Note on Mineral Content and Location in Pearl Millet[1]

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Because pearl millet (*Pennesitum americanum* (L.) Leeke) is an important food crop in many developing countries in the semiarid tropics, many investigators are studying its nutrient composition. Although some work has been reported on the mineral content of Indian and African cultivars (Carr 1961; Deosthale et al 1971; Goswami et al 1969a, 1969b, 1970a, 1970b; Shah and Mehta 1959), only one article provides information on the mineral constituents (Ca, P) of pearl millet cultivars grown in the United States (Burton et al 1972). The following paper reports on the mineral content of four bulk populations and 17 lines of pearl millet grown in Kansas. In addition, the location of minerals in the grain was investigated.

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MATERIALS AND METHODS

We studied seventeen HMP 550 S_1 lines (Tift 23 DB_1/*2PI185642) of pearl millet and four bulk populations: HMP 550, a combination of 110 S_1 lines; HMP 1700 (PI263540/Tift 23 DB_1/2/Tift 239 DB_2/2 *Serere 3A); RMP I(S)CI (parentage from Serere 3A, Serere 17, and Tift 239 DB_2); and Serere 3A, developed by Serere Experiment Station, Uganda, Africa. The method of Purdy et al (1968) was used to describe pedigrees of the millet samples; HMP and RMP refer to Hays millet population and regional millet population, respectively.

Millet samples were not dehulled before mineral analysis. Mois-

ture content, ash, and crude protein were determined by standard AOAC methods (1970). Samples were prepared for Ca, Mg, Zn, and Fe analyses according to the methods of Liu et al (1974), and those minerals were determined by atomic absorption spectroscopy. Na and K contents of the samples were determined by the AOAC flame photometric method (1970); total P (as P_2O_5) was determined by the molybdovanadophosphate method (AOAC 1970). Duplicate mineral analyses were done on each sample.

Millet kernels were prepared for X-ray microanalysis by fracturing grains longitudinally with a razor blade, mounting the halves on stubs with colloidal graphite, and coating with carbon. X-ray spectra were obtained with a Tracor Northern TN-1710 X-ray energy dispersive analyzer attached to a Cambridge Stereoscan scanning electron microscope. Area scans were made on the germ,

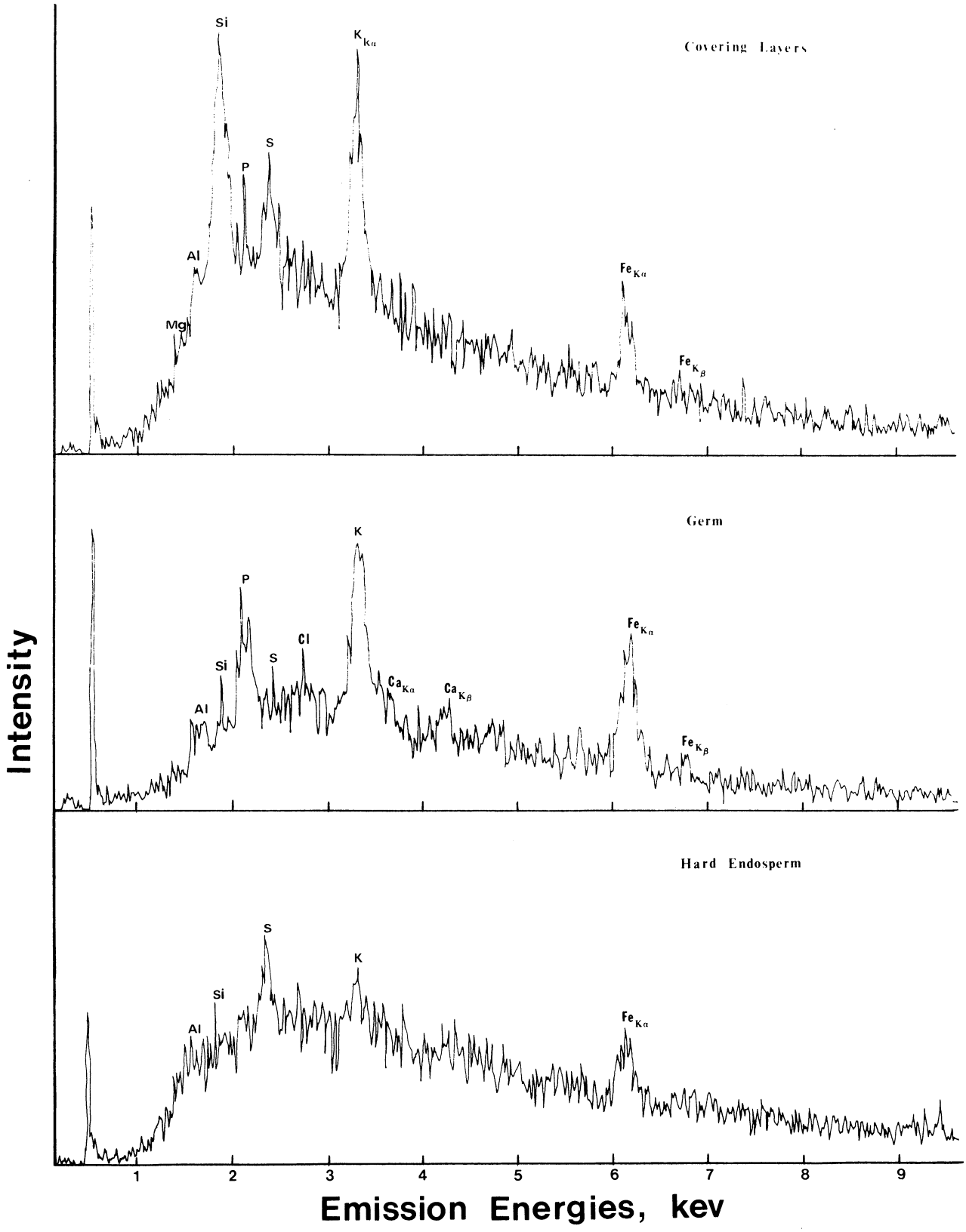

Fig. 1. X-ray spectra demonstrating some of the mineral constituents in the covering layer (top), germ (middle), and hard endosperm (bottom).

TABLE I
Protein, Moisture, and Ash Contents of Pearl Millet Cultivars

Sample	Protein (%)	Moisture (%)	Ash (%)
Bulk Populations			
RMP I(S)CI[a]	11.1	14.2	1.4
HMP 1700[b]	14.7	10.4	1.6
Serere 3A[c]	13.5	9.5	1.6
HMP 550[b]	13.6	9.6	1.8
HMP 550 S_1 lines[b]			
114	13.9	10.8	1.7
120	13.3	10.5	1.8
134	13.5	10.7	1.8
149	13.0	10.4	1.9
155	13.5	10.6	1.9
160	13.0	7.8	1.9
179	13.5	10.7	1.7
180	14.0	10.9	1.7
189	13.0	11.0	1.7
191	13.6	10.8	1.9
193	13.8	10.5	1.8
196	13.8	11.0	1.7
200	13.9	10.5	1.8
201	14.1	10.6	1.9
218	13.3	10.7	1.8
220	12.8	10.0	1.6
240	13.8	9.9	1.8

[a]1976, Manhattan, KS.
[b]1977, Hays, KS.
[c]1975, Hays, KS.

TABLE II
Minerals in Pearl Millet ($\mu g/g$)[a]

Sample	Ca	Mg	Zn	Fe	Na	K	P ($\times 10^2$)
Bulk populations							
RMP I(S)CI	99	1167	38	73	45	3660	66.5
HMP 1700	132	1330	31	61	43	3864	74.8
Serere 3A	126	1384	30	78	41	3679	79.4
HMP 550	89	1389	28	79	45	4605	86.4
HMP 550 S_1 lines							
240	98	1346	29	74	44	4224	76.1
220	116	1364	30	81	45	4037	92.3
218	76	1557	34	78	42	4203	87.3
201	84	1512	30	74	43	4657	92.2
200	79	1382	27	70	40	4605	85.0
191	92	1460	26	74	34	4954	90.5
189	81	1374	29	78	39	4643	82.8
180	65	1499	28	70	46	4628	89.7
160	109	1432	26	74	43	4808	92.3
155	79	1358	28	77	22	4876	85.9
134	74	1488	34	83	48	4471	89.0
120	112	1318	23	69	49	4993	87.8
114	81	1399	34	83	45	4524	84.3
179	96	1507	28	79	43	5106	95.1
149	122	1450	27	68	20	4436	87.5

[a]Dry basis.

covering layers (including aleurone), and hard and soft endosperm. A counting time of 100 sec was used to obtain optimum peak-to-background ratios.

RESULTS AND DISCUSSION

Protein, moisture, and ash contents of millet samples are presented in Table I. Protein contents ranged from 11.1 to 14.7%, ash contents from 1.4 to 1.9%. Both are within the ranges reported by Goswami et al (1969a, 1969b, 1970a, 1970b) for pearl millets grown in India.

Mineral contents of the various millet samples are shown in Table II. Contents of individual mineral elements vary somewhat among populations and S_1 lines, which may be a function of agronomic conditions as well as of genetic background. In general, the data indicate that 1) P, K, and Mg are the major mineral constituents in the grain; 2) pearl millet is comparable to wheat in Fe and Zn contents; 3) the Ca content of our samples was lower than that reported by other authors (Goswami et al 1969a, 1969b, 1970a, 1970b); and 4) the P content in millet is more than twice that reported for wheat (Ziegler and Greer 1971). Millet's high P content may be an important factor in determining the total nutritional value of this grain, particularly if P is present in the grain as phytin, which may reduce the absorption of trace minerals from the gastrointestinal tract. Phytin phosphorus has been reported to constitute from 33 to 90% of the total phosphorus in cereal grains (Hamdy 1971). Studies characterizing the major sources of phosphorus in pearl millet would be valuable.

The locations of minerals in pearl millet kernels were determined by X-ray energy dispersive analysis. High levels of Si and K were present in the covering layers (including the aleurone), and a major portion of the phosphorus was located in the germ (Fig. 1). High levels of iron were found in both germ and covering layers. Low mineral concentrations were observed in the hard and soft endosperms; the predominant minerals detected in those areas were S, K, and Fe. The greater concentration of minerals in the covering layers and the germ than in the endosperm portions is typical of most cereal grains (MacMasters et al 1971).

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