Mineral Nutrient Composition of Green and White Asparagus Spears

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Abstract. Mineral nutrients were determined in green and white 'Jersey Giant' asparagus (*Asparagus officinalis* L.) spears grown in 1991 near Booneville, Ark. Green spears had higher concentrations of tissue N, K, P, S, Na, and Zn; similar levels of Fe, Al, and Cu; and lower levels of NO₃ than white spears grown under opaque plastic rowcovers or under sawdust mulch. Levels of Ca, Mg, and Mn were higher in plastic-grown white spears than in those grown in sawdust. The spear tip contained higher concentrations of K, S, and Cu than the butt. Less NO₃, Fe, and Al were in the tip than in the butt. Spear distribution gradients for K, Fe, and Cu were linear, whereas S and NO₃ gradients were both linear and quadratic. Nitrogen, P, Ca, Mg, Zn, Al, and Mn levels were influenced by spear production method and spear segment.

The 1990 Food Labeling and Education Act requires at the point of retail sale documentation of the percent reference daily intake for humans of Ca, Fe, and other nutrients found in 20 fresh vegetables, including asparagus. Zurera-Cosano and Moreno-Rojas (1990a) reported that the upper one-third of asparagus spears contained higher levels of Ca, Mg, Mn, Fe, Zn, and Cu than did the lower two-thirds of the spear. However, they did not mention spear type (green or white), cultivar, or length. White asparagus spears <9 mm in diameter were lower in K, Ca, Mg, Fe, Cu, and Na than were larger diameter spears (Moreno-Rojas et al., 1992). Seven-centimeter-long apical spear segments were higher in K, Ca, Mg, Fe, Mn, Zn, and Cu than were the corresponding mid- and butt segments. Both studies reported nutrient levels on a fresh-weight basis.

The objectives of this study were to examine mineral nutrient levels of a widely established asparagus cultivar, grown as green and white spears at the same location and in the same soil type, and to determine mineral nutrient gradients in the spears.

Materials and Methods

The experimental site was located at the U.S. Dept. of Agriculture, Agricultural Research Service Unit near Booneville, Ark. 'Jersey Giant' asparagus was planted in an Enders stoney, silt loam soil (clayey, mixed, thermic Typic Hapludults) in 1986. Spring 1991 P and K soil test levels were 130 and 280 kg-ha⁻¹, respectively, and were judged adequate. In early spring, supplemental N at 66 kg-ha⁻¹ was applied to the site, which normally tests 3 to 8 kg N/ha.

On 15 Mar. 1991, an opaque rowcover (Makus and Gonzalez, 1991) was installed for white asparagus production, and plots for green spears were left uncovered. White spears also were produced by covering existing beds to a 20-cm depth with sawdust. Production of white asparagus under sawdust mulch, though more labor-intensive than production under opaque plastic rowcovers, generally improves spear raw product quality (Makus, 1992). There were four complete blocks (replications) with spear types grown in plots, 7.3 m in length on 1.4-m centers (23,919 crowns/ha).

All three groups of spears were sampled on 15 Apr., during the fifth week of a 10-week cutting season. Spears >9.5 mm in diameter at the butt end after being trimmed to a 15-cm length, and weighing 10 to 20 g, were washed in tap water and rinsed in distilled water before being cut into three 5-cm segments, consisting of upper (tip), middle, and lower (butt) sections. Then segments were frozen in liquid N₂, freeze-dried, ground through a 40-mesh (0.36 mm²) screen, and stored at -20°C until analyzed. Tissue N was determined by the Leco combustion method, NO₃ colorimetrically, and mineral nutrients by ICP spectrometry (Plank, 1992).

The data were subjected to analysis of variance based on spear group as main plot and spear segment as subplot. Means were compared by *t* tests using the PDIF option of LSMEANS statement in PROC GLM of SAS version 6.04 (SAS Institute, Cary, N.C.).

Spear color. Green spears had higher levels of tissue N, K, P, S, Na, and Zn; similar levels of Fe, Al, and Cu; and lower levels of NO₃ than white spears grown under plastic or sawdust (Table 1). Levels of Ca, Mg, and Mn were higher in plastic-grown than sawdust-grown white spears. White spears produced under opaque white or black plastics were higher in NO₃ than green spears (Makus and Gonzalez, 1991). Iron levels reported here exceeded by ≈4-fold the "less than 2%" reference daily value for asparagus published by the Food and Drug Administration and should be considered a reportable source for Fe [Congressional Record 58(229):60889]. Calcium values were at or below 2% of the recommended daily intake for an adult, based on a 93-g (five spear) serving size.

Segment. The spear tip had higher levels of K, S, and Cu than the butt (Table 1). Nitrate and Fe were lower in the tip than in the butt. Other gradients in asparagus spears recently have been reported for soluble solids concentration, ascorbic acid, total phenolics, pulp pH, protein, amino acids, alcohol soluble carbohydrates (glucose, fructose, sucrose), CO₂ respiration rate, citric and malic acids, IAA, and ABA (Kojima et al., 1993; Kojima and Skurai, 1994; Lill et al., 1990; Makus and Gonzalez, 1991; Saltveit and Kasmire, 1985). With the exception of malic acid and alcohol soluble carbohydrates, these constituents decrease from the tip to the base of the spear. The mineral gradients do not appear to be based on anion-cation charge (Lill et al., 1990; Makus and Gonzalez, 1991), but are likely related to the source-sink relationship (Marschner, 1986) associated with a meristematically active growing tip and cell density per unit spear length. Commercially washed white asparagus spears had higher Pb levels in the upper one-third compared to the lower two-thirds of the spear, whereas Cd levels were similar throughout the spear (Zurera-Cosano and Moreno-Rojas, 1990b).

Interactions. Phosphorus levels in all green spear segments were higher than corresponding levels in white spear segments grown under plastic. Likewise, such spear segments had higher levels of P than corresponding segments of spears grown under sawdust, with the exception of the butt segment, which was similar in both white types. Other interactions are shown for N, Ca, Mg, Zn, Al, and Mn (Fig. 1). With the exception of Al and Mn, the concentration of minerals generally decreased from the apex to the base of the spear.

In this study, green spears generally contained higher concentrations of mineral nutrients than white spears. Most of the mineral nutrients measured decreased from the spear tip to the base. Since the mineral nutrient levels found in asparagus spears are influenced by the length of the spear, reducing the inedible fibrous portion (butt end) would reduce transportation costs and provide consumers with a nutritionally better product with respect to essential minerals. Growers should expect to receive a premium for such a product.

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Table 1. Mineral distribution in green and white asparagus spears (dry-weight basis).

Variable	N	K	P	S	Ca	Mg	NO ₃	Na	Fe	Zn	Al	Mn	Cu
	(%)						(µg·g ⁻¹)						
Spear color													
Green	5.30 a ^c	3.28 a	0.776 a	0.611 a	0.212 b	0.196 a	1006 b	209 a	99.9	77.3 a	44.6	21.4 a	18.0
White /P ^y	4.66 b	3.09 b	0.684 b	0.541 b	0.235 a	0.186 a	1202 a	177 b	86.8	70.0 b	22.1	22.7 a	16.3
White /S	4.54 b	3.03 b	0.653 b	0.529 b	0.189 c	0.170 b	1205 a	189 b	98.3	68.0 b	26.5	18.5 b	16.2
	**	*	*	**	*	*	**	*	NS	*	NS	*	NS
Segment ^x													
Tip	6.79 a	3.42 a	0.972 a	0.781 a	0.260 a	0.205 a	687	205	82.0 b	96.7 a	27.7 b	21.6 a	20.3 a
Mid	4.47 b	3.10 b	0.644 b	0.518 b	0.226 b	0.194 b	1247 b	181	89.9 ab	67.4 b	20.9 b	20.5 b	16.6 b
Butt	3.25 c	2.88 c	0.487 c	0.382 c	0.150 c	0.154 c	1479 a	190	113.2 a	51.2 c	44.5 a	20.4 b	13.6 c
	**	**	**	**	**	**	**	NS	*	**	**	NS	**
Polynomial fit	L ^{**} , Q ^{**}	L ^{**}	L ^{**} , Q ^{**}	L ^{**} , Q ^{**}	L ^{**} , Q ^{**}	L ^{**} , Q ^{**}	L ^{**} , Q ^{**}	---	L ^{**}	L ^{**} , Q ^{**}	L [*] , Q ^{**}	---	L ^{**}
Interaction	**	NS	**	NS	**	**	NS	NS	NS	**	*	**	NS

^aMeans followed by different letters are significantly different at probability shown.

^y/P and /S are plastic- and sawdust-grown white asparagus, respectively.

^xTip, mid, and butt segments were 0–5, 5–10, and 10–15 cm from spear apex, respectively.

NS, *, **Nonsignificant or significant at $P < 0.05$ or 0.01 , respectively.

Fig. 1. Interaction of spear type with spear segment for N, Ca, Mg, Zn, Al, and Mn. Spear types were green, white produced under opaque plastic (/P), and white produced under 20-cm of sawdust mulch (/S). Lowercase letters are used to separate spear type by segment differences ($P \leq 0.05$).

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