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The Seed-Hull Weight Ratio as an Index of Peanut Maturity[1,2]

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ABSTRACT

A simple, quantitative method was developed to determine peanut *(Arachis hypogaea L.)* maturity. The method is based on the changing seed-hull weight ratio during maturation of the fruit. The ratio or maturity index was determined for fresh as well as air-dried pods, and these ratios correlated well with a physiological maturity index. The relationship between arginine maturity index and the air-dried seed-hull maturity index (DMI) was also determined, and the two indexes were negatively correlated. The DMI values across nine planting and eight harvest dates over a 2-year period showed that DMI could be applied to estimate average peanut seed maturity under field harvest conditions. The two peanut varieties tested, Florigiant and Florunner, were found to differ in maximum DMI values. The study also showed that peanut seed weight increased with maturity then decreased after full maturity.

Key words: Seed/Hull Ratio, Maturation, Maturity Index, Harvest Dates, Groundnut.

The peanut *(Arachis hypogaea L.)* plant is indeterminate in growth habit. Consequently, its seeds at any of several harvest dates span a broad range of development. The need for criteria to determine the average maturity of seed on a plant has been recognized for over 25 years. Methods for evaluating maturity have been devised by Holley and Young (1963), Mills (1964), Valli (1966), Emery *et al.* (1969), Young and Mason (1972) and Holaday *et al.* (1976). One of two methods that has received major attention is the peanut oil coloration method suggested by Holley and Young (1963) and tested extensively by Emery *et al.* (1966). However, Pattee *et al.* (1968) showed that a carotene oxidase activated in peanuts under water stress or during harvest decolorizes carotene pigments and causes false maturity estimations. The second of the two methods involves use of the arginine maturity index (AMI) which is based on the free arginine content of developing peanut fruits (Young and Mason 1972). This method has been used to predict maximum yields of runner-type peanuts in the southeastern peanut area, but its application to large-seeded Viginia type peanuts in the Carolina-Virginia area has not been successful (Johnson *et al.* 1976).

At present, the maturity of individual seeds is classified subjectively on the basis of physical and morphological characteristics of the hull and testa. Pickett (1950) suggested the use of a combination of seed texture, color, tightness of the seed in the hull, degree of fleshy material, and change of color on the inner side of the hull as the most reliable and simple method. Several workers have suggested broad, general criteria for immature, intermediate, and mature classifications (Whitaker and Dickens, 1964; Young *et al.* 1972). The only extensive physiological maturity classification scheme available was developed by Pattee *et al.* (1970, 1974). It designates 14 stages, from pegging to over maturity, and describes the visual characteristics of each. The physiological maturity classification has been used for the study of changes in enzyme activity levels, of protein, nucleic acids, starch, sugars, lipids, relative changes in the composition of hull, testa and seed, and of seed volatiles during maturation (Aldana *et al.*, 1972; Pattee *et al.*, 1970, 1974; Rudd and Fites, 1972). In attempting to relate the physiological maturity classification to optimum harvest time, we found that the weight ratio between peanut seeds and hulls (seed-hull ratio) might be an objective maturity indicator, and might thus obviate the need for the subjectivity and extensive physical labor involved in the physiological maturity classification. This paper reports on the peanut seed-hull ratio as a maturity index.

Materials and Methods

The peanut seed-hull weight ratio is obtained by dividing the weight of seeds by the weight of hulls. The fresh weight seed-hull maturity index (FMI) is calculated using fresh weight values and the air-dried weight seed-hull maturity index (DMI) is calculated using air-dried weight values.

Peanuts used in this study were grown at the Upper Coastal Plain Research Station at Rocky Mount, N.C. and the Peanut Belt Research Station at Lewiston, N.C. All peanuts were grown according to cultural practices recommended for North Carolina.

At Rocky Mount the cultivar Florigiant was planted on May 16, 1974 and May 8, 1975 in two-row plots 12.2m long. Harvest dates in 1974 were September 17, 24 and October 1, 7, 14; in 1975 they were September 9, 30 and October 7. Plots were machine dug and two plants from each row randomly selected for physiological maturity classification. Plots were replicated 4 times during 1974 and 6 times during 1975 at each harvest date.

The cultivars Florunner and Florigiant were grown during both 1974 and 1975 at the Lewiston location. They were planted

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each year on nine different dates (4/17, 4/26, 5/8, 5/17, 5/31, 6/6, 6/13, 6/20, 7/1/74 and 4/18, 4/24, 5/5, 5/12, 5/22, 6/3, 6/10, 6/20, 7/1/75) as part of a study to develop a model of peanut growth. Each cultivar-planting date combination was replicated 3 times. Each plot consisted of six rows of peanuts approximately 45m long.

During 1974 and 1975 growing seasons at Lewiston, subplots which consisted of 0.9m of a row were manually dug and hand-harvested from every plot at approximately 10-day intervals. For each harvest date, seeds and hulls from samples of air-dried pods were determined and the DMI calculated. Samples used for physiological maturity classification from Lewiston in 1975 were also hand-harvested from every plot. Each sample consisted of 4 plants.

During both years and at each location, the plants selected for physiological maturity classification and subsequent FMI and DMI determinations were transferred to the laboratory on the day of harvest and stored overnight at 4 C. All pods were removed from the plants regardless of size and ranked before drying according to Pattee *et al.* (1974). Air-drying was accomplished by placing the seeds in forced air drying bins at room temperature for one week. The hulls, which were placed in 5.5 cm diameter wire cylinders, were also dried with forced-air for one week.

AMI values were determined by C. T. Young, University of Georgia, Experiment, Georgia, according to Johnson *et al.* (1976).

Results and Discussion

DMI and FMI were highly correlated with the physiological stages of development described by Pattee *et al.* (1974)(Table 1). The R^2 values from the multiple regression (linear and quadratic terms) of the FMI and DMI on the physiological maturity index were 0.99 for both maturity indexes. Further statistical analyses indicated that both the FMI and DMI values differed significantly with maturity up to stage 10. Beyond stage 10 changes in these values were not statistically significant.

These relations indicate that FMI and DMI could be used in place of the physiological maturity index for classifying peanut seeds through maturation stage 10. Classifications on the bases of these indexes have the distinct advantage of being objective.

Comparison of seed weight on both the fresh and air-dried weight bases across maturity levels showed that the peanut seeds reached maximum weight at or near maturity. This finding suggests that when seeds are allowed to develop beyond full maturity (Stage 12) they lose weight. We have long suspected that the weight of peanut seeds reaches a maximum then decreases but data in this regard have not been presented. Existence of a maximum peanut seed weight means that a loss in total pod weight would occur if the loss in weight of over-mature pods exceeds the weight gain of developing pods.

Table 1. Relationship between the physiological stage of maturation and the seed-hull ratio for Florigiant peanuts at Rocky Mount, N.C. during 1974 and 1975 and Lewiston, N.C. during 1975.

Physiological Maturity Stage	Number of Observations	Fresh Wt. Per Seed (g) Ave.	Std. Dev.	Fresh Seed-Hull Ratio Ave.	Std. Dev.	Air-Dried Wt. Per Seed (g) Ave.	Std. Dev.	Air-Dried Seed-Hull Ratio Ave.	Std. Dev.
6	64	0.33[a]	0.12	0.42[a]	0.16	0.10[a]	0.05	0.56[a]	0.31
7	67	0.65[b]	0.15	1.07[b]	0.35	0.26[b]	0.09	1.30[b]	0.47
8	69	0.91[c]	0.15	1.59[c]	0.40	0.42[c]	0.10	1.80[c]	0.53
9	71	1.11[d]	0.16	2.03[d]	0.51	0.59[d]	0.11	2.17[d]	0.60
10	66	1.24[e]	0.15	2.35[e]	0.44	0.76[e]	0.11	2.52[e]	0.50
11	58	1.34[f]	0.13	2.62[f]	0.43	0.91[f]	0.10	2.84[f]	0.35
12	45	1.34[f]	0.17	2.79[fg]	0.49	0.92[f]	0.12	2.99[f]	0.37
>12	30	1.29[ef]	0.20	2.85[g]	0.76	0.89[f]	0.17	2.89[f]	0.67
R^2		0.9991		0.9997		0.9742		0.9965	

Means in each column with the same letter are not signiciantly different at 0.05.

Table 2. Correlation of arginina maturity index (AMI) and air-dried weight seed-hull maturity index (DMI) values for five digging dates during 1974 at Rocky Mount, N.C.†

DIGGING DATE	AMI	DMI
Sept. 17	137	1.84
Sept. 24	134	2.24
Oct. 1	102	2.40
Oct. 7	80	2.62
Oct. 14	86	2.78
r =		-.905*

† Average of four replications for all values

* Significant of 0.05 probability level

Because the AMI is used extensively in the Southeastern peanut growing region to estimate peanut maturity, we compared it with DMI. They were negatively correlated (r = -0.905*) when the comparisons were made with samples from five 1974 harvests of Florigiant grown at Rocky Mount, N. C. (Table 2). The DMI values increased linearly with maturity. On the other hand, with the exception of the last digging date, the AMI values decreased sequentially with maturity. AMI values characteristically begin to increase at full maturity and beyond. Thus, the trend in the AMI values of

Table 3. Air-dry weight seed-hull maturity index values for Florigiant and Florunner varieties at selected planting and harvest date combinations during 19 7 4 at Lewiston, N. C.

Planting Dates	Harvest Dates															
	8/1/74		8/12/74		8/22/74		9/3/74		9/12/74		9/23/74		10/3/74		10/14/74	
	FR†	FG††	FR	FG	FR	FG	FR	FG	FR	FG	FR	FG	FR	FG	FR	FG
Apr. 17	0.70	0.51	1.52	1.02	1.82	1.34	2.84	2.04	3.54	2.60	3.76	2.74	3.86	3.09	4.03	3.19
Apr. 26	0.49	0.38	1.06	0.97	1.81	1.29	2.52	1.76	3.16	2.62	3.50	2.72	3.59	2.81	4.04	3.15
May 8	0.18	0.17	0.48	0.44	0.79	0.75	1.96	1.31	2.86	2.09	3.64	2.06	3.54	2.45	4.09	2.82
May 17	0.08	0.03	0.32	0.08	0.67	0.51	1.72	1.24	2.77	1.98	3.13	2.52	3.40	2.70	3.83	3.04
May 31	-	-	0.12	0.07	0.47	0.36	1.46	0.95	2.20	1.65	3.06	2.06	2.94	2.41	3.46	2.85
June 6	-	-	-	-	0.39	0.24	1.24	0.86	1.74	1.51	2.74	1.84	2.62	1.67	3.01	2.43
June 13	-	-	-	-	0.13	0.11	0.98	0.75	1.71	1.03	1.97	1.47	2.28	1.75	2.59	2.15
June 20	-	-	-	-	0.01	0.03	0.61	0.57	1.07	0.90	1.51	1.28	1.80	1.52	2.06	1.87
July 1	-	-	-	-	-	-	-	0.11	0.50	0.30	0.58	0.61	0.60	0.58	1.00	0.84

† FLORUNNER

†† FLORIGIANT

Table 4. Air-dry weight seed-hull index for Florunner and Florigiant varieties at selected planting and harvest dates during 1975 at Lewiston, N.C.

Planting Dates	Harvest Dates															
	7/27/75		8/7/75		8/18/75		8/28/75		9/8/75		9/18/75		9/29/75		10/10/75	
	FR†	FG††	FR	FG	FR	FG	FR	FG	FR	FG	FR	FG	FR	FG	FR	FG
Apr. 18	0.82	0.59	1.11	0.85	2.20	1.49	2.88	1.88	3.62	2.34	3.68	2.72	3.92	2.90	4.39	3.02
Apr. 24	0.59	0.63	1.00	0.85	1.69	1.30	2.46	1.59	3.21	2.35	3.70	2.47	3.25	2.78	3.64	2.82
May 5	0.33	0.27	0.90	0.52	1.70	1.19	2.45	1.68	2.82	2.42	3.05	2.28	3.09	2.54	3.61	2.56
May 12	0.27	0.16	0.90	0.48	1.74	1.02	2.17	o.50	3.25	2.20	3.38	2.35	3.41	2.53	3.82	2.82
May 22	0.07	0.06	0.50	0.33	1.05	0.95	1.66	1.30	2.62	2.09	2.67	1.87	3.17	2.36	3.61	2.66
June 3	-	-	0.23	0.14	0.41	0.27	0.97	0.51	1.46	1.26	1.86	1.16	2.27	1.30	2.91	1.91
June 10	-	-	-	-	0.12	0.13	0.44	0.40	0.66	0.49	0.78	0.76	0.95	0.82	1.41	0.85
June 20	-	-	-	-	-	-	0.21	0.10	0.28	0.16	0.56	0.35	0.65	0.61	1.21	0.85
June 1	-	-	-	-	-	-	-	-	0.08	0.12	0.39	0.26	0.81	0.47	0.83	0.51

† FLORUNNER

†† FLORIGIANT

the samples must be known for estimation of crop maturity by AMI.

The data in Table 2 suggest that DMI should correlate well with changes in maturity caused by variations in planting and harvest dates of peanut varieties. Thus we examined the changes in DMI across nine planting dates and eight harvest dates at Lewiston, N.C. during 1974 and 1975. Florunner was also included in the study so that the effect of variety on DMI might be determined. In both 1974 and 1975, the DMI for both varieties generally increased with successive harvest dates regardless of planting date (Table 3 and 4). The data thus suggest that DMI can be applied to field conditions to estimate the average stage of maturity of a peanut crop. In 1974 and 1975, maximum DMI values were 3.19 and 3.02, respectively, for Florigiant and 4.09 and 4.39 respectively, for Florunner. Tables 3 and 4 show that DMI values were higher for Florunner than for Florigiant and, hence, likely differ with variety. Thus, a DMI range may have to be determined for each variety. Because Florigiant and Florunner are large-and small-seeded Virginia types, respectively, the DMI may only have to be determined for selected varieties within the different types of peanuts.

The maximum DMI values obtained from the field studies of Florigiant (Tables 3 and 4) indicate that the average DMI for the entire crop can approach the DMI for fully mature pods. Because peanuts are an indeterminate crop, and because there is a limit on how long mature peanuts may remain attached to the plant, the optimum harvest date may occur before the average DMI of the crop indicates full maturity. Future studies will be conducted to determine whether DMI can be used to predict optimum harvest date.

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