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Seed Mineral Composition of Diverse Peanut Germplasm[1]

W. D. Branch* and T. P. Gaines[2]

ABSTRACT

Quality of peanut (*Arachis hypogaea* L.) seed is of major concern to the grower, processor, and consumer. Past investigations have mainly focused upon organic compounds, thus basic information pertaining to inorganic elements is relatively sparse. A chemical evaluation study was conducted over a three-year period to determine the concentration of elemental constituents among diverse germplasm and to examine the extent of correlation among element concentrations. Twenty-six distinct genotypes were analyzed for N, K, P, S, Mg, Ca, Fe, Zn, Mn, B, and Cu.

Significant differences were found among the germplasm lines for each of the inorganic elements. In general, the means were within the ranges that have been previously reported. Both highly significant positive and negative relationships were observed for several elemental combinations. The largest correlation was negative between seed Ca and K concentrations. These data indicate that careful consideration should be given to the selection method used in a breeding program for improving the compositional balance of peanut seed.

Key Words: *Arachis hypogaea* L., Groundnut, Inorganic constituents, Elemental correlations.

Human consumption of peanut (*Arachis hypogaea* L.) in the United States is primarily in the form of peanut butter and as a salted or confectionery food. This contrasts with other countries throughout the world where peanut is used principally as a source of oil (11).

Peanut seeds consist of approximately 50% oil, 25% protein, 15% carbohydrates, 6% moisture, 2% fiber, and 2% ash (1). The organic constituents have been frequently investigated, however, fewer studies have delt with elemental constituents.

Certain physiological dysfunctions of peanut seeds have long been associated with elemental constituents. Lack of sufficient Ca in the fruiting zone causes numerous empty pods, "pops" or seed with damaged embryos, "dark plumules" (13). High seed Ca may also increase germina-

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[2]Assistant Geneticist and Research Chemist, respectively, University of Ga., Dept. of Agron., Coastal Plain Expt. Sta., Tifton, GA 31793.

tion (6) and decrease the incidence of pod rot (14). Inadequate B during seed development often causes depressed internal cotyledonary cavities, "hollow heart" (13).

In previous studies, chemical analyses were commonly restricted to the more popular cultivars, and very little information is available regarding elemental differences among exotic genotypes. Such information would be useful in a breeding program for improving the elemental quality of peanut. Our objectives in this research were to determine the seed mineral concentrations of several diverse germplasm lines, and to determine the extent of correlation among these inorganic constituents.

Materials and Methods

Twenty-six homogeneous germplasm lines within species *A. hypogaea* were selected because of their variation for known descriptive characteristics (Table 1). The lines were grown on a Tifton loamy sand during 1979 and 1980 and on a Greenville sandy clay loam in 1981. Standard cultural practices were utilized each season. Plants were dug as each line reached maturity, then harvested and dried. Pods were presized and shelled on Federal-State Inspection Service equipment. Samples then were screened, and only sound mature seed used for chemical evaluation.

A 50 g sub-sample of seed was oven-dried at 70 C for 24 h. The dried seeds were ground in a Virtis '45' homogenizer to pass a 1 mm sieve and stored in sealed polyethylene bags under refrigeration until analyzed.

Table 1. List and brief description of *A. hypogaea* L. germplasm.

Germplasm	Descriptive Trait	Seed wt.	Testa color
		(g/100)	
Florunner	U.S. cultivar	53	Pink
Tennessee Red	Landrace valencia	47	Red
NC 13	Seed dormancy	70	Pink
Chico	Early maturity	30	Tan
Jenkins Jumbo	Parental line	127	Pink
Tifrust-4	Rust resistance	45	Tan
Tifrust-8	Rust resistance	41	White + red
Tifrust-12	Rust resistance	81	Red
Tifrust-14	Rust resistance	37	Tan
Tifton-8	Drought tolerance	88	Pink
GA 186-28	Rapid autoxidation	58	Pink
PI 109839	Leafspot resistance	36	Pink
PI 221068	Variegated testa	140	Purple + white
PI 288160	Bland flavor	41	White
PI 341879	Rust resistance	55	Purple
PI 405915	Narrow leaves	54	Pink
PI 414331	Leafspot + rust resistance	51	Pink
PI 414332	Leafspot + rust resistance	47	Pink
T-900	Krinkle leaf	30	Tan
T-1921	Aureus leaves	39	Tan
T-2289	Non-nodulation	51	Red + white
T-2374	Large seeded	114	Pink
T-2378	Non-nodulation	45	Red
T-2499	Small seeded	26	Purple
T-2500	Flop phenotype	52	Purple
T-2501	Curly leaflets	49	Pink

The chemical methods used were described by Gaines and Mitchell (5). Seed samples were dry ashed at 500 C for 4 h, 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, N, S, and B were detemined by atomic absorption spectroscopy. Phosphorus was determined colorimetrically as molybdophosphorus after ascorbic acid reduction. Nitrogen was determined by a modified Kjeldahl method, wherein the converted ammonia was measured as indophenol blue on a Technicon Auto-Analyzer. Sulfur was determined turbidimetrically after $Mg(NO_3)_2$ ashing all seed S to sulfate and precipitating the 3 *N* HCl-dissolved sulfate as $BaSO_4$. Boron was determined by a colorimetric method using azomethine-H in an acid extract of plant ash.

The data were statistically analyzed by multivariate analysis of variance. Means were rounded-off to coincide with recorded values prior to separation using Waller-Duncan's exact Bayesian k-ratio LSD rule. Total mean correlation coefficients were based upon the relationship between elemental concentrations across germplasm lines and years.

Results and Discussion

Significant differences were found among the 26 germplasm lines for each of the 11 elements derived from peanut seed (Table 2). These results corroborate earlier findings of nutrient differences among cultivars (2, 3, 4, 7, 8, 10).

The mean elemental concentrations are in good agreement with the ranges reported by Gaines and Hammons (4) from the more recent literature. Nitrogen percentages are also within the range presented as protein by Holley and Hammons (9), except for the two non-nodulating accessions, T-2289 and T-2378, which were significantly lower in N, as has been recently reported (12).

Germplasm lines were ranked as follows for each element by highest versus lowest concentration, respectively: (N) Jenkins Jumbo *vs* T-2289 and T-2378; (K) Tifrust-12, PI 221068, and T-2289 *vs* PI 288160; (P) T-2378 *vs* Tifton-8; (S) T-2378 *vs* PI 414332; (Mg) Tifrust-8 and T-2499 *vs* NC 13, Tifton-8, and PI 405915; (Ca) T-2501 *vs* T-2500; (Fe) PI 341879 *vs* T-2374; (Zn) Tifrust-8 *vs* NC 13; (Mn) Tennessee Red and PI 414331 *vs* T-2289 and T-2500; (B) T-2378 *vs* PI 414332; and (Cu) T-2378 *vs* T-2501.

The cv. Florunner, currently grown throughout the southeastern U. S., was relatively high in Ca and Mn; moderate in N, Mg, Fe, B, and Cu; but low in K, P, Mg, and Zn. Thus, improvement of seed mineral composition in cultivated peanut merits further breeding efforts.

Approximately half of the total correlations among the 11 elements was found to be significant (Table 3). However, it should be emphasized that the majority of the significant correlations was < 0.5. Positive relationships were observed for each significant P, S, Mg, Zn, Mn, and Cu correlation, and each significant K correlation was negative. The largest correlation ($r = -0.78$) was detected between seed K and Ca concentrations. This association is of particular concern because of seed germinability. Hallock (6) noted that germination was positively correlated with seed Ca and negatively correlated with seed K concentrations. Contradictory correlations have been previously reported by Deosthale (2) for similar trace elements found in nineteen groundnut cultivars. Possible reasons for these discrepancies could be the different germplasm and/or sample material (defatted meal) analyzed.

From our data, one may speculate that by increasing the seed protein in a breeding program, one might also tend to increase Ca and Mn concentrations with a reduction in K and B. Such high protein selections could result

Table 2. Mineral composition of peanut seed from diverse germplasm lines, 1979-81.

Germplasm	Element: N	K	P	S	Mg	Ca	Fe	Zn	Mn	B	Cu
	%						ppm				
Florunner	4.46def*	0.56g-i	0.42d-g	0.27def	0.19de	0.07ab	28ab	29efg	19ab	13cd	12a-e
Tennessee Red	4.82ab	0.61c-h	0.47bcd	0.33abc	0.19de	0.06bc	35ab	40ab	20a	14c	14a-d
NC 13	4.45d-g	0.60d-i	0.39fg	0.27def	0.17f	0.05cd	31ab	25g	15def	12cde	9de
Chico	4.63bcd	0.59e-i	0.45c-f	0.31bcd	0.22ab	0.05cd	40a	34a-e	18abc	15bc	13a-e
Jenkins Jumbo	4.98a	0.61c-h	0.44c-g	0.28def	0.20cd	0.06bc	34ab	29efg	17bcd	12cde	12a-e
Tifrust-4	4.34e-h	0.63b-f	0.42d-g	0.30cde	0.20cd	0.05cd	39ab	33b-f	14ef	20a	13a-e
Tifrust-8	4.65bcd	0.68ab	0.46cde	0.35ab	0.23a	0.04d	35ab	41a	16cde	12cde	15abc
Tifrust-12	4.46def	0.71a	0.53ab	0.28def	0.21bc	0.04d	33ab	31d-g	17bcd	13cd	13a-e
Tifrust-14	4.13h	0.62b-g	0.41d-g	0.30cde	0.21bc	0.05cd	36ab	34a-e	16cde	19a	11b-e
Tifton-8	4.30fgh	0.61c-h	0.38g	0.27def	0.17f	0.05cd	28ab	26fg	15def	12cde	11b-e
GA 186-28	4.44d-g	0.62b-g	0.44c-g	0.28def	0.19de	0.07ab	32ab	32c-g	16cde	14c	13a-e
PI 109839	4.75abc	0.58e-j	0.41d-g	0.30cde	0.19de	0.06bc	32ab	30d-g	13f	13cd	14a-d
PI 221068	4.17gh	0.71a	0.44c-g	0.27def	0.20cd	0.04d	33ab	32c-g	15def	15bc	15abc
PI 288160	4.62b-e	0.52j	0.40efg	0.27def	0.19de	0.06bc	37ab	31d-g	17bcd	13cd	12a-e
PI 341879	4.26fgh	0.66a-d	0.42d-g	0.29c-f	0.20cd	0.04d	41a	34a-e	16cde	12cde	13a-e
PI 405915	4.63bcd	0.54ij	0.42d-g	0.28def	0.17f	0.06bc	29ab	28efg	16cde	10de	16ab
PI 414331	4.46def	0.55hij	0.41d-g	0.29c-f	0.21bc	0.06bc	33ab	34a-e	20a	13cd	14a-d
PI 414332	4.23fgh	0.54ij	0.40efg	0.25f	0.19de	0.06bc	36ab	28efg	15def	9e	13a-e
T-900	4.71a-d	0.57f-j	0.43d-g	0.29c-f	0.20cd	0.07ab	37ab	35a-e	19ab	13cd	12a-e
T-1921	4.70a-d	0.54ij	0.42d-g	0.30cde	0.20cd	0.07ab	36ab	37a-d	18abc	15bc	13a-e
T-2289	3.07i	0.71a	0.45c-f	0.33abc	0.18ef	0.05cd	30ab	32c-g	13f	15bc	15abc
T-2374	4.67bcd	0.61c-h	0.46cde	0.26ef	0.19de	0.05cd	24b	32c-g	17bcd	12cde	11b-e
T-2378	3.30i	0.64b-e	0.55a	0.37a	0.21bc	0.06bc	35ab	39abc	15def	21a	17a
T-2499	4.61b-e	0.60d-i	0.47bcd	0.31bcd	0.23a	0.06bc	37ab	35a-e	15def	18ab	10cde
T-2500	4.50c-f	0.67abc	0.50abc	0.28def	0.18ef	0.04d	31ab	32c-g	13f	12cde	11b-e
T-2501	4.46def	0.61c-h	0.42d-g	0.29c-f	0.19de	0.08a	29ab	30d-g	15def	12cde	8e
LSD:	0.29	0.06	0.06	0.05	0.02	0.01	15	8	2	4	5
Mean:	4.42	0.61	0.44	0.29	0.20	0.06	34	32	16	14	13
CV%:	4.3	6.3	8.4	9.3	5.7	15.1	17.4	12.9	9.1	16.8	20.0

* Means within the same column followed by the same letter are not significantly different at the 0.05 level of probability using Waller-Duncan's multiple range test.

Table 3. Total mean correlation coefficients among eleven mineral elements from peanut seed of twenty-six germplasm lines over three years.

Element	K	P	S	Mg	Ca	Zn	Fe	Mn	B	Cu
N	-0.45**	-0.06	-0.11	0.08	0.30**	0.06	0.09	0.34**	-0.26*	-0.17
K		0.03	-0.05	-0.07	-0.78**	-0.11	-0.28*	-0.16	-0.03	0.11
P			0.36**	0.23*	0.09	0.41**	0.27*	0.07	0.34**	0.33**
S				0.51**	0.16	0.52**	0.28*	-0.10	0.50**	0.18
Mg					0.20	0.50**	0.51**	0.03	0.35**	-0.16
Ca						0.28*	0.32**	0.15	0.17	-0.10
Zn							0.42**	0.27*	0.45**	0.32**
Fe								0.06	0.36**	0.05
Mn									-0.04	0.20
B										0.17

*, ** Significant at the 0.05 and 0.01 probability levels, respectively.

in a line prone to hollow heart disorders because of low B. Thus, the employment of tandem or index selection procedures for simultaneously improving the overall elemental balance may be more advantageous than any singular approach.

In conclusion, the status of peanut quality is of paramount importance with regard to certain physiological, pathological, and nutritional aspects. Differences were found in diverse germplasm that offer potential for improving the seed mineral composition. However, careful consideration must be given to the mode of selection because of various elemental correlations.

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Literature Cited

1. Cobb, W. Y. and B. R. Johnson. 1973. Physiochemical properties of peanuts. *In* Peanuts--Culture and Uses. Amer. Peanut Res. Educ. Assn., Stillwater, OK, pp. 209-263.
2. Deosthale, Y. G. 1981. Trace element composition of common oilseed. J. Amer. Oil Chem. Soc. 58:988-990.
3. Derise, N. L., H. A. Lau, S. J. Ritchey, and E. W. Murphy. 1974. Yield, proximate composition and mineral element content of three cultivars of raw and roasted peanuts. J. Food Sci. 39:264-266.
4. Gaines, T. P. and R. O. Hammons. 1981. Mineral composition of peanut seed as influenced by cultivar and location. Peanut Sci. 8:16-20.
5. Gaines, T. P. and G. A. Mitchell. 1979. Chemical methods for soil and plant analysis. Univ. Ga. Coastal Plain Exp. Sta. Agron. Handbook No. 1, 105 pp.
6. Hallock, D. L. 1980. Soil or foliar applied nutrient effects on mineral concentrations and germinability of peanut seed. Peanut Sci. 7:50-54.
7. Hallock, D. L., D. C. Martens, and M. W. Alexander. 1969. Nutrient distribution during development of three market types of peanuts. I. P, K, Ca, and Mg contents. Agron. J. 61:81-85.
8. Hallock, D. L., D. C. Martens, and M. W. Alexander. 1971. Distribution of P, K, Ca, Mg, B; Cu, Mn, and Zn in peanut lines near maturity. Agron. J. 63:251-256.
9. Holley, K. T. and R. O. Hammons. 1968. Strain and seasonal effects on peanut characteristics. Ga. Agric. Exp. Sta. Res. Bull. 32. 27 pp.
10. Martens, D. C., D. L. Hallock, and M. W. Alexander. 1969. Nutrient distribution during development of three market types of peanuts. II. B, Cu, Mn, and Zn contents. Agron. J. 61:85-88.
11. Mottern, H. H. 1973. Peanuts and human nutrition. *In* Peanuts--Culture and Uses. Amer. Peanut Res. Educ. Assn., Stillwater, OK, pp. 593-602.
12. Pancholy, S. K., S. M. M. Basha, and D. W. Gorbet. 1982. Composition of seeds obtained from non-nodulating and nodulating peanut lines and cultivars. Peanut Sci. 9:50-52.
13. Reid, P. H. and F. R. Cox. 1973. Soil properties, mineral nutrition and fertilization practices. *In* Peanuts-Culture and Uses. Amer. Peanut Res. Educ. Assn., Stillwater, OK, pp. 271-297.
14. Walker, M. E. and A. S. Csinos. 1980. Effects of gypsum on yield, grade and incidence of pod rot in five peanut cultivars. Peanut Sci. 7:109-113.

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