EFFECT OF NITROGEN AND MICRONUTRIENT FERTILIZATION ON CHILI PEPPERS (*CAPSICUM ANNUUM L.*)

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CHAPTER I

INTRODUCTION

In 1978, seed of several pungent type peppers were collected and grown at the Bixby Vegetable Research Farm to search for a pungent pepper that would grow in Oklahoma and be harvested by machine. Most highly pungent peppers used by the spice industry are imported from countries in Asia and Africa. Due to political unrest in some exporting countries the spice industry prefers a domestic source. However, due to the large amount of hand labor required to harvest spice peppers, domestic production must be harvested by machine to be economically competitive.

From the peppers grown in 1978 the Bahamian Hot Chili (BHC) appeared to have the yield, pungency and plant structure needed for production in Oklahoma. In 1979 a large planting of BHC was made and from this planting 28 individual plant selections were made which varied in important morphological characteristics. The 28 BHC selections were field tested in 1980 to evaluate the yield and pungency as well as evaluation for machine harvesting.

Pungency and yield of the selections varied between 1979 and 1980 but the most pungent remained pungent relative to selections with lower pungency. Improving pungency would make the peppers more valuable to the spice industry by reducing transportation and processing costs. Improving yield would benefit producers since peppers are sold on a weigh basis with no consideration for pungency above a minimum desired level of

150,000 Scoville units of pungency.

Using the 1979 and 1980 field data and pungency values, the KSB 7 and KSB 10 BHC selections were chosen to evaluate the effect of nitrogen and micronutrient fertilization on pungency and yield at two soil pH levels.

CHAPTER II

LITERATURE REVIEW

The pepper belongs to the family Solanaceae which also includes the eggplant and tomato. The genus Capsicum contains over two hundred varieties or species which cover the broad range from very hot chilies to sweet bell peppers. The compound capsaicin is responsible for the heat in chili pepper. Capsaicin is a fat soluble, colorless, odorless and flavorless compound (3).

Capsaicin, the crystalline pungent compound of *Capsicum annuum*, is a mixture of at least five closely related vanilylamides with varying acid side chains (2). Iwai et al. (6) examined the fluctuation in the amount of pungent compound of hot pepper fruits at various stages of pod development. They showed that capsaicinoid was first formed 20 days after flowering, and reached a maximum level around 40 days after flowering; then later decreased gradually. They also showed that the main formation and accumulation sites of capsaicinoid are in the placenta of the fruits.

According to Ohta (16), the stage at which the capsaicinoid begins to accumulate should not be species specific, but rather dependent on cultivation conditions such as temperature, the period of light exposure, and fertilization. Of these the first two factors are the most important. As proof of this statement he showed that in nature even under good fertilization conditions, sweet pepper would not become pungent at low temperature or under short day length. In addition to climatic factors, other factors such as geographic location, growing and processing conditions and stage of maturity also influence the capsaicin content.

Past studies have shown that fertilization effects pepper pungency and yield (2, 6, 11, 18). There are various methods of fertilization. With foliar fertilization the plant takes up nutrients through leaf, stems and other aerial parts. This is an active process dependent on temperature, light and oxygen. Some nutrients (N, K, Ca, Mg, Mn and Zn) are absorbed very rapidly while others (P, S, Fe and Mo) are absorbed more slowly (18).

Foliar fertilization is not a new practice, since over a century ago iron sulphate was used as a foliar spray to correct iron clorosis. Success in using foliar fertilization is still limited almost exclusively to micronutrients (18). Most investigations have suggested that foliar feeding is not practical where large quantities of nutrients are required. Application of large amounts of major nutrients (N, P and K) may cause leaf burn. Foliar application of micronutrients is practical since they are required in small amounts and are difficult to mix uniformly with the soil or fertilizer. Besides most micronutrients, urea is absorbed very rapidly by plant foliage and it also accelerates absorptions of other materials (19).

Foliar application will assume greater significance with changing cultural practices. Foliar fertilization is more practical with narrower rows, equidistant spacing, higher plant populations and widespread adoption of irrigation for major food crops (19).

Cuticular penetrations is necessary for absorption of micronutrients through the outer leaf surface or within stomata (8). Wetting substances or surfactants enhance absorption of nutrients applied to leaf surfaces (8).

Two properly timed applications are enough for crop plants which respond well to foliar micronutrient fertilization (19). It has been demonstrated that foliar application of fertilizer can increase the yield. Some examples are: Two sprays of zinc sulfate at the rate of one pound of zinc per acre increased yields of Michigan field beans from 0 on the control to 1229 kg/ha (19). In California, a three percent spray solution of ferrous sulphate resulted in grain sorghum yields of 4491 kg/ha compared to only 250 for the non-sprayed. The effectiveness of one or two Mn sprays for soybeans is due to rapid absorption, resulting in luxury consumption which will then support the crop to maturity. Mn sprays were also effective on cabbage and onion crops. Absorption by leaves is facilitated by light, high temperature and a hydrated surface. There are three stages in plant development when added growth factors may produce large crop increases. These are during early seedling growth, at flowering and at early seed and fruit development. For the second, foliar applications have greatest potential since leaf areas are large and often the leaf canopies are complete (19).

Fertilization, especially N, effects pepper pungency and yield. With broadcast placement of N, marketable yield can be increased if rate of N application is increased (10).

No more than 90 kg/ha should be applied. Nitrogen is an essential nutrient for plant growth as well as pepper yield. Excess N may hinder machine harvest due to increased lodging and plant size (14).

Boron has a direct and an indirect effect on the formation of capsaicin content. Excessive amounts of B stimulates formation of phenylalimine through the pentose shunt pathway. Phenylalimine is a component of capsaicin compounds. But B deficiency can produce excessive phenols which can lead to necrosis and eventual death of the tissue (9).

Pungent compounds were produced in fruits of sweet pepper during post harvest ripening under continuous light. The initial formation was observed after four days ripening. After seven days ripening, the capsaicinoid content in the placenta increased to 12.9 mg per fruit which was 2.5 fold that found in the pericarp. No pungent compounds were detected in fruits during ripening in the dark or in seeds under continuous light (5).

The pungent compound (capsaicinoid) is synthesized in both red peppers and sweet peppers mostly by enzymes localized in placenta and pericarp. No enzyme activity was found in seeds (4). Dihydrocapsaicin is also a pungent compound of capsicum fruits, formed and accumulated in sweet pepper fruits after 6 days post harvest ripening under continuous light (7). This pungent compound can be extracted from dried peppers using organic solvents (17).

Soluble nutrient loss through leaching is very harmful for growth. To avoid this, split fertilizer application, fertilizer placement, mulching (11), and slow release N sources (11) can be used. Nitrogen uptake is increased by mulching (13). Increased yields have been found with slow release fertilizer applied with mulch. Slow release fertilizer such as IBDU (isobutylidene), SCU (sulfur coated urea) and urea formaldehyde (UFA) provide N in a release pattern more similar to pepper plant growth needs (12).

CHAPTER III

MATERIALS AND METHODS

Two selections of BHC were used in this experiment, KSB 7 and KSB 10. In 1979 and 1980, these two selections were grown at the Bixby Research Farm and pungency tested (15) by KALSEC, Incorporated, Kalamazoo, Michigan. Tests determined that KSB 10 was extremely pungent (220,000 Scoville) and KSB 7 was less pungent (138,000 Scoville).

In a preliminary evaluation the pod mineral content of four BHC selections, including KSB 7 and KSB 10, that ranged in pungency from very low to very high, was determined and correlated with yield and pungency. Pod Mn content ranged from 13 to 27 ppm and was highly correlated with pungency ($r = 0.996$). Yield was correlated with pod Zn content and Zn content ranged from 7 to 17 ppm. Pod B content ranged from 36 to 67 ppm and was negatively correlated with pungency and yield ($r = -0.73$ and -0.88, respectively).

A 20 x 60 m field plot on (Coarse-silty, Mixed (calcareous), Thermic Typic Udifluvent) soil at the Bixby Research Farm was divided into half and soil tested. One-half received 4490 kg/ha lime (0.45 ECCE), applied and incorporated to a depth of 20 cm with a power tiller on April 1, 1981. Soil test results from the two areas before liming and planting and again after harvest are in Table I.

Prior to transplanting the two BHC selections the entire plot area received 0.63 kg/ha trifluralin and 281 kg/ha 12-5.2-10 fertilizer.

TABLE I

SOIL TEST RESULTS

			kg/ha					ppm			
	pH	B.I.	NO_3^-	P	K	Ca	Mg	Fe	Zn	Mn	B
Before Planting (April 1, 1981)											
Unlimed Area	5.8	7.2	32	117	227	1936	330	29.3	0.97	11.5	0.31
Limed Area	6.0	7.3	16	99	193	1940	348	24.8	0.68	10.5	0.52
After Harvest (January 5, 1982)											
Unlimed Area	6.4	7.2	4	157	272	2191	296	99.9	0.85	13.6	0.12
Limed Area	6.9	---	4	155	261	2520	259	99.9	1.02	9.0	0.06

Both the herbicide and fertilizer were incorporated to a depth of 10 cm with a power tiller.

Peppers were transplanted on April 18, 1981, and each plant received 235 ml of transplant starter fertilizer solution which contained 0.72 kg of soluble 20-8.7-16.6 fertilizer in 100 ℓ water. Plant spacing was 30 cm in-row and 90 cm between rows (37,000 plants/ha). Alternate rows were used as test rows to avoid foliar spray drift between treated plots and soil applied N fertilizer from reaching untreated plants.

The experimental design in the limed (higher pH) and unlimed (lower pH) areas was a randomized complete block with four replicates. Each of the fertilizer nutrients (B, Mn, N and Zn were examined as separate experiments with each BHC selection and soil pH. Treatments in each experiment were none, one or two foliar applications of B, Mn or Zn. Nitrogen treatments were none, one or two sidedress applications during the growing season. Each plot contained five plants in a row and the three middle plants were used for data collection.

Plots that received one or two foliar micronutrient or N sidedress applications were treated on June 22, 1981, at the beginning of fruit set. Plots that received a second micronutrient application were treated on August 29 and the second N sidedress on September 1, 1981. First fruit set had matured and were mostly dry at the time of the second application. Most plants were also initiating a second flush of growth and flowering. Table II provides the rate and source of micronutrients and N fertilizer.

Recommended disease and insect control practices were followed. No pesticides containing B, Mn or Zn were used in pest control. Sprinkler irrigation was applied to the entire plot area as needed.

Plots were harvested in mid-December after plants had been killed

TABLE II

SOURCE AND RATE OF FERTILIZER APPLICATION

Element	Source	Rate (A.I.)	Method of Application*
Boron	$Na_2BO_3 \cdot 10\ H_2O$ (11.34% B)	0.40 kg/ha	Foliar spray - 1,000 l/ha
Manganese	$MnSO_4 \cdot H_2O$ (32.51% Mn)	2.50 kg/ha	Foliar spray - 1,000 l/ha
Zinc	$ZnSO_4 \cdot H_2O$ (36.43% Zn)	1.25 kg/ha	Foliar spray - 1,000 l/ha
Nitrogen	NH_4NO_3 (33% N)	33.70 kg/ha	Sideplaced by hand

*Foliar spray included one ml/l Surfking surfactant.

by frost and pods had field dried to about 15 percent moisture. In harvesting, the three middle plants in each plot were cut at soil level and placed in a paper bag. Bags were placed in the greenhouse to air dry for approximately one month before pods were separated from other plant materials to determine total top plant dry weight and pod dry weight. From this data pod yield and percent pods was determined.

To determine pungency a 150 g pod sample was collected from the three-plant yield and shipped to KALSEC, Incroporated, Kalamazoo, Michigan, where standard industry analysis was conducted. To determine pod mineral content pod samples, less seeds, were shipped to the University of Georgia Soil Testing and Plant Analysis Laboratory where B, Mn and Zn results were obtained. Total N content of pods was determined by Kejdahl procedure.

Field and laboratory data was subjected to analysis of variance and correlation procedures (1) to determine statistical significance between treatment means. Analyses were conducted on data for pod yield, percent of plant top dry weight that was pods (percent pods), pungency and pod content of B, Mn, N and Zn. Simple correlations between the above yield and quality components and pod mineral content were determined.

CHAPTER IV

RESULTS

Dry pod yield of KSB 7 in the higher pH soil was significantly less with one application of B than with no applied B or two B applications (Table III). Similar yield results occurred with Mn in the lower pH soil. Yield of KSB 7 was not significantly affected by N or Zn application at either soil pH or with B at lower soil pH and Mn at higher soil pH. Dry pod yield of KSB 10 was not significantly influenced by fertilizer treatment at either soil pH (Table IV).

Percent of the KSB 7 plant dry weight that was pods in the higher soil pH was less with one application of B than no application. One application was not significantly different than two applications (Table V). Percent pods was significantly less with one or two applications of Mn on the higher soil pH than with no Mn applications. Nitrogen significantly reduced percent pods in the lower soil pH when applied once compared to no N applications. One N application did not differ significantly from two applications. Percent pods was not significantly effected by Zn application at either soil pH or by N at the higher soil pH and B and Mn at the lower soil pH. Results in Table VI show that KSB 10 produced no significant differences in percent pods due to soil pH or fertilizer treatments.

Pungency of pepper pods produced by KSB 7 was not significantly influenced by soil pH or fertilizer treatments (Table VII). Pungency

TABLE III

POD YIELD OF KSB 7 PEPPER WHEN FERTILIZED WITH ZERO, ONE OR TWO APPLICATIONS OF B, Mn, N OR Zn AT TWO SOIL pH LEVELS

Number of Applications	B High Soil pH	B Low Soil pH	Mn High Soil pH	Mn Low Soil pH	N High Soil pH	N Low Soil pH	Zn High Soil pH	Zn Low Soil pH	Mean High Soil pH	Mean Low Soil pH
					kg/ha					
0	2610 A[z]	1620 A	2851 A	2845 A	3258 A	2312 A	3028 A	2063 A	2937	2210
1	1753 B	1985 A	2293 A	2202 B	2806 A	2032 A	3330 A	2563 A	2545	2196
2	2462 A	1673 A	2274 A	2947 A	2659 A	2218 A	3127 A	1980 A	2631	2204
Mean	2275	1759	2473	2665	2908	2188	3162	2202	2704	2203
Coefficient of Variation (%)	16.2	29.8	28.1	13.2	25.6	31.3	15.6	29.4	----	----

[z] Mean values in columns followed by a common letter are not significantly different at the 5% level (Duncan's New Multiple Range Test).

TABLE IV

POD YIELD OF KSB 10 PEPPER WHEN FERTILIZED WITH ZERO, ONE OR TWO APPLICATIONS OF B, Mn, N OR Zn AT TWO SOIL pH LEVELS

Number of Applications	B		Mn		N		Zn		Mean	
	High Soil pH	Low Soil pH	High Soil pH	Low Soil pH	High Soil pH	Low Soil pH	High Soil pH	Low Soil pH	High Soil pH	Low Soil pH
					kg/ha					
0	3444 A[Z]	2838 A	3587 A	3559 A	3292 A	3351 A	3996 A	2392 A	3580	3035
1	3169 A	3052 A	3312 A	3849 A	2440 A	3314 A	3574 A	2916 A	3124	3283
2	3290 A	3405 A	3683 A	4042 A	2796 A	3362 A	3301 A	3254 A	3268	3491
Mean	3301	3065	3528	3817	2843	3342	3624	2854	3324	3270
Coefficient of Variation (%)	25.6	21.0	22.4	19.0	30.3	21.8	20.5	24.5	----	----

[Z] Mean values in columns followed by a common letter are not significantly different at the 5% level (Duncan's New Multiple Range Test).

TABLE V

PERCENT PODS IN PLANT DRY WEIGHT OF KSB 7 PEPPER WHEN FERTILIZED WITH ZERO, ONE OR TWO APPLICATIONS OF B, Mn, N OR Zn AT TWO SOIL pH LEVELS

Number of Applications	B High Soil pH	B Low Soil pH	Mn High Soil pH	Mn Low Soil pH	N High Soil pH	N Low Soil pH	Zn High Soil pH	Zn Low Soil pH	Mean High Soil pH	Mean Low Soil pH
					percent pods					
0	63.9 A[z]	54.7 A	64.9 A	54.6 A	62.8 A	61.2 A	61.9 A	56.4 A	63.4	56.7
1	53.6 B	53.4 A	56.0 B	58.7 A	65.4 A	52.4 B	60.6 A	62.2 A	58.9	56.7
2	60.5 AB	51.4 A	58.6 B	60.0 A	61.8 A	56.4 AB	65.7 A	55.5 A	51.7	55.8
Mean	59.4	53.1	59.8	57.8	63.3	56.7	62.8	58.0	61.3	56.4
Coefficient of Variation (%)	8.3	14.8	5.4	11.0	7.9	7.9	7.6	17.0	----	----

[z]Mean values in columns followed by a common letter are not significantly different at the 5% level (Duncan's New Multiple Range Test).

TABLE VI

PERCENT PODS IN PLANT DRY WEIGHT OF KSB 10 WHEN FERTILIZED WITH ZERO, ONE OR TWO APPLICATIONS OF B, Mn, N OR Zn AT TWO SOIL pH LEVELS

Number of Applications	B High Soil pH	B Low Soil pH	Mn High Soil pH	Mn Low Soil pH	N High Soil pH	N Low Soil pH	Zn High Soil pH	Zn Low Soil pH	Mean High Soil pH	Mean Low Soil pH
					percent pods					
0	64.9 A[z]	57.8 A	63.3 A	57.3 A	70.5 A	60.2 A	62.9 A	59.3 A	65.4	58.6
1	62.8 A	62.0 A	62.6 A	56.8 A	63.5 A	60.0 A	65.1 A	64.5 A	63.5	60.8
2	63.1 A	59.4 A	64.3 A	58.7 A	61.6 A	61.9 A	63.9 A	59.8 A	63.2	60.0
Mean	63.6	59.8	63.4	57.6	65.2	60.7	64.0	61.2	64.0	59.8
Coefficient of Variation (%)	8.7	11.8	7.4	7.7	11.3	9.5	5.5	8.0	----	----

[z] Mean values in columns followed by a common letter are not significantly different at the 5% level (Duncan's New Multiple Range Test).

TABLE VII

PUNGENCY OF KSB 7 PEPPER WHEN FERTILIZED WITH ZERO, ONE OR TWO APPLICATIONS OF B, Mn, N OR Zn AT TWO SOIL pH LEVELS

Number of Applications	B		Mn		N		Zn		Mean	
	High Soil pH	Low Soil pH	High Soil pH	Low Soil pH	High Soil pH	Low Soil pH	High Soil pH	Low Soil pH	High Soil pH	Low Soil pH
	Scoville Units x 1,000									
0	152 A[z]	169 A	155 A	156 A	153 A	158 A	142 A	160 A	150	161
1	154 A	166 A	172 A	152 A	163 A	151 A	144 A	153 A	158	156
2	150 A	168 A	159 A	169 A	152 A	159 A	139 A	153 A	148	162
Mean	150	168	162	159	156	156	141	156	152	160
Coefficient of Variation (%)	10.6	9.7	7.1	7.8	9.4	12.7	6.3	9.9	---	---

[z]Mean values in columns followed by a common letter are not significantly different at 5% level (Duncan's New Multiple Range Test).

of KSB 10 pods (Table VIII) was significantly increased on the lower pH soil by two applications of Zn compared to no Zn applications. One Zn application did not differ significantly in pungency from no Zn or two applications of Zn at the lower soil pH.

Simple correlation coefficients for KSB 7 and KSB 10 between pod yield and pod content of B, Mn, N and Zn were not significant under any of the fertilizer and soil pH treatment combinations (Tables IX and X). Yield of KSB 7 was positively correlated with percent pods in five of the eight fertilizer and soil pH treatments. Yield of KSB 7 was not significantly correlated with pungency (Table IX). Yield of KSB 10 was positively correlated with percent pods in four of the eight fertilizer and soil pH treatments (Table X). Yield of KSB 10 was positively correlated with pungency when B was applied at the lower soil pH. Significant yield and pungency correlations did not occur under other fertilizer and soil pH treatments (Tables X and XI).

Significant correlation coefficients occurred in KSB 7 between pungency and pod content of Mn only when B was applied at the higher soil pH and pod content of Zn was effected only when N was applied at the higher soil pH (Table XI). Pungency and pod content of B and N were not significantly correlated under any fertilizer and soil pH combination. With KSB 7 neither pungency and percent pods nor pungency and yield were significantly correlated under any fertilizer and soil pH combination (Table XI).

Correlation coefficients in KSB 10 between pungency and pod content of B, Mn and N were not significant (Table XII). Pod content of Zn in KSB 10 under the N treatment was correlated with pungency. However, the correlation was negative under the N treatment on higher pH

TABLE VIII

PUNGENCY OF KSB 10 PEPPER WHEN FERTILIZED WITH ZERO, ONE OR TWO APPLICATIONS OF B, Mn, N OR Zn AT TWO SOIL pH LEVELS

Number of Applications	B		Mn		N		Zn		Mean	
	High Soil pH	Low Soil pH	High Soil pH	Low Soil pH	High Soil pH	Low Soil pH	High Soil pH	Low Soil pH	High Soil pH	Low Soil pH
	Scoville Units x 1,000									
0	186 A[z]	198 A	178 A	180 A	174 A	188 A	179 A	184 B	179	188
1	178 A	200 A	186 A	193 A	173 A	189 A	188 A	187 AB	181	192
2	188 A	201 A	186 A	190 A	180 A	185 A	184 A	198 A	184	194
Mean	184	200	183	188	176	187	184	190	182	191
Coefficient of Variation (%)	8.6	10.1	12.0	6.7	7.3	7.4	9.6	4.2	---	---

[z] Mean values in columns followed by a common letter are not significantly different at the 5% level (Duncan's New Multiple Range Test).

TABLE IX

CORRELATION COEFFICIENTS BETWEEN KSB 7 PEPPER POD YIELD AND MINERAL CONTENT, PERCENT PODS AND PUNGENCY

Pod Yield Correlated With	Field Fertilizer Treatment							
	B		Mn		N		Zn	
	High Soil pH	Low Soil pH	High Soil pH	Low Soil pH	High Soil pH	Low Soil pH	High Soil pH	Low Soil pH
B Content	0.15	0.27	0.25	-0.52	-0.11	0.02	0.13	0.07
Mn Content	-0.36	0.38	0.04	0.37	-0.24	-0.38	-0.14	0.31
N Content	-0.19	-0.14	0.01	-0.01	-0.25	-0.51	0.29	0.11
Zn Content	0.13	0.39	-0.39	0.08	-0.36	0.14	-0.24	0.18
Percent Pods	0.81*	0.56	0.68*	-0.18	0.62*	0.58*	-0.20	0.75*
Pungency	-0.01	-0.26	-0.17	0.41	-0.03	-0.22	0.19	-0.28

*Correlation coefficient significant at the 5% level.

TABLE X

CORRELATION COEFFICIENTS BETWEEN KSB 10 PEPPER POD YIELD AND MINERAL CONTENT, PERCENT PODS AND PUNGENCY

Pod Yield Correlated With	Field Fertilizer Treatment							
	B		Mn		N		Zn	
	High Soil pH	Low Soil pH	High Soil pH	Low Soil pH	High Soil pH	Low Soil pH	High Soil pH	Low Soil pH
B Content	-0.25	0.52	0.42	0.14	0.28	-0.39	-0.34	-0.15
Mn Content	-0.21	0.47	0.23	0.35	0.25	-0.03	-0.21	-0.39
N Content	0.04	-0.18	-0.53	0.06	0.37	0.12	-0.16	0.56
Zn Content	-0.03	0.05	-0.14	0.32	0.03	-0.03	-0.28	-0.51
Percent Pods	0.48	0.78*	0.26	0.77*	0.78*	0.76*	0.03	0.12
Scoville Pungency	-0.36	-0.60*	0.30	-0.08	0.14	-0.42	-0.07	0.26

*Correlation coefficients significant at the 5% level.

TABLE XI

CORRELATION COEFFICIENTS BETWEEN KSB 7 PUNGENCY AND POD MINERAL CONTENT, PERCENT POD AND YIELD

Pungency Correlated With	Field Fertilizer Treatment							
	B		Mn		N		Zn	
	High Soil pH	Low Soil pH	High Soil pH	Low Soil pH	High Soil pH	Low Soil pH	High Soil pH	Low Soil pH
B Content	-0.07	-0.56	-0.41	-0.35	0.23	-0.11	-0.43	-0.06
Mn Content	0.57*	-0.30	-0.08	0.46	0.24	-0.10	-0.47	-0.18
N Content	0.08	-0.12	-0.40	-0.08	-0.10	-0.08	0.47	0.36
Zn Content	0.54	-0.17	-0.19	0.20	0.67*	-0.43	-0.16	0.04
Percent Pods	0.15	-0.53	-0.43	-0.24	0.03	-0.16	-0.28	-0.55
Yield	-0.01	-0.26	-0.17	0.41	-0.03	-0.23	0.19	-0.28

*Correlation coefficient significant at the 5% level.

TABLE XII

CORRELATION COEFFICIENTS BETWEEN KSB 10 PUNGENCY AND POD MINERAL CONTENT, PERCENT PODS AND YIELDS

Pungency Correlated With	Field Fertilizer Treatment							
	B		Mn		N		Zn	
	High Soil pH	Low Soil pH	High Soil pH	Low Soil pH	High Soil pH	Low Soil pH	High Soil pH	Low Soil pH
B Content	0.36	-0.09	-0.14	0.24	-0.53	0.36	0.24	-0.44
Mn Content	0.48	-0.23	0.06	0.17	-0.30	0.22	0.15	-0.31
N Content	-0.33	0.24	-0.29	0.09	0.53	-0.06	-0.14	0.21
Zn Content	0.39	-0.20	-0.11	0.14	-0.59*	0.75*	-0.48	-0.16
Percent Pods	-0.62*	-0.72*	-0.36	-0.45	-0.05	-0.66*	-0.70*	0.19
Yield	-0.36	-0.60*	0.30	-0.08	0.14	-0.42	-0.07	0.26

*Correlation coefficient significant at the 5% level.

soil and positive on the lower pH soil. Pungency of KSB 10 had a significant negative correlation with percent pods in four of the eight fertilizer and soil pH treatments (Table XII).

Pod content of B, Mn and Zn changed very little between one foliar application and no application of the micronutrient. Two applications generally increased the pod content of B, Mn and Zn over one or no foliar applications. Sidedressing N did not influence pod N content which averaged 3.2 percent and ranged from 3.0 to 3.4 percent. Pod B content averaged 17.3 ppm and ranged from 15.2 to 20.6, Mn content averaged 11.4 ppm and ranged from 6.8 to 18.2 and Zn content averaged 16.4 ppm and ranged from 11.3 to 24.0.

CHAPTER V

DISCUSSION

Pod yield of KSB 7 and KSB 10 was not generally influenced by nitrogen sidedress applications or foliar applications of B, Mn or Zn. Coefficients of variation for pod yield were high, ranging from 20 to 30 percent in most experiments. Larger plots or more replicates would have been desirable. Although high positive correlations had been found between pod Zn content and yield in four BHC selections, the yield of these two selections was not influenced by foliar Zn applications in this study. Soil test results showed available Zn was near one ppm which is considered adequate for most crop plants.

The preplant N application of 23.4 kg/ha was apparently sufficient for maximum yields although a darker green foliage color was evident when one or two additional applications of 33.7 kg/ha N were used. Previous N fertilization studies with BHC and paprika peppers at the Bixby Vegetable Research Farm produced similar results. However, increased yield in bell peppers has been reported for N application rates up to 224 kg/ha (10).

Available B, Mn and Zn in the soil was apparently adequate for BHC pepper production and foliar application of these nutrients did not effect the quality of the harvested product. Soil pH appeared to influence yield of the KSB 7 selection of BHC but not the KSB 10 selection (Table XIII). The higher soil pH produced a 22.7 percent greater average yield with KSB 7 but only a 1.6 percent increase with KSB 10. Differences in the 28 BHC selections was observed for soil moisture stress tolerance during 1980. This study provides some indication that differences may also exist in tolerance to small differences in soil pH by these two BHC selections. Soil pH after harvest was 6.9 in the limed area and 6.4 in the unlimed area. Soil pH differences early in the growing season were probably less than 0.5 pH units since the lime was applied only 17 days in advance of transplanting the crop.

Percent pods in the plant dry weight of KSB 7 and KSB 10 was not generally influenced by nitrogen sidedress applications or foliar applications of B, Mn or Zn. Additional N was expected to increase the percent trash or nonpod plant material in the harvest but this did not occur. From this data it is indicated that liberal N fertilization does not influence pod yield or cause a reduction in the quality (percent trash) of the harvested product should the entire plant be harvested along with the pods. Percent pods appeared to be influenced by soil pH. On the higher soil pH compared to the lower soil pH KSB 7 had an 8.7 percent increase in percent pods and KSB 10 a 7.0 percent increase (Table XIII). Although these differences appear small they are economically important to the processor when the cost of transporting, storing, grinding and solvent extracting of the trashier compared to cleaner raw product is considered.

Pungency of KSB 7 and KSB 10 pods were not generally influenced by N sidedress applications or foliar applications of B, Mn or Zn. Although high positive correlations had been found between pod Mn content and pungency in different BHC selections, the pungency of these two lines was not influenced by foliar Mn applications in this study.

TABLE XIII

INFLUENCE OF THE LOWER COMPARED TO THE HIGHER SOIL pH ON YIELD, PERCENT PODS AND PUNGENCY OF TWO KSB SELECTION

	KSB 7			KSB 10		
	Lower Soil pH	Higher Soil pH	Percent Difference	Lower Soil pH	Higher Soil pH	Percent Difference
Yield (kg/ha)	2203	2704	+22.7	3270	3324	+1.6
Percent Pods	56.4	61.3	+ 8.7	59.8	64.0	+7.0
Pungency (Scoville x 1,000)	160	152	- 5.0	191	182	-4.7

Similarly, negative correlations between pod B content and pungency in different BHC selections had been observed but were not verified by this study. Also, no relationship was found between yield and pod Zn content. The higher soil pH appeared to have a detrimental effect on pungency in both KSB selections. The average pungency in the KSB 7 selection was reduced 5.0 percent in the higher compared to the lower soil pH while KSB 10 was reduced 4.7 percent. Having a high pungency level is an important quality factor to the processor in a manner similar to having a low trash content. A greater quantity of capsaicin can be extracted from a smaller quantity of pepper pods when pungency is higher.

Percent pods in the total plant dry weight was positively correlated with yield and negatively correlated with pungency in both KSB selections (Table XIV). The percent pod and pungency relationship could suggest that the plants ability to produce capsaicinoid compounds may be limiting when a comparatively larger portion of the pepper plant is pods.

TABLE XIV

CORRELATIONS BETWEEN POD MINERAL CONTENT AND POD QUALITY FACTORS OF TWO KSB SELECTIONS

Pod Factor	Pungency		Yield		Percent Pods	
	KSB 7	KSB 10	KSB 7	KSB 10	KSB 7	KSB 10
B Content	-0.21*	-0.11	0.06	-0.04	0.08	0.08
Mn Content	-0.14	-0.02	0.18	0.10	0.05	0.11
N Content	0.01	-0.12	0.06	-0.00	0.05	0.16
Zn Content	0.05	-0.05	-0.03	0.08	0.00	0.08
Percent Pods	-0.35*	-0.47*	0.62*	0.38*	----	----
Yield	-0.25*	-0.09	----	----	----	----
Pungency	----	----	----	----	----	----

*Correlation coefficient significant at the 5% level.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Pod yield, percent pods and pungency of the KSB 7 and KSB 10 selections of Bahamian Hot Chili pepper were not influenced by N fertilizer rates of 23.4, 57.1 or 90.8 kg/ha. Foliar application of B, Mn and Zn did not consistently effect yield, percent pods or pungency of either KSB selection.

Yield and percent pods appeared to be slightly higher when peppers were grown on the higher pH soil, particularly with the KSB 7 selection. However, pungency of peppers appeared to be slightly lower with both KSB selections at the higher soil pH.

Correlations between pungency and percent pods were negative indicating with both selections that a high pod percentage tends to cause pods to be lower in pungency. Positive correlations between percent pods and yield indicated higher yields/ha were produced when percent pods were higher.

From this study it can be concluded that yield and pod quality of the KSB 7 and KSB 10 BHC selections are not influenced significantly by N fertilization rates between 23.4 and 90.8 kg/ha or by foliar application of micronutrients B, Mn and Zn. Soil pH may influence the yield of KSB 7 and may have some influence on percent pods and pod pungency of KSB 7 and KSB 10. It is apparent that growing conditions such as light, temperature and probably other factors have far greater influence on BHC yield and pungency than N or micronutrient (B, Mn, Zn) fertilization.

Additional research is suggested to verify the possible undesirable relationship between percent pods and pungency since selection efforts toward plant types with a high percentage pods may also tend to reduce pungency. Efforts to improve pepper pungency through cultural practices do not appear promising. Although more time consuming, a more promising approach may be to genetically transfer higher pungency into BHC type plants from existing extremely pungent type Capsicums that have undesirable plant types and lack other horticultural characteristics needed for machine harvesting.

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