Effect of Selection for Emergence and Maturity on Yield of Ontario Peanuts

T. E. Michaels[1]

ABSTRACT

Seed yield of valencia peanut *(Arachis hypogaea* L. ssp. *fastigiata* Waldron var. *fastigiata)* cultivars currently grown in Ontario, Canada appears quite sensitive to cooler or shorter than normal growing seasons. High seed yield may be associated with high percentage emergence and early maturity in this unique peanut-growing region. Selection for percentage emergence and maturity was practiced among F_2 derived F_4 families of five populations. Maturity was determined by percentage of pod yield as sound mature seeds. Percentage emergence selections and percentage sound mature seed selections were recombined in a Comstock and Robinson design II mating design to develop 16 crosses. F_3 and F_4 bulk progeny of these crosses were entered in three trials in two locations. Crosses on average had significantly higher percentage emergence and percentage sound mature seeds than the ancestors at only the coolest, shortest season location. Crosses on average were not significantly different from ancestors for pod or seed yield in any trial. General combining ability (GCA) and its interaction with trial were significant for all characteristics except percentage emergence for the percentage sound mature seed selections. The GCA x trial interactions appeared to be associated with differences in rainfall and temperature in August and September between the two years. Specific combining ability and its interaction with trial were also significant for all characteristics except emergence.

Key Words: *Arachis hypogaea* L., early generation selection, maturity, emergence, yield, combining ability.

Commercial peanut *(Arachis hypogaea* L.) production in Ontario, Canada is limited to a region along the northern shore of Lake Erie at approximately 43 degrees N Lat with a mean temperature of 18.2 C during a 130 day growing season. Seed yield of the valencia (ssp. *fastigiata* Waldron var. *fastigiata)* cultivars currently grown in that region appears quite sensitive to cooler or shorter than normal growing seasons. Seed yield in Ontario in 1982 was 68% of the 7 year mean following a 0.5 C cooler growing season and an early killing frost that shortened the normal growing season by 21 days.

A cultivar development project in Ontario has included high percentage emergence and early maturity among its selection criteria with the expectation that these characteristics are associated with higher yield in a cool, short growing season. Plant stand and percentage of pod yield as sound mature seeds has been shown to influence yield in Ontario (9). Ablett *et al.* (1) reported that abnormal seedling growth in Ontario re-

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[1] Associate Professor, Department of Crop Science, University of Guelph, Guelph, Ontario, Canada N1G 2W1.

sulted in decreased emergence, stand and yield. High percentage of pod yield as sound mature seeds was associated with high yield in a cool growing season in Ontario (Michaels, unpublished).

Conventional methods are used for evaluating yield and emergence in Ontario, but evaluation of maturity is problematic. Conventional pod and seed indicators of maturity that rely on pericarp or mesocarp darkening, or testa color changes (4,6,7,11) are not fully expressed in Ontario. As an alternative, the percentage of pod yield as sound mature seeds following the first killing frost is used to differentiate late maturing, unadapted segregates with a low percentage sound mature seeds from earlier maturing, adapted segregates with a higher percentage of sound mature seeds. Use of this percentage as an indicator of maturity is an extension of the concept of a seed/hull ratio maturity index (8,10), although the seed/hull index was originally proposed for use in determining maturity of samples of cultivars whose seed/hull relationship is known.

The objective of this study was to identify the significant sources of variation in percentage emergence, pod yield, seed yield and percentage sound mature seeds among progeny of crosses derived from a Comstock and Robinson design II mating design where one set of parents was selected for high percentage emergence and the other set was selected for high percentage sound mature seeds. It was hoped that this experiment would also indicate whether recombination of early generation emergence and maturity selections would result in breeding populations from which cultivars could be selected.

Materials and Methods

The following crosses among ancestors were made in 1979 to establish five populations: 1) Blanco Rio Segundo x Honduras, 2) Blanco Rio Segundo x Chico, 3) Line 546 x Honduras, 4) Line 546 x Chico, and 5) Delhi x Chico. Blanco Rio Segundo, Honduras and Line 546 are high yielding valencia peanut introductions to Canada from Argentina, Honduras and Zambia, respectively. Chico is an early maturing spanish peanut (2). Delhi is an early maturing spanish peanut of undocumented origin that is traditionally grown in home gardens near Delhi, Ontario. Two hundred families were initiated in each population from individual plants. Seeds were bulked within families in the F_3 generation, and in 1982 the F_2 derived F_4 families were grown in single, nonreplicated, 7 m rows at Delhi, Ontario. During the 1982 growing season, which was cooler and shorter than normal, the 200 families within each population were evaluated for percentage emergence and percentage sound mature seeds riding a 0.60 x 1.9 cm slotted screen. One family with high percentage sound mature seeds and one family with high percentage emergence were selected from each of the five populations. The percentage sound mature seed selection from population 4 (Line 546 x Chico), and the percentage emergence selection from population 5 (Delhi x Chico) were subsequently lost. The remaining eight selected families were designated as parental families.

Plants representing each of the four parental families selected for percentage sound mature seeds were crossed with plants representing each of the four parental families selected for percentage emergence in a Comstock and Robinson design II mating design (3). Parental families were represented by different plants when making each cross.

The five ancestors (Blanco Rio Segundo, Honduras, Line 546, Chico and Delhi) and the F_3 bulks derived from each of the sixteen crosses were evaluated at Delhi, Ontario in 1985. The five ancestors and the F_4 bulks of the sixteen crosses were evaluated at Delhi and Cambridge, Ontario in 1986. The Delhi location is a Fox loamy sand situated at 42° 52' N Lat with a mean temperature during the growing season of 18.2 C, and is representative of the peanut producing region in Ontario. The Cambridge location is a Fox loamy sand situated at 43° 27' N Lat with a mean temperature during the growing season of 17.4 C, and is used to screen breeding lines for tolerance to cooler, shorter seasons. Plots at both locations were one row, 7 m long with 0.6 m between rows, seeded at a rate of 13 seeds/m^2 in a randomized complete block design with four replications. The central 6 m of each plot were harvested at the end of the growing season. Percentage emergence, pod yield, yield of seed riding a 0.60 x 1.90 cm slotted screen and percentage sound mature seeds were recorded for each plot. Data were analyzed using an analysis of variance where effects were considered fixed. Mean squares were partitioned to determine variance due to combining ability as outlined by Hallaurer and Miranda (5) for model I since the parental families represented a fixed sample. Residuals for all characteristics were randomly, independently and normally distributed.

Results and Discussion

Mean temperature at Delhi was approximately 17.2 C in both the 1985 and 1986 growing seasons, while at Cambridge in 1986 the mean temperature was 16.2 C. Rainfall during the growing season at Delhi in 1985 and 1986, and Cambridge in 1986 was 92, 102 and 125 mm, respectively. Effects due to trial, entry, and entry by trial interaction for all four characteristics were highly significant (Table 1). As expected, yield and percentage sound mature seeds were lowest at Cambridge, although emergence was lowest at Delhi in 1986.

The entry and entry by trial interaction variances were further partitioned into several components, including among ancestors, ancestors versus crosses, combining ability and the interactions of each of these components with trial. The among ancestors and ancestor by trial interaction partitions indicated that there were significant differences among ancestors for all four characteristics, but that their relative performance with regard to percentage emergence and sound mature seeds was dependent on the trial (Table 1). The ancestors versus crosses partition indicated that on average, the crosses had higher emergence and percentage sound mature seeds than their ancestors at Cambridge, but not at either Delhi trial (Table 2). On average, the crosses were not superior to the ancestors in any trial for pod or seed yield. Therefore, it appears that in this experiment, selection for emergence and percentage sound mature seeds was only effective at improving emergence and percentage sound mature seeds at the coolest, shortest season location, but had no effect on pod or seed yield at any location. The lack of improvement in yield might be due to ineffective selection for emergence and maturity, or might be because improvements in emergence and maturity beyond a threshold value do not result in higher yield.

The combining ability partitions included effects due to general combining ability of the parental families selected for percentage sound mature seeds (GCA_s), parental families selected for percentage emergence (GCA_e) and their interactions with trial. GCA_s and its interaction with trial were highly significant for all characteristics except emergence (Table 1). GCA_e and its interaction with trial were highly significant for all four characteristics. Parental family means, which are indicative of general combining ability effects, illustrate

Table 1. Mean squares from the analysis of variance for percentage emergence, pod yield, seed yield and percentage sound mature seeds.

		Mean Square			
Source	df	Percentage emergence	Pod Yield	Seed Yield	Percentage sound mature seeds
Trial	2	3917.8**	50936400**	11666300**	522.6**
Entry	20	156.7**	1475652**	448695**	131.0**
Within ancestors	4	161.4**	2452367**	784626**	915904.0**
Ancestors vs. crosses	1	371.2**	108143	16496	32419.0
GCA_s †	3	41.9	3163509**	843214**	920980.0**
GCA_e ‡	3	386.1**	1654690**	431401**	460759.0**
SCA §	9	92.7**	571204**	221673**	195002.0**
Entry x trial	40	77.6**	440820**	211986**	105.2**
Within ancestors x trial	8	122.1**	321496*	158992**	119.2**
Ancestors vs. crosses x trial	2	157.4**	373947	100362	46.3*
GCA_s x trial	6	39.6	642396**	373990**	206.3**
GCA_e x trial	6	107.9**	784070**	452056**	206.6**
SCA x trial	18	51.8	319674**	113916**	38.0**
Error	180	32.7	128524	40766	15.2

*, ** Significant at the 0.05 and 0.01 probability levels, respectively.
† General combining ability among parental families selected for high percentage sound mature seed.
‡ General combining ability among parental families selected for high percentage emergence.
§ Specific combining ability.

Table 2. Mean percentage emergence, pod yield, seed yield and percentage sound mature seeds of ancestors and crosses.

	Emergence			Pod yield			Seed yield			Sound mature seeds		
	Delhi	Delhi	Cambridge	Delhi	Delhi	Cambridge	Delhi	Delhi	Cambridge	Delhi	Delhi	Cambridge
Entry	1985	1986	1986	1985	1986	1986	1985	1986	1986	1985	1986	1986
	%			kg ha^{-1}						%		
Blanco Rio Segundo	89.1	70.5	73.6	2954.0	1642.4	991.7	1461.2	751.2	396.5	49.5	45.7	40.0
Chico	86.4	81.8	84.5	2180.5	459.1	274.7	1145.5	164.3	96.0	52.5	35.8	34.9
Delhi	92.3	62.3	73.6	2608.2	1407.8	520.6	1049.5	638.7	179.4	40.2	45.4	34.5
Honduras	83.6	70.9	69.5	2465.8	1962.9	806.4	1110.8	1084.1	367.7	45.0	55.2	45.6
Line 546	82.3	74.1	80.0	2892.8	1991.1	1664.5	1410.8	1196.5	800.9	48.8	60.1	48.1
1 x 1 †	82.3	74.1	85.5	3086.8	1334.6	1102.5	1528.2	620.5	474.1	49.5	46.5	43.0
1 x 2	86.4	75.5	89.1	2898.5	995.3	700.0	1451.0	442.3	274.7	50.1	44.4	39.2
1 x 3	88.2	73.2	84.5	2558.2	2431.7	1154.9	1073.0	1388.1	500.7	41.9	57.1	43.4
1 x 4	87.7	70.0	77.3	2316.2	1829.6	1108.4	975.2	934.6	449.0	42.1	51.1	40.5
2 x 1	88.2	81.4	88.6	1976.8	1068.1	897.9	927.8	490.5	375.1	46.9	45.9	41.8
2 x 2	88.2	78.2	89.5	2984.2	614.6	776.8	1509.8	224.0	396.5	50.6	36.4	51.0
2 x 3	81.4	69.1	75.9	2171.2	1194.5	652.0	993.0	572.9	260.7	45.7	48.0	40.0
2 x 4	89.5	74.1	85.0	2012.2	988.2	568.6	974.3	467.9	271.0	48.4	47.3	47.7
3 x 1	90.9	73.6	76.8	2263.5	2272.4	1681.1	1061.5	1361.6	840.9	46.9	59.9	50.0
3 x 2	86.4	70.0	91.8	1998.8	1349.6	760.6	954.5	651.2	305.7	47.7	48.2	40.2
3 x 3	86.8	70.9	77.7	2982.7	2017.7	1665.5	1420.5	1223.4	784.7	47.6	60.6	47.1
3 x 4	89.1	74.5	73.6	2199.7	1951.4	1088.4	805.0	1053.0	526.5	36.6	54.0	48.4
5 x 1	90.0	70.9	84.1	2534.8	1619.4	1048.6	1269.7	849.4	479.2	50.1	52.4	45.7
5 x 2	86.8	80.0	88.6	2079.2	545.3	606.2	1175.3	261.6	298.3	55.7	48.0	49.2
5 x 3	84.5	66.8	70.5	2157.2	1333.9	768.0	968.7	615.3	321.3	44.9	46.1	41.8
5 x 4	85.5	77.7	85.0	2477.0	1445.1	828.5	1134.3	739.1	360.3	45.8	51.1	43.5
$LSD_{0.05}$ ‡	7.9	7.9	7.9	496.8	496.8	496.8	279.8	279.8	279.8	5.4	5.4	5.4
Ancestor mean	86.7	71.9	76.3	2620.3	1492.7	851.6	1235.6	767.0	368.1	47.2	48.4	40.1
Cross mean	87.0	73.7	82.7*	2418.6	1437.0	963.0	1137.7	743.5	432.4	46.9	49.8	44.5*

* Cross mean significantly greater than ancestor mean within the same environment at the 0.05 probability level.
† Parental family selected for percentage sound mature seeds x parental family selected for percentage emergence.
‡ Least significant difference for comparisons between entries within an envirnoment.

the GCA by trial interaction through changes in rank across trials (Table 3). Even though the parental families were selected and therefore were presumably more homogeneous than a random sample, these results suggest that there were still differences in breeding value among the parental families. The GCA x trial interactions were most apparent when trials at the same location in different years were compared, while a much greater correspondence in parental family ranking occurred between trials in the same year at different locations. Based on this pattern of GCA x trial interaction, one could speculate that combining ability in this experiment was dependent on environmental conditions in a particular year that were common to both locations rather than on characteristics common to a particular location across years. The environmental conditions common to Delhi and Cambridge in 1986 may have occurred in August and September when rainfall was higher and temperatures lower than at Delhi in 1985.

Table 3. Mean percentage emergence, pod yield, seed yield and percentage sound mature seeds of selections in each family for percentage sound mature seeds.

Selection criterion	Parental family	Emergence			Pod yield			Seed yield			Sound mature seeds		
		Delhi 1985	Delhi 1986	Cambridge 1986	Delhi 1985	Delhi 1986	Cambridge 1986	Delhi 1985	Delhi 1986	Cambridge 1986	Delhi 1985	Delhi 1986	Cambridge 1986
		%			kg ha^{-1}						%		
Percentage sound mature seeds	1	85.3	72.4	83.3	2714.9	1647.8	1016.5	1256.9	846.4	424.6	46.3	51.4	41.8
	2	85.9	74.9	83.9	2286.2	966.4	723.8	1101.2	438.8	325.8	48.2	45.4	45.0
	3	87.5	71.6	79.2	2361.2	1897.7	1298.9	1060.4	1072.3	614.5	44.9	56.5	47.3
	5†	85.9	73.1	81.2	2312.1	1235.9	812.8	1132.5	616.4	364.8	49.0	50.0	44.9
Percentage emergence	1	86.9	74.2	83.0	2465.4	1573.6	1182.5	1196.8	830.5	542.3	48.5	52.8	45.9
	2	86.0	75.1	88.9	2490.2	876.2	710.9	1268.1	394.8	318.8	50.9	45.0	44.8
	3	84.4	69.3	76.3	2467.5	1744.4	1060.1	1113.8	949.9	466.8	45.1	54.4	44.0
	4†	87.1	73.4	79.4	2251.3	1553.6	898.5	972.2	798.7	401.7	43.2	51.4	44.7
LSD$_{0.05}$ ‡		ns	ns	ns	248.4	248.4	248.4	139.9	139.9	139.9	2.7	2.7	2.7

† The percentage sound mature seed selection from parental family 4 and the percentage emergence selection from parental family 5 were lost.
‡ Least significant difference for comparisons between parental family means within an environment.

The main effect of SCA was highly significant for all characteristics, and the SCA by trial interaction was highly significant for all characteristics except emergence (Table 1). These results suggest that genotypic performance of a cross could not be predicted solely by the breeding value of its parental family.

This experiment was initiated in part to help determine whether early generation selection for emergence and maturity, followed by recombination of those selections in a design II mating design, would result in useful breeding populations from which higher yielding cultivars for Ontario might be selected. If the criterion for judging a population is mean yield, then the proposed breeding method would not be considered particularly successful, since on average crosses were not better yielding than ancestors, nor were there any instances where a cross was significantly higher yielding than the highest performing ancestor. However, due to heterogeneity within each cross, a cultivar that is higher performing than any of the ancestral lines might be selected from among the individual genotypes making up the cross. Such selection efforts might be especially directed toward the highest performing bulks, but selection of superior cultivars from crosses with lower mean yield in early generations might also occur (12).

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