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Adaptability of the Arginine Maturity Index Method To Virginia Type Peanuts in North Carolina[1]

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ABSTRACT

The Arginine Maturity Index (AMI)- method for estimation of optimum maturity and highest quality of peanuts was evaluated in a two-year research station study (1977 and 1978) of large-seeded Virginia type peanuts grown in North Carolina. A one year study was conducted on farms in seven North Carolina counties in 1978. Samples were collected weekly from both the research station and farms and analyzed for arginine by the modified Sakaguchi reaction. Maximum yield corresponded to minimum AMI values for each cultivar in 1977 and for the NC 5 cultivar in 1978 in the research station study. Prediction curves were derived from each cultivar for each year using a quadratic polyonomial equation. Large differences in AMI data existed between 1977 and 1978 and between cultivars in 1978 at early harvest dates; however, near minimum AMI values, all six curves appear to be similar. AMI and yield data obtained from individual county farms fluctuated throughout the growing season. Generally, higher AMI values were observed for Virginia type than have been reported for Spanish type peanuts. Using the predicition curve derived in Georgia, and subtracting one week, predicted digging dates were within 4 days of the date of maximum dollar return per ha in five of the seven counties. Based on previous experience, the farm data of six counties (with the exception of Nash), was used to derive a tentative optimum harvest prediction equation for North Carolina.

Key Words: groundnut, *Arachis hypogaea* L., maturity, optimum harvest date.

Maturity of peanuts (*Arachis hypogaea* L.) has been related to roasting quality, yield, market grades, and economic returns. Exact maturity assessment is desirable if optimum yields and highest quality are to be realized (2, 4). Various maturity tests used for prediction of optimum harvesting of peanuts include methods based on internal hull coloration (6, 16, 20, 21), light absorption properties, (8, 9, 14, 17), and quantitative physiological measurements (18, 19).

The Arginine Maturity Index as developed by Young and co-workers (15, 22, 25), has been under examination in both southeast and southwest areas since its conception as a rapid, objective maturity test. Considerable testing in Georgia and Oklahoma (22, 24) showed that the AMI was a reliable method for prediction of most profitable harvest dates. Earlier evaluation of the AMI in North Carolina by Johnson *et al.*, (12, 13) resulted in inconclusive findings. Further testing of the AMI methods on Virginia type (ssp. *hypogaea* var. *hypogaea*) peanuts was necessary in order to substantiate its use in the North Carolina-Virginia area. The purpose of this study was to establish a tentative prediction curve for the AMI and determine its adaptability to large-seeded Virginia type peanuts.

Materials and Methods

A two year (1977 and 1978) study was conducted at the Lewiston, N. C. Peanut Belt Research Station. All peanuts were grown according to recommended cultural practices. Three Virginia type cultivars, NC 5, NC 2, and Florigiant, were used both years. NC 5 is a late maturing cultivar with a intermediate growth habit (5); NC 2 is an intermediate maturing bunch cultivar (7); and Florigiant is an intermediate maturing runner cultivar (3). At each harvest, peanuts were evaluated for AMI. percent dry matter, yield, and market grades.

In 1977 peanuts planted May 18 were sampled weekly from September 13 to October 11. Plots consisted of three rows, 35 plants each. Two rows were harvested for yield and one row for maturity evaluation. In 1978 peauts planted May 22 were harvested weekly seven times from September 12 to October 24. Plots consisted of four rows, 35 plants each; two rows for yield data and two for maturity studies. In both years, the tests were replicated six times in a randomized complete block design.

A one year (1978) study was conducted on a grower farm in seven North Carolina counties: Bertie, Northampton, Hertford, Nash, Halifax, Chowan, and Pitt. Peanuts (cv. Florigiant) were planted on May 5 in all counties except Bertie which had an April 12 planting date. Plants for AMI were selected from two random areas in each plot. Sufficient plants were selected at each sample area to yield 1 to 2 liters of peaut fruits when all fruit was removed from the plants. The remaining plants were stacked for use in determining yield and market grade. The number of weekly samplings varied from five to eight among the counties.

In sampling the peanuts for the maturity study at both the research station and county levels, all pods including the most immature were removed from the vine. In addition, all pods that came off the vine while removing the plant from the soil were included. A sample size of approximately 1.5 liters was adequate for maturity determination. After picking, the pods were chilled on ice in order to retard enzymatic and chemical degradation. Peanuts, after being returned to the laboratory, were washed and prechopped for 1 min in a Hobart Food Chopper. Duplicate 20 g subsamples were dried for 5 hr at 110 C in a forced air oven for dry matter determination. Duplicate 30 g samples were each blended for 30 sec in a Waring Blendor with 200 ml 2% TCA. The solution was then poured into a beaker, allowed to stand 10 min and filtered through Whatman #2V fluted filter paper. It was necessary to allow the solution to stand a minimum of 10 min in order to avoid a milky filtrate which could interfere with color readings (23).

Prepared samples were anlayzed with a continuous automated flow system (Technicon AutoAnalyzer II) using the modified Sakaguchi reation for arginine determination (10, 11).

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Some modifications of Young's (23) method were used in this study. A 10% KOH solution was used instead of a 20% solution. Stabilization of the color with KNO_2 was not necessary as had been reported. Pump tubes used in the present system are sample (0.10 ml/min), KOH (1.60 ml/min), acetic anhydride (part no. 116-0581 pol), air (1.60, 0.10, 1.00 ml/min), α-naphthol (0.80 ml/min), and KOBr (1.40 ml/min). In addition, the original acetylated sample was not subsampled for mixing with the α-naphthol solution. Mixing of the solution was originally via two 14-turn coils and one 4-turn coil. The present method uses one 5-turn, one 14-turn, and two 10-turn coils for mixing. An automatic timer (Knoblesdorff Instruments, Inc.) was used to standardize a 40 sec wash solution (2 ml Brij/liter deionized water) and a 30 sec sampling.

The colorimetric response was measured at 510 nm (Turner Model 330 Spectrophotometer) using a flow cell. Standard arginine solutions (lg/liter) with 10, 20, 30 ml/100 ml dilutions) were used to standardize the recorder (Health Scholumberger Strip Chart Recorder) resonse. A power fit curve program (Hewlett Packard 97 calculator with curve-fitting program SD-03A) was used to derive arginine values. All AMI values were calculated on a dry weight basis. Estimated digging dates were calculated from the equation established for Georgia (y = 7(x-36) ÷ 32) where y = days to harvest and x = AMI (26). Data was statistically analyzed by general linear models and analysis of variance procedures (1).

Calibration curves were derived for both the Lewiston and county studies using curves best fitted to quadratic and cubic equations. A prediction curve based on the counties, excluding Nash, was developed for use at the farm level in North Carolina. The curve was prepared from combined analysis of the quadratic curves.

Results and Discussion

Lewiston Maturity Study

Maximum yield per ha corresponded to minimum AMI values for each cultivar in 1977 (Table 1). In 1978, maximum yield corresponded to minimum AMI values for NC 5 but not for the NC 2 and Florigiant cultivars. Maximum value/ha corresponded for NC 5 and Florigiant. The 1977 AMI values showed consistent decreases with time until optimum maturity. The AMI values for 1978 were more erratic. Florigiant showed constant decreases in AMI values with time; however, both NC 5 and NC 2 showed several fluctuations of AMI values.

Table 1. Percent dry matter, AMI values, official grade data, [a] yield, and value per hectare for peanuts grown two years at the Lewiston Research Station.

Variety	Harvest date	Dry matter	AMI	FM	LS	FS	XL	SMK	OK	SS	Yield/ ha	Value/ ha
		%		-	-	-	-	%	-	-	kg	$
				1977 Research Plots[b]								
NC 5	9/13	26.2	207.1	1.2	0.1	64	2	50	9.0	0.1	1944	691
	9/20	28.2	166.8	1.2	0.1	64	5	59	3.8	0.1	2677	1101
	9/27	33.4	112.3	0.8	0.1	72	20	61	4.7	0.1	3213	1373
	10/4	43.2	95.3	0.6	0.1	67	25	63	4.4	0.3	4096	1822
	10/11	41.8	101.0	1.2	0.3	70	35	66	2.2	0.7	4024	1889
NC 2	9/13	28.0	226.1	1.6	1.0	71	6	57	4.8	0.0	1868	728
	9/20	33.1	166.2	0.9	0.8	70	13	64	2.8	0.1	2690	1188
	9/27	37.0	116.8	1.7	1.3	73	30	67	2.7	0.4	3296	1531
	10/4	44.4	96.4	1.0	0.5	75	35	69	2.3	0.6	3558	1723
	10/11	44.6	82.3	1.8	1.7	73	40	70	1.2	0.7	3789	1854
Florigiant	9/13	28.8	221.8	0.5	0.2	79	7	54	6.7	0.1	2324	886
	9/20	32.4	156.4	0.3	0.0	81	10	62	2.8	0.2	2875	1232
	9/27	36.3	108.0	0.7	0.3	77	21	64	3.5	0.2	3415	1533
	10/4	45.2	84.3	0.7	0.1	82	29	65	3.8	0.3	3671	1699
	10/11	43.1	89.4	1.0	0.3	81	39	67	2.1	0.3	3540	1672
				1978 Research Plots[c]								
NC 5	9/12	35.5	134.4									
	9/19	40.6	151.1	1.5	0.6	43	20	67	3.8	1.3	3681	1674
	9/26	42.0	121.8	1.6	0.9	48	27	72	1.9	0.7	4094	1968
	10/3	44.1	85.7	1.1	0.3	44	29	73	1.6	1.1	4685	2336
	10/10	42.6	99.9	0.7	0.3	47	34	75	0.8	1.9	4597	2365
	10/17	40.0	90.3	0.8	0.7	43	37	74	1.1	2.5	4351	2183
	10/24	45.6	94.9	1.4	0.7	49	40	75	1.0	1.7	4311	2215
NC 2	9/12	33.8	200.6									
	9/19	40.6	174.1	1.8	2.0	31	10	65	5.0	0.4	3197	1338
	9/26	42.4	146.9	2.1	2.0	24	10	69	3.3	0.6	3362	1511
	10/3	44.5	109.6	1.3	0.5	30	18	73	1.9	0.7	4597	2188
	10/10	43.7	124.3	1.3	1.1	31	20	74	1.1	1.3	4209	2025
	10/17	45.0	97.6	1.2	0.9	29	19	75	1.0	0.8	4268	2062
	10/24	49.6	85.8	1.0	0.8	33	25	74	1.0	1.0	3875	1867
Florigiant	9/12	33.0	174.8									
	9/19	41.7	154.7	0.8	0.6	49	16	65	4.8	0.7	3445	1526
	9/26	42.1	135.3	0.8	0.6	54	21	70	2.5	0.8	4549	2156
	10/3	41.5	121.3	0.8	0.1	55	27	73	1.4	0.7	4505	2242
	10/10	44.0	108.4	0.8	0.8	52	30	75	1.1	2.0	4055	2064
	10/17	44.6	90.5	1.4	0.9	54	34	74	1.2	1.5	4723	2395
	10/24	47.2	86.9	1.0	0.3	59	40	75	0.8	1.4	4708	2420

[a] FM,LS,FS, XL,SMK,OK,SS indicates foreign matter, loose shelled kernels, fancy sized pods, extra large kernels, sound mature kernels, other kernels, and sound splits, respectively.
[b] Planted May 18, 1977.
[c] Planted May 22, 1978.

The data for separate years, as well as combined years, was statistically analyzed using the general linear models procedure (1) (Table 2). In both 1977 and 1978, the effect of harvest dates on both AMI and percent dry matter (PDM) was significant (0.01 level). Cultivar effects for AMI were not significant in 1977 but both cultivars (0.01 level) and the harvest X cultivar interactions (0.05 level) were significant in 1978. The analysis combined over years showed significance for years, cultivars, harvests within years, and most interactions.

Prediction curves were derived from the Lewiston AMI data using a quadratic polynomial equation. Separate curves were obtained for each cultivar for each year. Multiple determination coeffcient (R^2) values ranged from 0.720 (NC 5 in 1978) to 0.999 (Florigiant in 1977). The derived curves are shown in Figure 1. Comparison of the two years shows large differences between years at early harvests and between cultivars in 1978. Near minimum AMI values however, all six curves appear to be correlated. The 1977 curves showed that the AMI values of the peanuts did reach a minimum and begin to increase with later har-

Table 2. Mean squares from general linear models procedure for Lewiston maturity study.

Source	df	% Dry matter	AMI
		1977 Research Plots	
Harvest	4	1903.52**	108322.91**
Cultivar	2	149.61**	524.91
Har x Cult	8	8.62	725.32
Error	75	22.70	1212.04
Lab duplicate	90	0.32	28.78
		1978 Research Plots	
Harvest	6	589.40**	37380.36**
Cultivar	2	36.11	11164.41**
Har x Cult	12	27.83	2041.32*
Error	105	34.07	1606.89
Lab duplicate	126	0.43	56.64
		Combined Years	
Year	1	3441.25**	15399.28**
Cultivar	2	145.03**	6942.48**
Yr x Cult	2	40.69	4746.83*
Har(Yr)	10	1115.05**	65757.38**
Har x Cult(Yr)	20	20.15	1514.92
Rep(Har x Cult)	105	31.32**	1216.70**
Error	180	29.34	1442.37
Lab duplicate	216	.38	45.03

*,** Indicates significance at the 0.05 and 0.01 levels of probability, respectively.

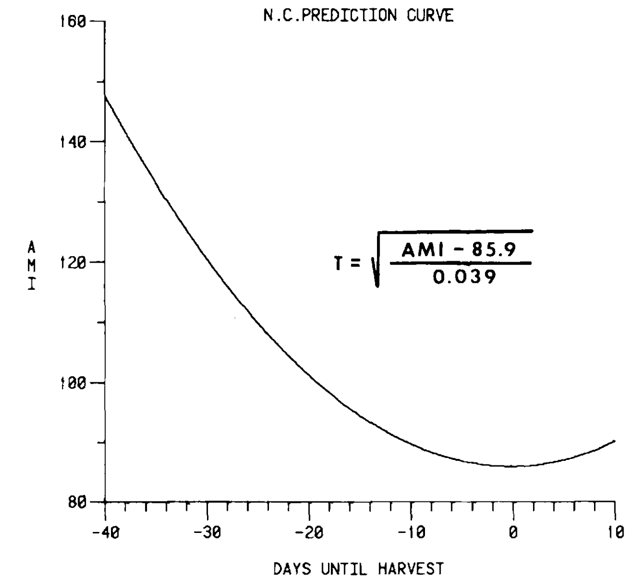

Fig. 1. Predicted values for AMI on three varieties of peanuts grown at Lewiston in 1977 and 1978.

vests. In 1978, it appeared that optimum maturity had not been reached by the final harvest date. The AMI values appeared to be at a minimum but had not begun to increase substantially.

County Maturity Study

Constant decreases of the AMI with time were not observed in any of the seven counties. Rather, fluctuation within the season were noted as were also seen in the 1978 Lewiston study. Yield per ha fluctuated as widely as did the AMI values; therefore, it was difficult to determine exact optimum harvest dates. Instead, more appropriate was an optimum harvest period ranging from one to two weeks. The minimum AMI values corresponded to the optimum maturity period for five of the seven counties studied (Table 3). Yield and grade information for Pitt County was not available. Generaly, higher AMI values were observed for Virginia than for Spanish (ssp. *fastigiata* var. *vulgaris*) peanuts as reported earlier by Johnson *et al.* (12). This was probably due to a higher proportion of immature peanuts at harvest on the plant of the large-seeded cultivar. Johnson *et al.* (12) attributed the AMI differences to geographical and/or cultivar factors.

The analysis of variance (Table 4) for the county maturity study showed harvest date for both percent dry matter and AMI was highly significant for each of the seven counties. The effect of field sample within harvest for the AMI was found to be significant (0.01 level) for Northampton, Hertford and Halifax counties. These differences could have been the result of sampling error, weather conditions, insects or disease in different areas of the field. Because of these differences, predicted value curves for each of the seven counties were derived.

Both quadratic and cubic polynomial derivations were obtained with the coefficient of multiple

Table 3. Percent dry matter, AMI values, official grade data,[a] yield, and value per hectar for peanuts from 1978 maturity study in seven counties.

County	Harvest date	dry matter	AMI	SMK	ELK	Fancy	Yield/ ha	Value/ ha
		%		%	%	%	kg	$
Bertie	9/5	46.0	70.5	65	24	86	1710	765
	9/12	50.1	53.8	65	26	88	2116	948
	9/19	56.1	35.8	75	22	90	2482	1272
	9/26	62.7	63.5	67	23	88	2523	1163
	10/3	51.1	89.0	69	27	88	2401	1136
	10/10	45.3	75.5	74	33	90	1465	746
	10/17	39.3	74.0	72	26	86	1058	521
	10/24	37.7	94.3	70	27	80	936	449
Northampton	9/5	31.2	202.0	56	5	79	1710	657
	9/12	30.3	193.8	62	10	83	2360	983
	9/19	43.9	100.5	66	18	87	3093	1393
	9/26	44.7	116.3	70	26	84	3337	1600
	10/3	42.8	127.3	71	36	89	3500	1721
	10/10	44.2	99.8	71	46	91	3269	1625
	10/17	42.6	77.3	71	36	82	3847	1889
	10/24	55.3	52.0	72	53	89	3864	1956
Hertford	9/5	27.4	226.0	57	10	89	2018	775
	9/12	36.0	174.5	61	14	92	2865	1185
	9/19	41.3	131.3	67	19	90	3189	1175
	9/26	43.8	141.0	68	22	88	2930	1328
	10/3	44.2	119.5	72	30	90	3548	1731
	10/10	45.7	107.0	72	37	89	3809	1867
	10/17	41.3	96.5	73	38	92	4476	2225
	10/24	51.5	72.8	72	39	88	3630	1812
Nash	9/5	25.8	163.0	57	11	76	1790	701
	9/12	30.3	136.3	55	16	83	1899	721
	9/19	39.7	139.8	57	24	84	1899	756
	9/26	40.0	161.8	58	27	83	2767	1116
	10/3	42.7	159.5	64	36	89	2930	1306
	10/10	41.8	140.5	65	32	85	3093	1393
	10/17	45.7	122.8	66	40	86	2604	1198
	10/24	54.2	100.8	64	38	84	2930	1311
Halifax	9/12	27.1	166.8	59	14	90	3580	1449
	9/19	31.6	175.3	61	21	91	4558	1928
	9/26	40.3	139.5	65	25	83	4558	2044
	10/3	41.0	130.8	69	37	87	5372	2568
	10/10	39.9	108.5	70	37	93	5293	2575
	10/17	39.6	124.5	67	33	86	5080	2358
	10/24	45.4	109.5	71	43	90	5413	2676
Chowan	9/12	37.4	125.5	70	43	93	3337	1632
	9/19	46.4	84.3	74	55	95	3011	1565
	9/26	47.7	104.5	70	52	89	3011	1481
	10/3	48.6	106.0	73	65	85	2116	1096
	10/10	49.8	85.8	74	58	93	2360	1232
Pitt	9/5	19.7	159.5					
	9/12	29.0	133.5					
	9/19	38.9	54.8					
	9/26	39.2	83.0					
	10/3	42.7	78.8					
	10/10	40.7	88.3					

[a]SMK = sound mature kernels.
ELK = extra large kernels

determination (R^2) ranging from 0.32-0.93 (quadratic) and 0.62-0.98 (cubic). The quadratic curves (Figure 2) show that the maturity study was not carried past optimum harvest in Northampton, Hertford, Halifax, and Chowan counties. Decreases in the AMI are shown; however, minimum values followed by increases were not observed. Both Bertie and Pitt County curves showed minimum AMI values with subsequent increases of the AMI after optimum maturity. The curve for Nash County was quite inconsistent with curves of the other counties. This "inverted" curve could have been the result of sampling error, weather, or other environmental conditions. Some of the peanuts could have been lost during digging. The cubic curves showed considerable variation among the counties as was reflected by highly significant location effects. Although R^2 values were higher for the cubic derivations, it was decided not to use these curves for calculating an overall equation because of the location discrepancies. Quadratic

Table 4. Mean squares from general linear models procedures for 1978 maturity study in seven counties.

County	Source	df	% Dry matter	AMI
Bertie	Harvest	7	277.99**	1413.25**
	Field sample (Har)	8	5.66**	69.09
	Error	16	0.94	48.78
Northampton	Harvest	7	220.65**	9126.22**
	Field sample (Har)	7	12.18**	496.32**
	Error	15	0.42	75.77
Hertford	Harvest	7	205.17**	9289.34**
	Field sample (Har)	8	23.87**	309.94**
	Error	15	0.37	51.12
Nash	Harvest	7	246.56**	1693.32**
	Field sample (Har)	7	5.91**	261.18
	Error	15	0.25	99.96
Halifax	Harvest	6	157.87**	2743.74**
	Field sample (Har)	7	13.59**	1344.54**
	Error	14	1.35	80.18
Chowan	Harvest	4	98.34**	1150.43**
	Field sample (Har)	5	4.47**	147.70
	Error	10	0.94	65.50
Pitt	Harvest	5	315.73**	6070.28**
	Field sample (Har)	6	9.77**	106.96
	Error	12	0.58	45.71

*,** Indicates significance at the 0.05 and 0.01 levels of probability, respectively.

curves were used based on earlier reliability usage in Georgia by Young et al. (26).

North Carolina Prediction Curve

Six of the quadratic equations for the county study were used to derive an optimum harvest prediction equation. Nash was eliminated because of its inconsistency with the other counties. The Lewiston equations were not used since maturity was not obtained except in the 1977 study. Young *et al.* (26) determined that the best way to obtain adequate prediction curves was to derive them at the grower level and then check for good fit at both grower and research station levels.

Combination of the six county equations resulted in the new equation $AMI = 85.9 + 0.02T + 0.39T^2$ where T = days until harvest. The middle term of the equation was eliminated since its contribution to the final answer would not be significant. Subsequent rearrangement of the equation solving for T is shown in Figure 3. This equation can be used for AMI values greater than 86. Using this new equation, the North Carolina prediction curve was derived (Figure 3). Predictions of digging date can be started up to 40 days prior to harvest based on this curve.

Application of this new equation to the 1977 Lewiston plots and Bertie and Pitt Counties gave predictions that showed minimum AMI values at 0 time. Since the maturity studies were not carried to completion in 1978 at Lewiston and in the other five counties, it was difficult to assess the consistency of this curve from year to year.

Further work is needed to establish the validity of this curve. The prediction curve must be checked

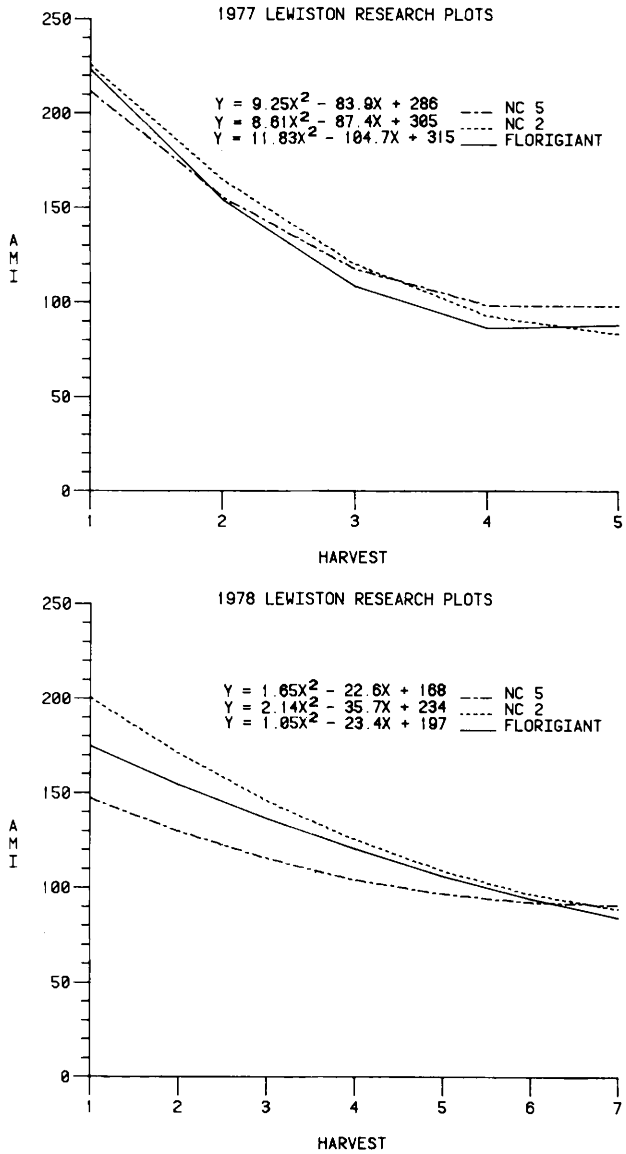

Fig. 2. Predicted values (quadratic) for AMI of peanuts grown in seven counties in 1978

for accuracy from year to year as well as for different locations. Future investigations should include additional cultivars to determine maturation differences between cultivars of Virginia type peanuts. Additional late season harvest dates are needed in order to substantiate increases in the AMI after the optimum maturity period.

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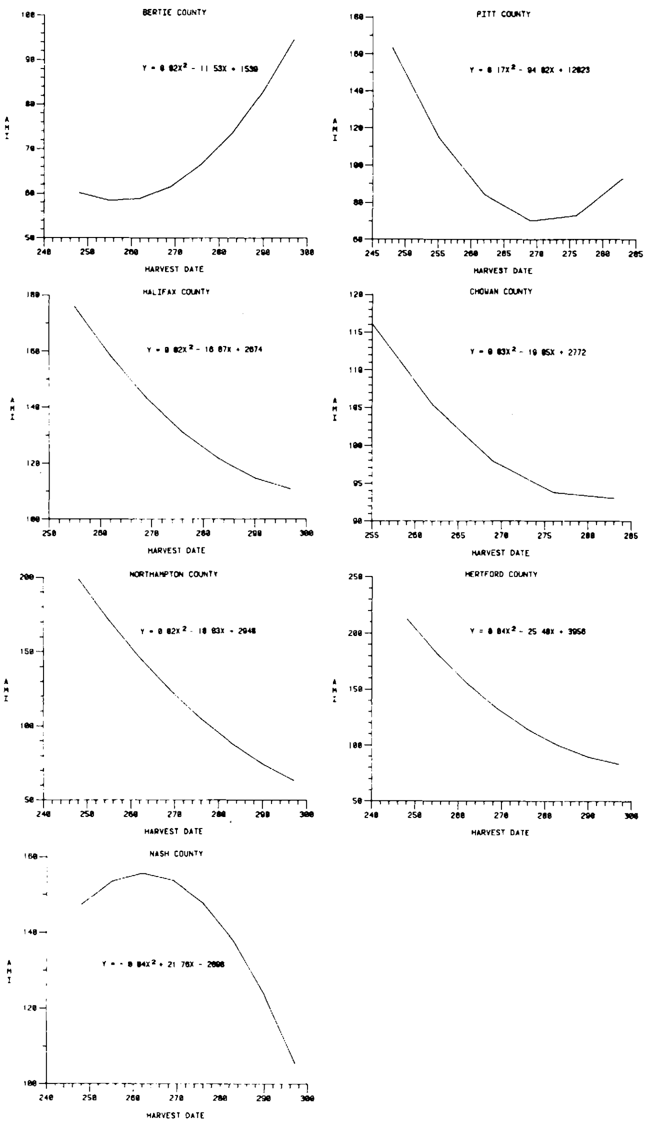

Fig. 3. Prediction curve dervied from data based on 1978 maturity studies in six counties.

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