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Mineral Composition of Peanut Seed as Influenced by Cultivar and Location [1,2]

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ABSTRACT

The range in macronutrient concentrations in peanut (*Arachis hypogaea* L.) seeds has been fairly well established over the years, but a considerable range in the micronutrient concentrations has been reported in the literature. A study was conducted to determine the elemental concentration in seeds of four peanut cultivars grown at six locations across the southern U. S. Two of the cultivars account for >85% of the current U. S. production. 'Early Bunch', 'Florigiant', 'Florunner', and 'Tifrun' were grown with and without irrigation at Tifton and Plains, GA, with irrigation at College Station, TX, and without irrigation at Suffolk, VA. These seeds were analyzed for 10 nutrients: P, K, Ca, Mg, S, Zn, Mn, Cu, Fe, and B. Significant differences were found in the levels of nine nutrients among locations and eight nutrients among cultivars, but these levels did not vary greatly among locations or cultivars. The only positive correlations found for locations were between seed Ca and total precipitation and between seed Mg and soil Mg. The nutrient levels found corroborate the work of others and point out an apparent 10-fold error in the upper limit of the Zn, Mn, Cu, Fe, and B ranges previously reported in the literature.

Key Words: *Arachis hypogaea* L., inorganic constituents, elemental chemical analysis, macro- and micro-nutrients.

Although the range of inorganic constituents in peanut (*Arachis hypogaea* L.) seeds is fairly well documented in literature reviews (2, 6, 14, 15, 16), little information was reported regarding peanut cultivars and the environmental regimes from which these data were obtained. Furthermore, the upper limit of the micronutrient range in most of these frequently quoted reviews (2, 6, 14, 16) appears to have a 10-fold error, as it is improbable that peanut seed has ever had concentrations of 800 ppm Zn, 500 ppm Mn, 300 ppm Cu, 1000 ppm Fe, and 500 ppm B.The macronutrient range was P=0.25 - 0.66, K=0.50 - 0.89, Ca=0.01 - 0.08, Mg=0.09 - 0.34, and S=0.19 - 0.24%. These levels are in agreement with those reported later by Walker (22) in studies where rates and application methods of N, P and K were varied on Georgia grown Spanish and Runner types, and Sullivan *et al.* (21) in a study on the interactive effects of dolomitic limestone, gypsum, and K on North Carolina grown 'NC 5'.

Hallock and co-workers (7, 8, 17) investigated which part of the plant to sample during development for highest concentrations of macro-(7) and micro-(17) nutrients. They sampled six plant portions, including fruit (shell plus seed), from three cultivars of commercial importance around 1970, and found slight variations in nutrient constituents of mature fruit for the three cultivars. The average mineral concentration of the mature fruit was P=0.30, K=0.72, Ca=0.08 and Mg=0.12% and Zn=24, Mn=20, Cu=6 and B=28 ppm. A subsequent study (8) related nutrient concentration of four plant parts, including fruit near maturity, with relative yields of 15 peanut cultivars. Only minor variations were observed in the nutrient concentration of the fruit, except for P, which varied from 0.27 to 0.38% among lines. The elemental means for these 15 cultivars were very similar to those means reported in their earlier study (7, 17), except for K and B, which were 0.60% and 13 ppm, respectively.

Derise *et al.* (3) reported the mineral composition of three Virginia-type peanut seed. These means were P=0.44, K=0.63, Ca=0.08 and Mg=0.17% and Zn=61, Mn=17, Cu=12 and Fe=16 ppm. Walker and Hymowitz (23) reported the nutrient concentration range of seeds from 16 peanut cultivars, and most of these levels were similar to those above, except for Ca, K and Fe. The upper limit values for K and Fe were relatively high at 1.14% and 57 ppm, respectively, and a possible error could be in their upper limit for Ca at 0.80%.

Recently Hallock and Allison (9) studied the effects of three sources of Ca on the nutrient concentration of Florigiant peanuts. Seed concentrations ranged from 0.33 - 0.40% P, 0.68 - 0.96% K, 0.03 - 0.06% Ca, 0.17 - 0.21% Mg, 42 - 63 ppm Zn, 12 - 22 ppm Mn, and 7 - 16 ppm Cu for the two year study. These ranges were very close to those Hallock later found for 'Florigiant' and 'Va72R' in a study where nutrients were applied to affect germination (10).

The purpose of this study was to compare the mineral composition of seed from four peanut cultivars grown at six locations in the southern U.S. and to make comparisons with published results. Two of the cultivars selected ('Florunner' and Florigiant) account for > 85% of the current U.S. production. The locations selected represent a diversity in latitude, longitude, fertilization, and precipitation.

Materials and Methods

The peanut cultivars were grown in 1979 as entries in the uniform peanut performance testing program. The six locations chosen for evaluation were the University of Georgia research stations at Tifton and Plains; Texas A & M University, College Station; and Virginia Tidewater Research Center, Suffolk. Location abbreviations used in the tables are defined as follows: TIR - Tifton, Irrigation; TNI - Tifton, no irrigation; PIR - Plains, irrigation; PNI - Plains, no irrigation; CIR - College Station, irrigation; and SNI - Suffolk, no irrigation. Land preparation, planting rates, cultural and production practices at the respective locations were essentially those recommended by the Extension Services of Georgia, Texas and Virginia. Fertilizer rates, total precipitation (rainfall

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Table 1. Location, fertilizer, precipitation and growing season for four peanut cultivars.

Location	Latitude	Longitude	Elevation	Fertilizer* N	P	K	Gypsum	Total Precipitation	Cultivar EBh	Fgt	Frr	Trn
	(N)	(W)	(m)	kg/ha				(cm)	Days/Growing Season			
TIR	31°28'	83°31'	110	11	15	57	1120	64	133	144	144	149
TNI	31°28'	83°31'	110	11	15	57	1120	45	132	140	140	132
PIR	32°05'	84°22'	152	34	29	28	0	73	161	161	161	161
PNI	32°05'	84°22'	152	34	29	28	0	37	135	135	135	135
CIR	30°40'	96°10'	100	34	38	72	1406	51	126	139	139	139
SNI	36°41'	76°47'	24	20	26	100	1008	81	157	157	157	157

*SNI also received 0.56 kg B/ha.

plus irrigation) during the growing season, and length of growing season are reported in Table 1. Yield and shelling grade characteristics and a summary of production practices are reported elsewhere (13).

Cultivars

The four cultivars are briefly described: 'Early Bunch' (EBh) has a spreading bunch growth habit, matures up to 10 days earlier than other cultivars in this study, and both pods and seed grade as Virginia market-type peanuts (19). Plants of Florigiant (Fgt) are spreading in habit; pods are generally large, uniform, straight and cylindrical, and are set somewhat deeper in the soil than those of other U. S. cultivars. A Virginia-type peanut, Fgt was released in 1961 by the Florida AES (1).

Florunner (Frr) is prostrate in growth habit, fruits prolifically, has a high shell-out percentage, and grades as a Runner market-type (20). Florunner was released in 1969 by the Florida AES. 'Tifrun' (Trn), a commercial runner developed by bulk population selection from a composite cross, was released by the Georgia AES and the USDA in 1977 (11). Tifrun has a strong shell with pods and seeds 5-10% larger than Frr, but smaller than minimum standards for Virginia-type peanuts.

The Fgt, Frr and EBh peanuts are multiline cultivars composed (presently) of 7, 3 and 5 components sib lines, respectively (18). Florigiant, Trn and EBh share a common ancestor, 'Jenkins Jumbo' (12), in their complex pedigrees. Seed for each of the cultivars in this study was grown at the originating experiment station in 1978: Tifrun in Georgia and the other three in Florida.

Chemical Analysis

A sample of fifty median size seeds was oven-dried at 70 C for 24 hrs. The dried seeds were ground in a Virtis '45' homogenizer to pass a 1 mm sieve and stored in sealed polyethylene bags under refrigeration before chemical analysis.

Methods used for all soil and plant chemical analysis are described in a handbook by Gaines and Mitchell (4). Soil pH was determined on a 1:2 soil:water ratio. All elements, except SO_4-S and B, were extracted from the soil with a 1:4 soil:double acid (0.05*N* HCl + 0.025*N* H_2SO_4) extracting solution. Phosphorus was determined colorimetrically as molybdophosphorus by ascorbic acid reduction, and the cations by atomic absorption spectroscopy. Sulfate S was extracted from the soil with 0.5N NH_4Cl buffered to pH 7.0 and determined turbidimetrically as $BaSO_4$. Boron was extracted from the soil with hot water and determined colorimetrically by the azomethine-H method (5). Soil analyses are reported in Table 2.

Plant samples were dry ashed at 500 C for 4 hr and P, K, Ca, Mg, Zn, Mn, Cu, and Fe were extracted by dissolving the ash in hot 3*N* HCl. All elements, except P, S, and B were determined by atomic absorption spectroscopy. Phosphorus was colorimetrically determined as described for soil. Sulfur was determined turbidimetrically after $Mg(NO_3)_2$ ashing all plant S to sulfate and precipitating the 3*N* HCl dissolved sulfate as $BaSO_4$. A colorimetric method using the azomethine-H reagent was used for determining B in an acid extract of plant tissue ash (5).

Statistical Analysis

The data was handled as a randomized block, split block design with two replications. Locations and cultivars made up the whole and split plots, respectively (Table 3). Correlation coefficients were determined on the relationship between elemental concentrations in the seeds, total precipitation, and element concentrations in the soils.

Results and Discussion

Variance ratios of the 10 chemical elements in peanut seed taken from the analysis of variance table for the six locations (Loc) and four cultivars (Cul) are shown in Table 3. There were significant (1% level, except 5% for Mn) location effects for all elements except S, and significant cultivar effects at the 1% level for P, K, Ca, Zn, Mn, and B and at the 5% level for S and Fe. A significant location by

Table 2. Soil data for six peanut experiments.

Location	Soil Series	Texture	Subgroup Classification	Soil Analysis pH	P	K	Ca	Mg	SO_4-S	Zn	Mn	Cu	Fe	B
					kg/ha									
TIR	Tifton	ls	Plinthic Paleudults	6.4	97	84	897	83	11.6	3.6	21.0	3.6	16.4	3.5
TNI	Tifton	ls	Plinthic Paleudults	6.6	56	94	926	106	11.6	1.3	18.4	3.1	13.2	1.5
PIR	Greenville	scl	Rhodic Paleudults	6.2	41	170	1450	255	24.2	2.7	74.0	2.0	13.2	1.8
PNI	Greenville	scl	Rhodic Paleudults	6.3	72	200	1540	258	28.7	3.1	76.0	3.6	12.3	2.0
CIR	Patilo	sl	Grossarenic Paleustalfs	6.5	20	65	490	18	0.9	2.7	21.0	0.7	24.2	1.8
SNI	Woodstown	lfs	Aquic Hapludults	6.0	54	114	1030	135	26.9	1.1	4.9	1.1	64.0	1.3

Table 3. Variance ratios of 10 different elements in peanut seed taken from the analysis of variance table for six locations and four cultivars.

Source	DF	Variance Ratios P	K	Ca	Mg	S	Zn	Mn	Cu	Fe	B
Loc	5	12.73**	53.06**	30.93**	75.33**	3.02	84.03**	7.08*	12.47**	17.51**	17.46**
Rep (Loc)	6	0.53	0.44	1.00	0.47	1.00	0.64	3.24*	0.57	0.51	1.44
Cul	3	7.00**	22.77**	5.11**	2.74	5.99*	5.74**	7.52**	0.84	4.48*	7.62**
Loc x Cul	15	1.60	1.27	1.16	2.80*	1.96	1.12	1.14	1.25	2.51*	5.51**

*,**Denotes significance at the 5 and 1% levels, respectively.

Table 4. Concentration of elements in peanuts seed for six locations and four cultivars.

Location	Cultivar	Element P	K	Ca	Mg	S	Zn	Mn	Cu	Fe	B
		%					ppm				
TIR	EBh	0.42	0.68	0.08	0.22^{a*}	0.28	26	17	11	30^{a}	15^{a}
	Fgt	0.40	0.66	0.07	0.23^{a}	0.29	31	18	14	28^{a}	15^{a}
	Frr	0.37	0.58	0.08	0.22^{a}	0.26	28	18	16	26^{ab}	14^{a}
	Trn	0.40	0.59	0.08	0.20^{b}	0.26	24	20	14	23^{b}	10^{b}
TNI	EBh	0.41	0.73	0.05	0.22	0.27	28	15	16	30^{a}	10^{bc}
	Fgt	0.37	0.66	0.06	0.22	0.29	27	16	14	26^{bc}	12^{ab}
	Frr	0.35	0.63	0.08	0.22	0.25	28	18	13	28^{ab}	14^{a}
	Trn	0.36	0.60	0.07	0.22	0.26	23	17	12	23^{c}	9^{c}
PIR	EBh	0.40	0.64	0.08	0.24	0.26	25	18	16	31	10^{b}
	Fgt	0.40	0.58	0.08	0.25	0.29	28	20	15	28	12^{ab}
	Frr	0.37	0.58	0.08	0.24	0.24	24	18	12	27	14^{a}
	Trn	0.41	0.58	0.08	0.24	0.26	24	20	12	27	12^{ab}
PNI	EBh	0.40	0.70	0.05	0.23	0.24	24	16	15	28	11^{bc}
	Fgt	0.37	0.64	0.05	0.23	0.27	28	14	16	32	10^{c}
	Frr	0.34	0.60	0.06	0.24	0.24	26	16	16	30	15^{a}
	Trn	0.40	0.62	0.06	0.24	0.28	24	17	13	28	13^{ab}
CIR	EBh	0.40	0.60	0.06	0.22^{a}	0.30	37	14	10	23	11
	Fgt	0.40	0.58	0.06	0.20^{b}	0.28	40	14	10	24	12
	Frr	0.41	0.54	0.06	0.21^{ab}	0.28	40	16	8	26	11
	Trn	0.43	0.58	0.07	0.21^{ab}	0.26	40	16	11	26	11
SNI	EBh	0.36	0.57	0.09	0.22^{a}	0.25	26	13	15	25	18^{a}
	Fgt	0.37	0.54	0.09	0.21^{ab}	0.26	28	14	15	23	18^{a}
	Frr	0.38	0.50	0.09	0.21^{ab}	0.26	30	16	15	24	15^{b}
	Trn	0.37	0.52	0.09	0.20^{b}	0.26	27	15	16	24	15^{b}

*Mean values within a column for each location not followed by the same letter are significantly different at the 5% level using Duncan's Multiple Range Test. Values without letters are not significantly different.

cultivar interaction occurred for Mg and Fe(P=0.05) and B (P=0.01). Locations showing significant interaction effects with cultivars were TIR, CIR and SNI for Mg; TIR and TNI for Fe; and TIR, TNI, PIR, PNI and SNI for B (Table 4). No consistent pattern emerged for cultivars and seed Mg and B concentrations at these locations, but for Fe, EBh was higher than Trn at the two Tifton locations.

Peanuts grown at CIR, TIR and PIR, all irrigated, were significantly higher in P than those locations not irrigated (Table 5). There was, however, no significant correlation between seed P and total precipitation, presumably because seeds grown under the most precipitation (SNI) were low in P at 0.37%. Potassium concentration in the seed ranged from 0.53% at SNI to 0.65% at TNI, but there was no significant correlation between seed K and soil K. Peanut seed Ca was the only nutrient significantly correlated (r = 0.97, P=0.001) with total precipitation as seeds produced from the three locations receiving the most precipitation (SNI, PIR and TIR) had the highest Ca levels of 0.09, 0.08, and 0.08% respectively. Peanut seed Mg was the only nutrient significantly correlated (r = 0.89, P = 0.02) with the same element in the soil as the two Plains locations had the highest seed and soil Mg at 0.24% and 255 kg/ha, respectively. Soil Mg for CIR was only 18 kg/ha and seed Mg from this location was significantly low at 0.20%. Seed Zn from CIR was significantly higher at 39 ppm than the other locations, yet soil Zn from CIR was intermediate. Seed Mn from irrigated experiments at Tifton and Plains was higher than values from other locations, but only soil Mn from Plains was relatively high. Both seed and soil Cu from CIR were lower than for the other locations. Soil Fe, although higher at SNI than at other locations, was not reflected in higher seed Fe. Seed B was significantly higher for SNI than for other locations, but 0.56 kg B/ha was applied as a foliar spray during the growing season. However, hot water soil extraction did not show a relatively higher soil B value for this location.

Table 5. Mineral composition of peanut seed for locations (across cultivars) and cultivars (across locations).

Location	Element P	K	Ca	Mg	S	Zn	Mn	Cu	Fe	B
	%					ppm				
TIR	0.40^{a*}	0.63^{a}	0.08^{b}	0.22^{b}	0.27	27^{b}	18^{a}	14^{a}	27^{bc}	13^{b}
TNI	0.37^{b}	0.65^{a}	0.06^{c}	0.22^{b}	0.27	26^{b}	16^{b}	14^{a}	26^{cd}	11^{c}
PIR	0.40^{a}	0.60^{b}	0.08^{b}	0.24^{a}	0.26	25^{b}	19^{a}	14^{a}	28^{b}	12^{bc}
PNI	0.38^{b}	0.64^{a}	0.06^{c}	0.24^{a}	0.26	26^{b}	16^{b}	15^{a}	30^{a}	12^{bc}
CIR	0.41^{a}	0.57^{c}	0.06^{c}	0.20^{d}	0.28	39^{a}	15^{b}	10^{b}	25^{de}	11^{c}
SNI	0.37^{b}	0.53^{d}	0.09^{a}	0.21^{c}	0.26	28^{b}	15^{b}	15^{a}	24^{e}	16^{a}
Cultivar										
EBh	0.40^{a}	0.65^{a}	0.07^{b}	0.22	0.27^{ab}	28^{c}	16^{b}	14	28^{a}	12^{b}
Fgt	0.38^{b}	0.61^{b}	0.07^{b}	0.22	0.28^{a}	30^{a}	16^{b}	14	27^{a}	13^{ab}
Frr	0.37^{b}	0.57^{c}	0.07^{b}	0.22	0.26^{b}	29^{b}	17^{a}	13	27^{a}	14^{a}
Trn	0.40^{a}	0.58^{c}	0.08^{a}	0.22	0.26^{b}	27^{c}	17^{a}	13	25^{b}	12^{b}
Mean	0.39	0.60	0.07	0.22	0.27	28	16	14	27	13

*Mean values within a column for each category not followed by the same letter are significantly different at the 5% level using Duncan's Multiple Range Test. Values without letters are not significantly different.

No cultivar was consistently higher or lower in elemental concentrations in seed than the other cultivars when all elements were considered, but some variability in these concentrations among cultivars was evident for all elements except Mg and Cu (Table 5). The location x cultivar effect, which was significant for Mg, apparently was negated when cultivars were averaged across locations.

Elemental ranges for the four cultivars grown at six locations were 0.34 - 0.43% P, 0.50 - 0.73% K, 0.05 - 0.09% Ca, 0.20 - 0.25% Mg, 0.24 - 0.30% S, 23 - 40 ppm Zn, 13 - 20 ppm Mn, 8 - 16 ppm Cu, 23 - 32 ppm Fe and 9 - 18 ppm B (Table 6). Our macronutrient levels are in good agreement with many frequently quoted ranges (2, 6, 14, 15, 16, 21, 22), except for S, which was slightly higher in our study. Values for both macro- and micro-nutrients also are similar to those reported by Hallock and co-workers (7, 17) for fruit (shell plus seed) from three different cultivars, except for P, Mg, Zn and Cu, which were a little higher in our study and B, which was a little lower. Our values were in better agreement with Hallock's later studies (8, 9, 10) where seed tissue only was analyzed and with values reported by Derise *et al.* (3). The range in elemental composition of seed reported by Walker and Hymowitz (23) for 16 cultivars also is in good agreement with our study, except their upper limit for K, which appears relatively high at 1.13%, and Ca, which appears dubious at 0.80%.

The upper limit for Zn, Mn, Cu, Fe, and B, reported in the older literature (2, 6, 14, 16), appears to have a 10-fold error when contrasted with the more recent values of others (3, 7, 8, 9, 10, 17, 23) and with our values. This apparent error first appeared in a literature review in 1949 (6), and has since been quoted in a review paper (16) and in two peanut reference books (2, 14). Results of our study and recent studies by others show the micronutrient ranges in peanut seed are narrow, even when soil and foliar nutrients are applied to affect mineral concentrations (10).

Our results indicate that slight variability in the elemental concentration of peanut seed can be expected among locations and cultivars with a few, small interaction effects between locations and vultivars. Only in a few instances could the small variability in seed concentration of an element among location readily be explained by soil test values, precipitation, and fertilizer practices. Generally, results reported here are in very close agreement with published values, especially for similar cultivars.

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Table 6. Ranges of mineral concentrations in peanut seed reported in literature.

Authors	Cultivars or Numbers	P	K	Ca	Mg	S	Zn	Mn	Cu	Fe	B
		%					ppm				
Hoffpauir & Guthrie (15)	Not Shown	0.25-0.66	0.68-0.89	0.02-0.08	0.09-0.34	0.19-0.24	17	8	7-20	18	26
Guthrie et al. (6) Harris & Bledsoe (14) Hoffpauir (16)	Not Shown	0.25-0.66	0.68-0.89	0.02-0.08	0.09-0.34	0.19-0.24	17-800	8-500	7-300	18-1000	26-500
Cobb & Johnson (2)	Not Shown	0.25-0.66	0.50-0.89	0.01-0.08	0.09-0.34	0.19-0.24	17-800	8-500	7-300	18-1000	26-500
Hallock et al. (7)* Martens et al. (17)*	Va 61 R Early Runner Starr	0.30-0.32	0.65-0.70	0.06-0.10	0.12-0.16		21-27	17-23	5-6		26-31
Hallock et al. (8)*	15	0.27-0.38	0.58-0.75	0.06-0.12	0.12-0.20		18-28	15-22	3-7		11-16
Walker & Hymowitz (23)	16	0.33-0.42	0.52-1.13	0.08-0.80	0.14-0.21		18-30	11-32	6-13	34-57	12-18
Walker (22)	Spanish & Runner types	0.35-0.39	0.58-0.66	0.04-0.06	0.28-0.34						
Sullivan et al. (21)	NC 5		0.68-0.74	0.04-0.08	0.15-0.16						
Derise et al. (3)	Va-70, NC-2, Fgt	0.41-0.47	0.62-0.63	0.07-0.09	0.16-0.18		61-62	18-20	11-13	14-18	
Hallock & Allison (9)	Fgt	0.33-0.40	0.68-0.96	0.03-0.06	0.17-0.21		42-63	12-22	7-16		
Hallock (10)	Fgt & Va 72R	0.36-0.40	0.70-0.83	0.04-0.06	0.18-0.23		34-50	14-21	10-19	21-70	
Gaines & Hammons (this paper)	EBh,Fgt,Frr, Trn	0.34-0.43	0.50-0.73	0.05-0.09	0.20-0.25	0.24-0.30	23-40	13-20	8-16	23-32	9-18

*Analysis included both seed and shell tissue.

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