other hand, is higher and more consistent in quality. Since many of the varieties grown in the humid portions of the cotton belt are also grown in Arizona, much of the cottonseed presently planted in the Mid-South and Southeast are produced in Arizona and shipped east for conditioning and marketing.

Non-Climatic Aspects

The non-climatic components of the environment can have as great an influence on the selection and development of seed production sites as the climatic components. In the production of insect pollinated seed crops, for example, an abundance of pollinators is important. Sweet corn seed are produced in Idaho not only because yields are good, but also because isolation is available to minimize or prevent cross pollination with field corn.

India is the only major producer of hybrid cottonseed. The main factor in India's hybrid cottonseed production is an abundance of low-cost labor for hand pollination and individual boll harvest. China is now producing hybrid rice seed utilizing rather laborious procedures for pollination. The male sterile system in these crops facilitates the development of hybrids by eliminating the need for emasculation, but does not solve the pollen transfer problem. Considerable work on hybrid rice and cotton is underway in the U.S. and, perhaps, the problem will be overcome sufficiently in a few years to make hybrid seed production economically feasible.

The main advantages of producing seed in areas especially adapted to seed production because of a favorable environment are high, stable seed yields, excellent recovery during harvest, high seed quality and the avoidance of many seedborne diseases. Yet, despite the advantages of the environmentally favorable seed production areas, the seed of most major field crops produced in the U.S. will continue to be produced in the same areas where the commercial crop is grown because of convenience and cost.

Effects of Environmental Stresses

Plants have evolved a rather remarkable capacity to adjust seed production to the resources available. Typically, plants produced under marginal conditions of water supply and low fertility respond by reducing the number rather than the quality of seed produced. The few seed (low yield) produced by plants under marginal conditions are usually as viable and vigorous as those produced under more favorable conditions. From an evolutionary viewpoint, the adjustment of seed
production to the available resources has survival value. A few good quality seed have an equal or better chance of surviving environmental hazards, germinating, and developing into at least a few plants to continue the species as a greater number of poor quality, deficient seed. Furthermore, the species can extend its range into marginal areas.

Examples of the adjustments of seed production to the available resources while still maintaining quality are numerous. The severe droughts of the past two years (1980 and 1981) in many areas of the South cut yields (number of seeds produced) by 30% or more. Yet, the seed which did mature were of exceptionally high quality because of less post-maturation deterioration. Farmers fight weeds tooth and nail, yet a few plants usually survive to produce a few seed to re-infest the soil and insure a population of weeds the following year.

Although plants have the capacity to adjust seed production to the available resources, the environment in which the plants develop and complete their life cycle can influence the quality of seed. Shortages in resources that develop suddenly - acute shortages as opposed to chronic deficiencies - can be especially damaging to seed quality. Shriveled, chaffy wheat seed is a good example of the effects of an acute shortage of moisture. The seed are set, and start to develop, then moisture supply diminishes to a critical level. Normal seed filling does not occur so the seeds are light and chaffy. If the moisture supply is deficient before and during the flowering period, fewer seed are set, hence, there is a lesser demand on the moisture resources. In this situation the plant does not have a chance to adjust the number of seed produced to the available resources, so a good number of light, poor quality seed are produced.

Generally, acute shortages of resources that develop during the late flowering and early seed development stage affect seed size and seed weight.

Seeds, Size, Weight and Density

Seed size, weight and density are inherent characteristics that are very much influenced by the total environment of crop production. Seed weight, which is usually closely related with seed size, and seed number are the major determinants of yield. High yields are obtained when the product of seed number x seed weight gives a high production of dry material, i.e., grain per unit area of land. Trade-offs between seed or grain number and seed or grain weight permit - within limits - exploitation of different avenues for economically optimizing yield. An inherently small seeded variety of plants can yield as well as a large seeded variety provided there is a compensating increase in seed number per unit area - either more seed/head or more pods/unit area.
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Although I'm sure there are exceptions, there does not seem to be any consistent advantages associated with inherently small seed size (or weight) or inherently large seed size (or weight). Very small seed such as those of tobacco would probably find the going rough in a broadcast seeding on roughly harrowed soil. But then so would coconuts.

Seed size, hence weight, is seldom uniform even within a homogenous variety. Rather, seed sizes within the population are more-or-less normally distributed within limits. Variations in seed size within a variety can be related to soil fertility, moisture availability, lateness of the flower, position on the plant, i.e., main stem or tiller, position in the "head", and so on. The influence of environmental factors is such that even the mean seed size of a variety varies from season to season and location to location. For example, the mean size of Bragg soybean seed produced from a common seed lot varied by nearly 2/64 in. among locations ranging from South Carolina to Texas in 1972. (The Texas seed were largest - wouldn't you know).
While there doesn't seem to be any close relation between seed size per se and seed quality or between seasonal and location variations in mean seed size within a variety and seed quality, there does appear to be a rather consistent relationship between seed size within a population, or lot of seed, and quality. Seed substantially smaller — excluding obvious immatures — than the mean size of the population are less viable and less vigorous than the larger seed. Frequently, seed of the very largest size class are also lower in quality as compared to seed in the next largest size classes. The physiological causes of weaknesses in the smallest seed in a lot have not been elucidated. In the case of soybeans and peanuts the smaller or smallest seed respond in some ways similar to immature seed, although they do not "look" immature, i.e., they are not mishappen, shrivelled, or low in density. Perhaps, they are immature despite appearances. The association of lower quality with the largest seed in a population or lot has a much more clearly defined basis. Some diseased and badly deteriorated seed are sort of "puffed up", hence are large, sometimes abnormally so. The large seed also appear to sustain more mechanical damage during harvesting and handling, which reduces quality.

Usually, the smallest size seed and the abnormally large seed make up less than 5% of the lot weight of thresher run seed. Most of these seed are scalped off or dropped through the bottom screens during conditioning and end up in the screenings. It is very difficult to demonstrate a relationship between seed size and quality in properly conditioned seed lots. Conditioning essentially eliminates the problem.

Seed quality is generally associated with seed density (weight/unit volume) and the two are very strongly associated in certain kinds of seed. The association is closest in those kinds of seed in which the covering encloses a characteristic volume regardless of the stage of maturity of the embryo or true seed. For example, pine and rice "seed" (with hulls) are the same size whether the embryo or grain is well developed or essentially non-existent. A similar situation exists in cotton, castor bean, sunflower, and most grass seed enclosed in hulls. The density of the seed is determined by the degree of "fill", or development of the caryopsis, "true" seed, or embryo. The void space within the "seed units" of these species can be easily demonstrated by X-radiographic analysis, or even more simply by cutting the seed. The association between density and quality, therefore, is more of an association between degree of development or maturity and quality, than density per se and quality. The traditional methods of eliminating low density/low quality seed from seed lots are, of course, aspiration and gravity table separations.

Associations between density per se and quality can be demonstrated in certain seed lots. Nearly always, the low density seed are badly weathered, improperly dried, insect damaged, or otherwise deteriorated. Seed lose dry weight during weathering and during storage at high moisture contents and warm temperatures as a result of their own metabolism.
(respiration) and the "feeding" of molds, and/or insects. Since dry weight loss is not associated with a reduction in seed size, the density decreases.

Variations in seed size and density within a variety are very much a product of the environment. The smallest and largest size seed and those of lowest density are usually inferior in quality. Modern conditioning technology, properly applied, can eliminate these inferior seed from lots usually without excessive losses.

Effects During Development/Maturation

Environmental conditions during the late ripening and post-maturation period probably have the greatest influence on the quality of seed within a variety, i.e., exclusive of inheritance.

An early freeze sends shivers through everyone, but hybrid corn seed producers are shaken up most. Overnight freezing temperatures when corn seed is still high in moisture is a matter of most serious concern. The damage to germinability and vigor can be devastating. Such an early freezing "event" brings out the jackets and a host of production and quality control fellows to mull over the degree of damage, and the portion of the acreage affected.

Cool nights in September shake up cotton seed producers nearly as bad as the early freeze shakes up corn seed producers. Cooler than normal September nights mean poorly filled, immature cotton seed in the seed house.

A couple of days of rainy weather during the warm days and nights in September or even early October in Mississippi, for example, means - in more cases than not - that the seed soybeans of the varieties in the final stages of dry-down (below 20%) during the rainy period will not have an acceptable germination. A similar period in August when sorghum seed are drying down will result in extensive "germination in the head" in some varieties or deteriorated seed in others.

Environmental conditions during seed maturation, especially as moisture content drops down to below 25-30%, has a great influence on the expression of seed dormancy, an inherited trait that is very much influenced by environmental conditions. Researchers have reported that alfalfa seed which develop and mature under "cool" temperatures are heavier and have a higher hard seed (dormancy) percentage than seed produced under warmer temperatures. In 1980, the time of the great and prolonged heat and drought in the South, seed of some varieties of soybeans had hard seed percentages as high as 35-40%, whereas, in normal times more than 2-3% hard seed was viewed as rather extraordinary.
While the expression of seed dormancy is influenced by climatic conditions, the effects of climatic conditions, i.e., weathering, are moderated by dormancy. Peanut varieties selected for naturally well-watered areas such as the Southeast have more dormancy than those selected for dryer, arid regions. The higher degree of dormancy inhibits sprouting in the soil during rainy periods that delay harvest. The importance of seed dormancy in preventing preharvest germination was deeply impressed on me during a visit to a country in West Africa a few years ago. Peanuts were beginning to be produced in an arid area under irrigation - there wasn't much experience. Some defoliation and wilting that about the expected time of harvest must have turned on a "light" for one of the managers, and he decided to give the crop one last, good shot of water. At the time of my visit, a thick stand of peanut seedlings had emerged. The crop was ruined because of preharvest sprouting.

Some varieties of sorghum have a higher degree of dormancy and tolerate considerable rain without sprouting in the head. I know of at least one case where a variety of rice was released - not in the U.S. - which had so little dormancy that it regularly sprouted in the head. The variety had to be "rebred" to introduce more dormancy in its inheritance.

"Miscellaneous" Effects

The environment has some rather unexpected effects on seed quality. Research reports indicate that wheat seed produced under heavy nitrogen fertilization have a higher protein content and are more vigorous than seed produced under normal nitrogen fertility levels. Calcium deficiencies cause "concealed" damage of peanut seed and several types of seedling abnormalities. Many years ago it was observed that some kinds of pea seed produced abnormal seedlings in sand tests but not in soil tests. Investigation revealed that the affected pea seed were produced in a boron deficient area. The seedling abnormalities in the sand tests were caused by the absence of boron in the sand, while the good seedling performance in soil was attributed to good boron status of the soil. A pinch of borax in the water used to wet the sand corrected the problem. Soybean seed produced in soil with good molybdenum status are not any better in quality than those produced on marginal - for moly - soil, but they produce higher yields when planted in low pH, moly deficient areas. The seed carry moly internally that is often applied externally to improve production on soils of the type mentioned.

Summary

Someone once said, "you can't get away from the environment, its all around you." In a non-waggish sense this is true. The environment is all around us and our productive activities. There is no escape. One can, of course, move from an environment ill-suited to his purposes
to one he perceives to be more favorable. But that is not possible in many cases. Very largely, we have to adjust our activities to the environment in which we live and work.
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