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Relation of the Seed/Hull Ratio to Yield And Dollar Value in Peanut Production[1]

Harold E. Pattee*, Johnny C. Wynne, Timothy H. Sanders and A. Michael Schubert[2]

ABSTRACT

The seed/hull ratio maturity index (SHMI) methodology has been modified to better meet less than optimal growing conditins. The modifications include sampling methodology for minimizing variation in small plot samples, rapid drying of samples to minimize variation due to moisture content differences, and a preferred method for estimating SHMI. Data are also given on variations in the seed/hull ratio found in selected commercially grown cultivars of peanuts. The optimum seed/hull ratio values for 'NC5', 'NC2', and 'Florigiant' are between 2.9 and 3.1. Correlations between yield, dollar value, and the seed/hull ratio were found to be significant for NC5, NC2, and Florigiant.

Key Words: Seed Hull Maturity Index, Yield, Dollar Value, Field Sampling Method, Groundnut, Peanut, *Arachis hypogaea* L.

The ratio of seed weight to hull weight has been shown to be an index of fruit maturity of peanuts (*Arachis hypogaea* L.) (4). This ratio might also be helpful in estimating the optimum time for harvesting peanuts to obtain maximum yield (2,3). Reports from a cooperative study which involved the major peanut growing areas, i.e., southeast, southwest, and Virginia-Carolina and which was undertaken to establish the relation of seed/hull ratio to yield (2, 5-7) showed that the seed/hull ratio has the potential for use in determining when peanuts should be dug. The seed/hull ratio method was found to be generally equal to or better than other methods for estimating or predicting optimum harvest date - arginine maturity index (AMI) (8,9), methanol extract (1), and a shellout method.

Continuing research indicated that initially proposed methodology (3,4) for determination of the seed/hull ratio required modification to better measure the maturity of peanuts grown under less than optimal growing conditions. While studying maturity in several environments, we examined some possible sources of variation in the seed/hull ratio and the means of minimizing this variation. In this study, we report sampling methodology for minimizing variation in small plot samples, variations in the seed/hull ratio found in selected commercially grown cultivars of peanuts, observed correlations between yield-dollar value and the seed/hull ratio, and a recommended method for estimating the seed/hull ratio.

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[2]Research Chemist, AR/SEA, USDA and Associate Professor, Crop Science, North Carolina State University, Raleigh, NC 27650. Research Plant Physiologist, National Peanut Research Laboratory, AR/SEA, USDA, P. O. Box 637, Dawson, GA 31742; Assistant Professor, Plant Disease Research Station, Texas A&M University, P. O. Box 755, Yoakum, TX 77995, respectively.

Materials and Methods

We tested peanuts grown in three different regions: the Virginia-Carolina area, Georgia, and Texas. Peanuts from the Virginia-Carolina area were grown at the Peanut Belt Research Station, NCDA, at Lewiston, N. C. Peanuts of cultivar 'NC2', 'NC5', and 'Florigiant' were grown according to recommended cultivar practices. Peanuts were planted on May 18, 1977 and on May 22, 1978 in four row plots 8.53 m long. Two rows were used for manual seed/hull sampling and two rows were machine harvested for yield and dollar value determinations. Plots were replicated six times in a randomized complete block design.

During both years, the plants selected for fresh weight maturity index (FMI) and dry weight maturity index (DMI) (4) determinations by the seed/hull ratio method were transferred to the laboaratory on the day of harvest and stored overnight at 4 C. All pods were removed from the plants and used in the seed/hull ratio determinations. In 1977, the samples analyzed were the fruit from four individual plants treated as individual subsamples within each of the six plot replications. In 1978, 16 plants from each plot replication (6) were harvested and the fruit from replications 1 through 3 and 4 through 6 combined. The combined replications were subdivided into 16 subsamples by a riffle divider and four subsamples from each of the combined replications samples used for analysis. Bulk samples in 1977 were obtained by combining all pods form 16 pre-selected plants and subdividing the bulked material on an 18-chute riffle sampler with 2.54 cm-wide chutes. Sixteen subsamples were obtained by repeated subdivision.

Samples were dried in a Precision-Freas Model 124 gravity convection oven over a range of pre-selected temperatures or in forced-air drying bins at room temperature.

'Florunner' peanuts were grown in Tift County, GA according to recommended cultural practices. They were planted on April 30, 1977 and hand-harvested on September 1, 1977. Plants were selected at random from a 0.69-ha plot and analyzed the same day. After FMI determinations were made, the sample portions were dried with forced air at room temperature for 7 days and reweighed; then DMI was calculated. Drying for 3 hr at 130 C after the 7-day period had no significant effect on mean DMI.

The three cultivars - 'Florunner', 'Tamnut', and 'Florigiant' - used from the southwest area were planted in 0.08-ha plots on May 18, 1977, at Yoakum, TX. Recommended cultural practices for that region were followed. Plants were selected at random on the specified harvest date and hand-harvested. After FMI values were determined, the sample portions were dried with forced air at room temperature for 7 days and reweighed; then SHMI was calculated.

Results and Discussion

Optimization of Sample Size

To determine the most efficient sample size for small plot work, sample variation was studied. Data were obtained for FMI and DMI values for fruits from individual plants and for an equal number of subsamples from a bulk sample obtained by harvesting all fruit frm the same number of individual plants and dividing the composited fruits over a riffle divider. The pertinent statistical data obtained from the analysis of these samples were used to obtain the sample size needed to estimate the seed/hull ratio with 95% confidence (Table 1).

Table 1. Effect of sampling method, digging date, location, and cultivar on the size sample needed to estimate the true seed/hull ratio with 95% confidence[a].

Harvest Date	Location	Cultivar	Seed/Hull Method	Sampling Method: Individual Plant[b] (Plants)	Sampling Method: Bulked Sample-Riffle Subsampling[c] (Fruit)
8-23-77	Lewiston, NC	Florigiant	FMI	344	1186
			DMI	523	700
8-30-77	Yoakum, TX	Florunner	FMI	24	379
			DMI	10	227
8-31-77	Yoakum, TX	Tamnut	FMI	102	489
			DMI	46	340
9-1-77	Yoakum, TX	Florigiant	FMI	86	420
			DMI	38	620
9-1-77	Tifton, GA	Florunner	FMI	51	214
			DMI	14	204
10-18-77	Lewiston, NC	Florigiant	FMI	24	110
			DMI	18	56

[a] Equation for estimating sample size: $n = \frac{(t^2 \cdot s^2)}{d^2}$, where s^2 = variance and d^2 = (sample value - true value)^2.

[b] Sixteen plants per harvest date analyzed.

[c] Sixteen subsamples analyzed.

Early field sampling (August 23, 1977, Lewiston, N. C.) produced sample size predictions that are not compatible with small plot techniques. However, the required sample size dropped to a reasonable level later in the season. By early September, the sample size predictions were more compatible with small plot techniques at the Tifton, GA, and Yoakum, TX locations. Thus, as the crop advances in average maturity level, the variability and, therefore, the sample size required to estimate the seed/hull ratio apparently decreases. Sample size reduction by using the bulk method results in a considerable saving in shelling time over the individual plant sampling method. With an average of 7 fruit per plant, the reduction in fruit to be shelled would be 2961 [9523 x 7) - 700] for DMI on August 23, 1977, at Lewsiton, N. C.

The data indicate that the number of plants to be selected at random from experimental size plots of up to 9081 ha range from 14 to 18 plants and subsample sizes from 56 to 204 fruit for DMI determinations. To minimize labor costs, we would recommend 18-plant samples with a 150 fruit subsample for plots up to 0.81 ha. If variability in soil type, drainage, or growth pattern has a visible effect, a proportionate number of plants should be taken from that area and the subsample size increased to 200 fruit to appropriately cover this increase in variation. Although the sample size estimates would be valid for infinitely large fields, provided that the variation does not exceed that in the small plots, extrapolation is not recommended. The larger and more variable the field to be sampled, the larger the plant sample and fruit subsample to be taken. Further studies are being undertaken to determine large field variation and the sampling regime that can best be utilized to overcome within field variations. Location effects on sample size estimation appear to be minimal. Thus, the above recommendation on sampling should be valid in all peanut-growing regions of the United States.

Fresh-Weight Index Versus Dry-Weight Index

Initial studies on the seed/hull method for maturity estimation suggested that both FMI and DMI methods were of equal accuracy under ideal conditions (3). Under less than ideal conditions the FMI method is subject to several sources of variation, such as water stress and moisture loss between harvesting and analysis, which result in erratic results. Comparison of the average coefficient of variation of FMI and DMI values for 1977 and 1978 (Table 2) shows that there is greater variability among FMI values compared to their mean than among DMI values. The observed differences between FMI and DMI suggest that DMI is the methd of choice for general usage.

If DMI is to be accepted as the method for seed/hull analysis, obviously the procedure of air drying at room temperature for 7 days must be modified. A series of rapid drying regimes were evaluated in 1978 to determine what effects rapid drying at elevated temperature has on DMI values. Twenty different drying regimes were evaluated. Eight of the drying regimes were considered satisfactory because the average SHMI value obtained was not more than ± 5% of its average control sample, which was dried at room temperature for 7 days. these drying regimes were 70 C, 24 hr; 75 C, 15 hr; 80 C, 17 hr; 105 C, 15 hr; 135 C, 6 hr; 135 C, 7 hr; 140 C 4 hr; and 150 C, 5 hr. The

Table 2. Comparison of FMI and DMI values obtained for the 1977 and 1978 crop year for three peanut cultivars.

Harvest Date	NC5 FMI	NC5 DMI	NC2 FMI	NC2 DMI	Florigiant FMI	Florigiant DMI
			1977[a]			
9-13	0.9 ± 0.1	1.3 ± 0.1	1.1 ± 0.3	1.6 ± 0.2	1.3 ± 0.2	1.5 ± 0.2
9-20	1.0 ± 0.2	1.4 ± 0.2	1.6 ± 0.4	2.0 ± 0.4	1.4 ± 0.1	1.9 ± 0.1
9-27	1.1 ± 0.2	1.6 ± 0.2	1.8 ± 0.2	2.5 ± 0.3	1.5 ± 0.1	2.0 ± 0.3
10-4	1.6 ± 0.2	2.0 ± 0.3	2.2 ± 0.2	2.6 ± 0.2	1.8 ± 0.2	2.3 ± 0.2
10-11	1.4 ± 0.2	2.0 ± 0.2	2.1 ± 0.2	3.0 ± 0.2	1.9 ± 0.2	2.5 ± 0.3
Ave. C.V.	35.51	26.96	30.72	21.74	24.70	23.29
			1978[b]			
9-21	1.4 ± 0.2	2.2 ± 0.2	1.2 ± 0.2	1.9 ± 0.1	1.3 ± 0.1	1.9 ± 0.2
9-19	1.6 ± 0.3	2.5 ± 0.1	1.8 ± 0.2	2.4 ± 0.2	1.8 ± 0.3	2.3 ± 0.1
9-26	2.5 ± 0.2	2.7 ± 0.3	2.6 ± 0.2	2.8 ± 0.1	2.8 ± 0.2	2.8 ± 0.1
10-3	2.4 ± 0.2	3.0 ± 0.1	2.4 ± 0.3	3.0 ± 0.1	2.4 ± 0.5	2.7 ± 0.3
10-10	2.8 ± 0.4	3.1 ± 0.2	3.2 ± 0.2	3.4 ± 0.1	3.1 ± 0.2	3.1 ± 0.3
10-17	2.2 ± 0.3	2.9 ± 0.4	2.6 ± 0.1	3.2 ± 0.1	2.5 ± 0.3	3.0 ± 0.1
10-24	2.4 ± 0.5	2.9 ± 0.2	3.0 ± 0.5	3.3 ± 0.2	2.1 ± 0.2	3.0 ± 0.2
Ave. C.V.	25.28	16.74	21.74	13.64	22.88	16.22

C.V. = Coefficient of variation.

[a] Average of six replications with four subsamples each.

[b] Average of four subsamples of sampling method described in Materials and Methods.

major source of variation was incomplete drying of the immature fruits, particularly in regimes of less than 4 hours of drying time.

Influences of Cultivars on DMI (SHMI)

It has previously been established that DMI values, to be referred to henceforth as seed/hull maturity index (SHMI), at similar maturity stages for Florigiant and Florunner are significantly different (3). However, we do not know the range of differences that might exist between cultivars in the different growing areas. At the same harvest dates in 1977 and 1978, SHMI values obtained and the pattern of SHMI progressions are different among cultivars (Table 3). In 1977, NC5 produced the most immature crop of the three cultivars; while in 1978, NC5 was similar to NC2 or Florigiant in maturity progression, although the data might suggest NC5 matured a week earlier than NC2 or Florigiant. We cannot readily declare that any of the cultivars have a significantly different maximum SHMI value, although NC2 tends to have a higher maximum SHMI value than NC5 or Florigiant. The relative constance of SHMI values over the last three harvest dates in 1978 suggests that these cultivars had reached their potential high values. When these SHMI values are used for comparative purposes, NC5 and Florigiant should be compared against a potential value of 3.1 and NC2 against a value of 3.4 (Table 3). Applying these values to the 1977 crop indicates that NC5 reached 67.7%, NC2 82.4%, and Florigiant 83.9% of their potential maturity, as expressed by the SHMI, compared to the 1978 crop.

The cultivar-SHMI data confirm that peanut cultivars respond differently to the environmental conditions of each year. Thus, the maximum potential SHMI value that each cultivar can achieve must be known so that each cultivar can be judged against its own potential. The decision to harvest or not to harvest can then be made on the basis of potential days left in the growing season, weather conditions, equipment scheduling, etc., balanced against the stage of maturity and the potential for it to increase.

Correlation of SHMI to Yield and Dollar Value

The value of any maturity index is its potential for helping to maximize yield and dollar value of the crop. The relationship between SHMI and harvest date, yield, or dollar value can be seen by comparison of the data presented in Table 3. The coefficients of correlation for SHMI to harvest date for cultivars, NC5, NC2 and Florigiant are 0.970, 0.980, 0.990, respectively for 1977, and 0.950, 0.970, and 0.920, respectively, for 1978. The correlation of dollar value to SHMI is 0.997, 0.890, and 0.970 for NC5, NC2, and Florigiant for 1977 and 0.997, 0.840, and 0.930, respectively, for 1978.

The correlation coefficients for SHMI vs yield and dollar value with the cultivar NC2 during 1978 are reduced in comparison ot the other cultivars. The maximum yield and dollar values were obtained at a SHMI of 3.0, but yield and dollar values were reduced when SHMI values reached 3.4. The correlation coefficients increased slightly when the 1977 and 1978 data were combined and analyzed.

The general conclusion from these data is that SHMI, yield, and dollar value are correlated. The variations shown between the 1977 and 1978 peanut crop illustrate the complexities of maturity. Seasonal variation virtually eliminates the possibility of developing a foolproof maturity index that will predict the optimum harvesting date. The SHMI values for NC5, NC2, and Florigiant are between 2.9 and 3.1 for obtaining maximum yield and dollar values. Data from a separate 5-year study (1974-1978, data not shown) indicate that SHMI value

Table 3. Comparison of SHMI, yield, and dollar value across selected cultivars and harvest dates during 1977 and 1978.

Harvest Date	NC5 SHMI	NC5 Yield (kg/ha)	NC5 Dollar Value ha^{-1}	NC2 SHMI	NC2 Yield (kg/ha)	NC2 Dollar Value ha^{-1}	Florigiant SHMI	Florigiant Yield (kg/ha)	Florigiant Dollar Value ha^{-1}
				1977					
9-20	1.4 ± 0.2	2677	1102	2.0 ± 0.4	2690	1188	1.9 ± 0.1	2873	1283
9-27	1.6 ± 0.2	3213	1372	2.5 ± 0.3	3296	1532	2.0 ± 0.3	3415	1532
10-4	2.0 ± 0.3	4096	1823	2.6 ± 0.2	3554	1724	2.3 ± 0.2	3671	1698
10-11	2.0 ± 0.2	4024	1890	3.0 ± 0.2	3789	1854	2.5 ± 0.3	3540	1673
LSD (0.5)		428	232		428	332		428	232
				1978					
9-19	2.5 ± 0.1	3681	1674	2.4 ± 0.2	3197	1585	2.3 ± 0.1	3445	1526
9-26	2.7 ± 0.3	4094	1969	2.8 ± 0.1	3362	1510	2.8 ± 0.1	4549	2156
10-3	3.0 ± 0.1	4685	2336	3.0 ± 0.1	4597	2188	2.7 ± 0.3	4505	2243
10-10	3.1 ± 0.2	4597	2365	3.4 ± 0.1	4209	2025	3.1 ± 0.3	4055	2066
10-17	2.9 ± 0.4	4351	2182	3.2 ± 0.1	4268	2063	3.0 ± 0.1	4723	2395
10-24	2.9 ± 0.2	4306	2216	3.3 ± 0.2	3875	1867	3.0 ± 0.2	4708	2421
LSD (.05)		563	294		563	297		563	294

LSD = Least significant difference

for harvesting Florigiant peantus would range between 2.8 and 3.0, which is in excellent agreement with the data shown.

Recommended Procedure

Randomly select 18 plants from a uniform plot area up to 0.81 ha (2 acres) and hand-harvest. If soil is tight and dry, use a shovel or other implement to assist in removing plants from the soil, thus insuring minimum stripping of mature peanuts from the plant. Remove all fruit including small peg swellings from the selected plants and place them in a container large enough to thoroughly mix the bulked batch of peanut fruit. If a divider is available, divide out a 150-fruit sample. If a divider is not available, randomly sample the bulked peanuts with a small container three or four times to obtain 150 fruit. Place the subsample in a paper bag or wire container and dry for 5-6 hr at 135-150 C (275-300 F). Allow sample to cool for about 0.5 hr, and shell out fruit except the raisins and pops. Place the raisins and pops with the hulls. Weigh the hull and seed fractions. Divide the seed weight by the hull weight. The value obtaned is indicative of the average maturity level of the peanut fruit in the plot with an average standard deviation of 0.2.

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