Variability in Okra Seed Quality[1]

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ABSTRACT

Ten characteristics of okra seed were defined on the basis of observation of characteristics of seed of 270 varieties. The variation of these characteristics was studied within one variety, Clemson Spineless, and the interrelationships of the characteristics were studied. Small, non-black, shriveled, or low-density seeds germinated poorly and were low in percent kernel, in oil, and in protein content. An index of okra seed quality was devised that permits farmers as well as specialists to assess rapidly the quality of a given seed lot.

INTRODUCTION

Okra seed is a potential high oil, high protein seed crop for the temperate zone as well as the tropics[3]. Data collected so far suggest that oil content can range from 6 to 27% and protein from 16 to 25%. The hull of the okra seed accounts for approximately 50 percent of the seed. When seeds are separated into hulls and kernels, the kernel fraction, in one case, contained 48.6 percent protein and 33.4 percent oil. The hulls contained only 5.3 percent protein and 2.3 percent oil[4]. By a simple grinding and sifting process, most of the hull can be removed, leaving a ground meal of about 32 percent protein and 33 percent oil.

We have found no published information concerning variation of principal characteristics of okra seed. Nevertheless, inspection of seeds of many varieties convinced the authors that seeds differ within and among varieties in such characteristics as size, weight, density, color, pubescence and rugosity, and percent kernel. Furthermore, in a preliminary study based on small-scale experiments, it appeared that size, color and density influenced oil content and seed germination.

In this study okra seeds were examined for differences that might affect germinability and yields of protein and oil. In addition, differences were described and techniques for measuring differences were developed. The relationships among characteristics were observed in one variety, Clemson Spineless. Okra seed quality was defined, and breeding goals for okra seed were established.

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[3] Karakoltsides, P. A. and Constantinides, S. M., 1975. Okra seeds, a new protein source, J. Agric. Food Chem. 23 (6): 1204–7.

[4] Martin, F. W. and Ruberté, R., 1979. Milling and use of okra seed meal at the household level, J. Agric. Univ. P.R. 63 (1): 1–7.

MATERIALS AND METHODS

Seeds of a collection of 270 cultivars received from the U.S. but representing most okra-growing regions of the world were examined to identify differences and to observe the range for each difference. Described below are ten characteristics, in which intra or intervarietal differences were identified. Techniques for measuring these differences were designed. Clemson Spineless was selected as a standard variety and differences of seed within this variety were measured. The influence of principal characteristics on content of protein and oil, and germinability of the seeds was observed in simple experiments. Based on these findings, a simple index for okra seed quality was devised.

DESCRIPTION OF DIFFERENCES

Surface

Under magnification, the surface of all okra seed is seen to be covered with a fine network of cells resembling a honeycomb. These have a dark black color. A series of fine parallel lines originating at the hilum and continuing completely around the seed appears to consist of a different type of cell, trichomes or hair-producing cells. The projections from these cells vary from insignificant to about 1 mm in length. The density of hairs and their color determine the grayish and greenish tones of the seed. When the surface is severely damaged or underdeveloped, there is an interior rusty-brown coat of the hull. Thus, colors observed by the unaided eye are due entirely to which features of the hull are most apparent, the rusty-brown inner coat, the black matrix, or the grayish or greenish pubescence. Degree of pubescence was estimated visually (table 1).

Color

Seed color was evaluated by two techniques. In the first, the three predominant colors, black, green, and brown, were evaluated separately on scales of 0-3. Zero represented the absence of the color, 1 a minimum, and 3 a maximum. Seed color was also evaluated on a scale of 1-5. The seed color rating corresponded to what appears to be a linear series of colors that depend on development of pubescence: dark brown, black, gray, green, khaki or yellow.

Seed weight

Seed weight was evaluated as the weight in g of 100 normal seeds. Seeds that were shriveled, broken, damaged by insects, or obviously underdeveloped were eliminated from the sample. Seeds were exposed to

TABLE 1.—*Differences observed among okra seeds, and techniques for rating differences*

Characteristic	Methods of obtaining rating	Method of rating characteristics
Surface	Observation	0 = smooth 1 = velvety 2 = short haired 3 = long haired
Color (linear scale)	Visual separation	1 = dark brown 2 = black 3 = grey 4 = green 5 = khaki or yellow
Seed weight	Weighing	100 normal seeds' weight
Seed size		
Percent small	Counting	Percentage of seeds that pass through screen of 11/64"
Percent medium	Counting	Percentage of seeds that pass 12/64" but not 11/64"
Percent large	Counting	Percentage of seeds that pass 13/64" but not 12/64"
Percent very large	Counting	Percentage of seeds that do not pass through screen 13/64"
Seed density		
Percent light	Counting	Percentage of seeds that float in water
Percent medium	Counting	Percentage of seeds that sink in water but float in 20% sugar solution
Percent dense	Counting	Percentage of seeds that sink in 20% sugar solution
Percent kernel	Hand separation and weighing	Percentage of total seed weight that is kernel
Oil content	Analysis	Percentage of total weight that is oil
Protein content	Analysis	Percentage of total weight that is protein
Gossypol content	Analysis	Percentage of total weight that is gossypol
Germinability	Germination test	Percentage of seeds germinated after 7 days

the uncontrolled air of the laboratory for 24 hours before weighing to permit equilibration to the ambient humidity.

Seed size

Normal seed obviously varies in size within and among varieties. Three screens with round holes 11/64, 12/64, and 13/64 inches in diameter (4.36,

4.76, 5.16 mm) were used to screen seeds into 4 classes, called 10, 11, 12, and 13. Seeds of size 10 passed through the screen of 11/64; seeds of 11 passed through the screen of 12/64; etc. Different lots of seed can be compared on the basis of percent large seeds (seeds of class 13, 5.6 mm or more in diameter).

Seed density

The density of 100 seeds was determined by immersing the seeds in water and removing those that floated. These were considered light seeds or density classification 1. Seeds that sank were then immersed in a solution of 20 percent sucrose (density approx. 1). Seeds that floated were considered of medium density or 2. Seeds that sank were considered to be heavy or 3. Average density of the seed lot was calculated. Different lots of seed can be compared on the basis of percent dense seed (class 3).

Percent kernel

When okra seed is cracked open and the hull is examined under the microscope, it is found to consist of at least 5 layers. The outermost is the pubescence, followed by the uniform black matrix, a cream-colored layer of variable thickness, a relatively thick dark rusty brown layer, and a thin, uniform inner black coat. Creamy transparent scales similar to the kernel are attached to the inner coat. The kernel consists of a meaty endosperm enclosing a small, flat embryo. A fine membrane separates the endosperm from the hull. The cracked seed can be separated readily into kernel and hull fractions. Although the kernel is free of hull, the hull fraction may contain small adherent bits of scale, membrane, and even kernel that are difficult to separate. Percent kernel was measured as the weight of the kernel divided by total weight of the seed.

Oil content

Fatty substances were extracted with II-heptane in a Soxhlett apparatus using preweighed flasks. The solvent was evaporated, and the residue was dried to a constant weight to determine oil content[5].

Protein content

Protein was estimated on defatted samples. The oils extracted, however, were considered part of the dry weight of the sample. Standard micro Kjeldahl technique was used and nitrogen content was multiplied by 6.25 in order to estimate protein content.

[5] American Oil Chemists' Society, 1975. Sampling and analysis of oil seed by-products, Ba 7-58. In Official and Tentative methods of the American Oil Chemists' Society, Champaigne, Ill.

Gossypol content

Gossypol was measured by official methods of the American Oil Chemists Society (1).

Germinability

Germinability was measured by soaking seeds overnight in water, placing them to germinate on wet filter paper, and observing number of sprouted and non-sprouted seeds after 7 days.

Techniques used to evaluate seed characteristics are summarized in table 1.

RESULTS

The seeds of Clemson Spineless are quite typical of the seeds of other varieties, but not all variation observed in the collection was seen in Clemson Spineless. The principal differences within one lot of seeds are given in table 2. Seeds are normally smooth with no sign of pubescence to the unaided eye. They are charcoal black, but not intensely so, with a small proportion of off-colored seeds. They vary in size and weight. The smallest normal seeds weighed 3.9 g per 100 as compared to 7.2 for the largest. A fairly high percentage (42) of seeds is dense.

About one-half of the seed is represented by kernel. The protein content is typical, 19.7 percent, and the oil content is high, 21.2 percent. Gossypol content is .0064 percent. Protein content of the kernel was 48.6% as compared to 5.3% protein in the hull; oil content of the kernel was 33.4 percent as compared to 2.3% in the hull.

Characteristics of the seed are by no means unrelated. Seed weight is associated with seed size, as expected. Abnormally appearing seeds including extremely small, malformed, shriveled, and off-colored seeds are most often found among the smallest seeds. Table 2 shows that seed size is associated with percent kernel in that the smallest seed has not only a smaller kernel but also a smaller percent kernel. The percentage of non-black seed is highest for the smallest, and thus probably the least developed seeds.

Seed size is also associated with density of seeds as shown by table 3. The most dense seeds are those of medium size. A large fraction of the small but normal appearing seeds is of low density, and surprisingly, a small but definite proportion of very large seeds is also low in density. Seed of low density have more hull than kernel (percent kernel equals 45.3). Seeds of medium density and high density appear to be similar in percent kernel, 49.7 and 49.9 percent, respectively. Seeds of low density are also often off-colored (21%, compared to 2 and 1% for seeds of medium and high density).

TABLE 2.—*Characteristics of seeds of Clemson Spineless, and range of differences*

Characteristic		Proportion of seeds	Notes
		%	
Surface	Smooth	100	Microscopical variation in pubescence
Color	Black	86	
	Green or Gray	12	
	Brown 1	1	Poorly developed seeds
Non-black seeds as related to seed size	Small	23	
	Medium	18	
	Large	4	
	Extra large	8	
Seed size	Small (4.36 mm)	3	Often shriveled
	Medium (4.36 to 4.76 mm)	58	
	Large (4.76 to 5.16 mm)	37	
	Extra large (5.16 mm +) (Average size = 4.71 mm)	2	
Seed weight as related to seed size	Small	3.91	Does not include very abnormal seeds
	Medium	5.46	
	Large	6.63	
	Extra large (Average = 5.88 g/100 seed)	7.20	
Seed density	Light	26	
	Medium	32	
	Dense	42	
Percent kernel as related to seed size	Small	.39	
	Medium	.50	
	Large	.50	
	Extra large (Average = .50)	.51	
Percent protein		19.7	
Percent oil		21.2	
Percent gossypol		0.0064	

Seed characteristics are related to seed germinability (table 4). Non-black seed, small seed, and light seed do not germinate as well as black seed, large seed, and dense seed.

Seed characteristics may also influence protein and oil content. The fact that small seeds have smaller kernel percentages would in itself affect protein and oil content, even if all kernels contained the same percentage of protein and oil. Effects of seed color, size, and density on protein and oil contents (table 5) were tested at two different times with two com-

TABLE 3.—*Relationship of seed size to seed density*

Size	Density			Seeds tested
	Light	Medium	Dense	
	%	%	%	
Small	65	8	27	100
Medium	8	13	79	100
Large	3	21	76	100
Extra large	10	23	67	100

TABLE 4.—*Relationship of seed characteristics to seed germination*

Characteristic	Phase	Percent germination
Color	Black 2	88
	Gray green	54
	Green	28
	Brown	0
Seed size	Small	32
	Medium	68
	Large	68
	Extra large	70
Seed density	Light	32
	Medium	72
	Dense	80

TABLE 5.—*Influence of some seed characteristics on protein and oil content of okra seeds*

Characteristic	Trial	Phase	Percent protein	Percent oil
Color	1	Black	18.7	17.3
	1	Gray green	18.2	16.3
	1	Green	20.0	17.9
	2	Black	19.8	17.9
	2	Gray green	18.8	20.3
	2	Green	18.5	19.1
Size	1	Small	11.3	4.7
	1	Medium	18.6	17.9
	1	Large	21.1	18.9
	2	Small	18.3	13.7
	2	Medium	20.5	15.1
	2	Large	20.3	17.6
Density	1	Light	19.1	12.9
	1	Medium	17.9	18.4
	1	Dense	20.6	18.0
	2	Light	18.3	10.4
	2	Medium	18.5	14.8
	2	Dense	20.5	14.6

pletely different samples of seed. In the first trial, seed came from a broadly based population; in the second, from the variety Clemson Spineless. In the first trial, small seeds included shriveled seeds. In the second trial shriveled seeds were removed from the small seeds fraction.

Color of seeds expressed as black, gray-green, and green was not associated with protein and oil contents. Small seeds which had not been selected were very low in oil and protein. Small seeds which had been selected for normality were slightly lower in oil and protein, as expected from their percent kernel values. Light seed contained less oil than medium or dense seed, but density was not related to protein content.

DISCUSSION

The observations reported here are useful in setting standards of okra seed quality. They show that small shriveled, and off-color seeds and, to a lesser extent, light (low density) seeds are of poorer quality than larger, plump, black, heavier seeds. The former contain less protein and oil, more hull, and do not germinate as well as the latter. Therefore, okra seeds for planting or for other uses should be black, plump, without wrinkles, larger than 11/64″ (4.36 mm), and more dense than water.

The quality of two lots of seed of the same variety can be determined by measuring the percentage of seeds (as a fraction of 1) in each category, and by multiplying these 4 fractions to give an Okra Seed Quality Index (OSQI).

In breeding okra seed for protein and oil, attention should be given to high OSQI and to high percent kernel as well as to protein and oil content.

The simple techniques of screening seeds to remove the smallest and removing seeds that do not sink when seeds are placed in water (a common pre-planting technique) can be used to improve the quality of seeds to be sown.

RESUMEN

Diez características de semilla de quimbombó se definieron basadas en observaciones de 270 variedades. La variación de estas características se basó en una variedad, Clemson Spineless, y las relaciones entre ellas se estudiaron. Las semillas pequeñas, que no eran negras, arrugadas o no muy densas tenían un porcentaje bajo en carne, aceite y proteína, y además no germinaban bien. Un índice de calidad se desarrolló que permite tanto al agricultor como al especialista evaluar rápidamente la calidad de un lote de semillas.