PATTERN OF FERTILIZATION FOR WATERMELONS: II INFLUENCE ON NUTRIENT DISTRIBUTION IN SOIL AND PLANT UPTAKE

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ABSTRACT

Soil and plant tissue samples were taken during growth of watermelons where 20 fertilization patterns were used identically on two soils in 1969 and 1970. Two rates, 1,500 and 3,000 lb./acre of 6-8-8 fertilizer, were applied in three applications either broadcast or as three bands. Preplant fertilizer was 10, 30, 50, 70, and 90 percent of the total with the remainder in two equal dressings. At the thinning stage, both soil and tissue values showed a significantly linear increase with the increase in the percent of the fertilizer applied initially. Tissue composition of plants sampled either at the early runner stage, at the flowering stage or at harvest, was not consistently affected by fertilization factors and did not correlate well with fruit yield. Soil determinations were affected by fertilization patterns at the flowering stage but few differences were found by fruit harvest. Significant correlations were obtained between soil and plant tissue compositions. Soluble salts were consistently much higher in banded than broadcast areas and were higher in nitrate than chloride.

INTRODUCTION

In a companion paper (6), watermelon responses to fertilization patterns were similar on Lakeland and Leon fine sands. Fruit yields increased 40 percent where the fertilizer was broadcast, but were also 18 percent higher at the higher banded rate than the lower one. In earlier work (3), broadcast placement of the fertilizer resulted in higher yields than band-placed fertilizer. Applications in a broad band below the seed were inferior to all other placement probably due to the concentration of soluble salts near the seed. It is probable that with the extensive root system produced by watermelons (1), that broadcast fertilizer (as compared with band placement) reduces the concentration of soluble salts near the seed, provides a more uniform soil fertility (1, 3, 4), utilizes the soil-exchange capacity more efficiently (2) and thereby increases yield. Increased yield with broadcast fertilizer was also reported for field corn (5) and potatoes (4).

The object of the study reported here was to evaluate the nutrient levels of the soil and watermelon tissue as influenced by the pattern of fertilizer application.

Florida Agricultural Experiment Station Journal Series No. 3749.

EXPERIMENTAL PROCEDURE

An experiment was conducted in 1969 on Lakeland fine sand near Live Oak which had been in coastal bermudagrass and on Leon fine sand near Gainesville that had been used for various vegetable trials. In 1970, the experiment on Lakeland fine sand was on land previously in Pensacola bahiagrass and that on the Leon fine sand was on land previously in vegetables. Fertilizer patterns were 10, 30, 50, 70, or 90 percent of 1,500 or 3,000 pounds per acre of 6-8-8 fertilizer containing 40 pounds per ton of FTE 503 (complete micro-nutrient frit) applied at planting. The balance of the fertilizer was split evenly in two side dressings applied at the thinning and early runner stages. Broadcast fertilizer was applied initially in a 3-foot strip at the center of the row, disced in, and the planting bed formed from this soil by disc hillers. Second broadcast application was spread 18 to 36 inches from the bed center on either side of the first area and the third application was spread 36 to 54 inches from the bed center on both sides of the bed. Banded fertilizer initially was placed 2 inches to one side and below the seed row. The second band was on the opposite side and 8 inches from the row center. The third band was 18 inches away from the bed center on the same side as the *initial band.*

After each side dressing, the bed was increased in width by disc hillers for the Lakeland soil and by a Louisiana bedder for the Leon soil.

Whole plants were excised 30, 40, and 64 days and mature leaves were sampled 120 days after first fertilization. Soil samples were obtained as 2-inch diameter cores taken to a 9-inch depth where the fertilizer had been placed. Unfertilized check plots were also sampled. Soil analyses for pH, Ca, Mg, K, and P were made in the Soil Testing Laboratory at Gainesville. Analyses of saturated extracts were made for pH, soluble salts (as KNO_3), Ca, Mg, P, NO_3, and Cl at the Analytical Service Laboratory in the Soils Department.

All data were statistically analyzed using orthogonal comparisons for effects of fertilization patterns on each element. This included the cation molar ration which is K divided by the square root of Ca plus Mg (modified Gapon equation).

Results and Discussion

Soil responses, 1969.

Mean values for all the first determinations (Table 1) indicated that sampling did give values reasonable representative of the fertilization pattern and provide a measure of soil fertility factors encountered by the watermelon plants. Greater nitrate levels in the Leon soil were attributable both to the soil being damper than the Lakeland and to its past use for vegetables. An increase in the percent of the fertilizer applied resulted in a linear response for all these determinations. There were few nonlinear responses. Interactions of placement and percent applied were noted for Ca and P values from Lakeland soil. This resulted from a linear response to change in banded fertilizer but no significant differences were observed for broadcast application. Placement interaction with rate was found for soluble salts. A greater difference occurred between banded and broadcast placement at the higher rate than the lower one. Slope of linear response was 3.75 for banded fertilizer and 0.93 for broadcast. There was also an interaction for soluble salts between placement and percent applied. These responses were linear for banded and cubic for broadcast. Some leaching appeared to have occurred because Cl values should have been one-half the K values (4% Cl in fertilizer) whereas much lower values were found.

Table 1 - Main effect means for soil determination at two watermelon sites sampled 30 days after first fertilization, 1969.

Fertilizer 6-8-8	Soil determinations							
	pH	Ca	Mg	K	P	S.S.	NO_3	Cl
		ppm						
				Lakeland fine sand site				
% applied initially[1]								
10	6.1	308	79	76	12	350	29	6
30	5.8	569	65	268	49	1,300	50	23
50	5.9	782	67	379	61	2,000	64	57
70	5.9	753	63	356	80	1,750	71	45
90	5.8	988	53	622	101	2,680	87	36
Rate applied[1]								
0	6.3	238	77	32	8	126	38	20
1,550	5.9	593	66	281	56	1,350	46	22
3,000	5.9	767	65	399	65	1,900	75	45
Placement[1]								
Banded	5.8	965	63	517	94	2,460	77	53
Broadcast	6.0	395	68	163	26	800	43	14
				Leon fine sand site				
% applied initially[2]								
10	6.3	574	116	54	10	650	530	20
30	6.2	636	123	103	19	1,060	750	35
50	5.8	696	129	163	31	1,610	1,180	53
70	5.8	824	129	192	27	1,950	1,440	76
90	5.5	845	108	243	40	1,950	1,380	58
Rate applied[2]								
0	6.3	579	107	44	8	316	111	13
1,550	6.0	685	116	128	25	1,180	866	34
3,000	5.9	745	126	174	26	1,750	1,250	62
Placement[2]								
Banded	5.9	799	116	206	33	1,760	1,170	53
Broadcast	6.0	632	125	96	18	1,160	945	43

[1]Significant effects of percent fertilizer applied initially were linear for all determinations; placement effects were significant for pH, Ca, K, and P; all rate effects were significant except for pH and Mg.

[2]Significant linear responses except for Mg were obtained for percent fertilizer applied initially; placement effect were significant for pH, Ca, K, P, and soluble salts; rate effects were significant for K, NO_3 and Cl.

Soil samples were taken in mid-May at the Leon site from the center of the bed where the three applications of fertilizer had been made. These determinations (Table 2) revealed some interesting changes in the row center where fertilizer had not been applied in that soluble salts, nitrate, and K values were not significantly different than where fertilizer had been applied broadcast. Data, not shown, indicated no differences also for pH, Ca, and Mg mean values for placements. Obviously, fertilizer had moved towards the row center from banded fertilizer. Soil from the initially fertilized area (first band) contained more K from banded than broadcast treatments and K responded linearly to the percent applied. Both pH and P values (not shown) also responded linearly to the percent applied and also to placement. Values were 65 ppm P from banded areas compared to 16 ppm from broadcast areas. At the location of the second and third bands, decrease in rate of side dressing resulted in a linear decrease for K and soluble salts (Table 2) and also for Ca, P, and pH values (not shown).

Table 2 - Effect of fertilization patterns on potassium, nitrate and soluble salts in saturated extracts from Leon fine sand sampled at flowering stage, 1969.

Fertilization 6-8-8 in 3 applications	Row center	First band	Second band	Third band
3,000 lb./acre		Potassium, ppm		
% banded				
10; 45; 45	59	88	319	234
50; 25; 25	202	393	102	197
90; 5; 5	77	314	51	38
% broadcast				
10; 45; 45	174	61	278	228
50; 25; 25	165	135	181	191
90; 5; 5	143	154	101	88
		Nitrate, ppm		
% banded				
10; 45; 45	264	702	675	508
50; 25; 25	1,670	1,080	667	847
90; 5; 5	600	668	167	167
% broadcast				
10; 45; 45	342	641	930	426
50; 25; 25	577	515	900	392
90; 5; 5	674	533	537	235
		Soluble salts, ppm		
% banded				
10; 45; 45	1,060	2,760	2,110	2,130
50; 25; 25	3,490	2,750	1,390	2,840
90; 5; 5	1,530	4,380	469	364
% broadcast				
10; 45; 45	1,420	1,770	2,730	1,830
50; 25; 25	1,470	1,450	2,030	1,610
90; 5; 5	1,510	1,400	1,600	675

*See text for significant effect. Unfertilized plots contained 28, 92, and 245 ppm of potassium, nitrate, and soluble salts, respectively.

At the time of fruit harvest, soil fertility levels were lower in all areas sampled (Table 3) than at the earlier growth stages. In banded areas pH values were affected by placement with values of 5.9, 6.2, and 6.7 for banded compared to 6.7, 6.3, and 6.3 for broadcast from initial, first and second side dressings, respectively. Soluble salt values from the first band showed highly significant responses both to percent of the fertilizer applied initially and placement. Soluble salt values obtained from the side dressings were 2 to 3 times higher where fertilizer was banded than broadcast. Significant correlations were found between combined values from the three bands and fruit yield: P($r = .376$), soluble salts ($r = .470$), and cation ratio in soluble salts ($r = .559$). Similarly, for Lakeland samples taken at fruit harvest, average Ca values correlated with yield ($r = .405$) and, for the last side dressing only, K values correlated with yield ($r = .423$) and also P values correlated with yield ($r = .580$).

Table 3 - Residual effects of fertilization found in Leon fine sand sampled at fruit harvest, 1969.[1]

Factor measured	No. fert.	Fertilizer 6-8-8 applied, %: Initial application 10	50	90	First side dressing 5	25	45	Second side dressing 5	25	45
pH	6.6	6.5	6.5	6.4	6.3	6.4	6.3	5.9	6.3	5.4
Ca, ppm	600	560	530	510	502	590	574	540	755	591
Mg, ppm	95	93	94	93	90	90	98	72	77	100
K, ppm	9	23	22	24	19	18	17	28	21	21
P, ppm	6	9	14	5	7	14	7	8	31	39
S.S., ppm	140	360	280	260	220	440	230	220	610	660
NO_3, ppm	60	127	121	126	107	112	109	126	126	136
Cl, ppm	15	17	13	15	27	25	19	17	19	17

[1]Average of four replications, sampled to 9-inch depth. See text for significant effects and correlations.

Soil responses, 1970.

Samples taken from the Lakeland site at the early runner stage reflected the residual effects of treatment following a previous period of high rainfall. Surprising amounts of K and nitrate were present. Response to percent fertilizer applied was linear for all determinations except Mg and cation ratio (Table 4). Mean value for K at the lower rate was 92 ppm compared to 161 at the higher rate. Also, soil with banded fertilizer contained 185 ppm K compared to 68 ppm for broadcast. Placement mean values for banded and broadcast placement, respectively, were: Ca, 409 and 224 ppm; K, 185 and 68 ppm; P, 32 and 9 ppm; soluble salts, 1,320 and 807 ppm; nitrate 273 and 183 ppm; and cation ratio,

Table 4 - Effect of fertilization patterns on variations in soil fertility found at early runner and fruit harvest stages of watermelons grown on Lakeland fine sand, 1970.

Factor measured	No. fert.	Fertilizer applied initially, %: 10	30	50	70	90
	Sampled in first band area at early runner stage[1]					
pH	5.7	5.7	5.6	5.6	5.5	5.5
Ca, ppm	190	184	240	288	402	468
Mg, ppm	33	35	30	29	25	27
K, ppm	42	50	85	98	177	223
P, ppm	4	5	10	16	30	40.5
S.S., ppm	363	556	935	904	1260	1670
NO_3, ppm	105	132	248	241	289	232
Cl, ppm	160	221	171	174	207	255
Cation ratio	0.15	0.54	0.83	0.90	1.26	1.54
	Sampled across bed at fruit harvest[2]					
pH	6.2	5.5	5.5	5.4	5.6	5.6
Ca, ppm	156	174	198	210	203	200
Mg, ppm	9	14	13	16	13	16
K, ppm	19	52	60	47	42	41
P, ppm	3	5	5	6	6	6
S.S., ppm	385	990	1140	970	740	750
NO_3, ppm	48	119	143	102	119	104
Cl, ppm	140	132	116	100	116	98
Cation ratio	0.08	0.64	0.74	0.51	0.52	0.50

[1]Significant effectsof percent fertilizer applied initially were linear for all factors except Mg, Cl and cation ratio but quadratic for NO_3 and Cl; placement effects were significant for all determinations except Mg and Cl; rate effects were significant for Ca, Mg, K, P, and cation ratio.

[2]Significant effects of percent fertilizer applied initially were linear for soluble salts and Cl; placement effects were significant for soluble salts, K, and cation ratio; rate effects were significant for pH, K, NO_3, and cation ratio.

1.33 and 0.70. Nitrate and P values correlated significantly with plant weights. Cation ratio, Mg, P, and K soil values gave significant correlations with corresponding tissue composition.

Soil determinations from the Leon site (not shown here) also indicated K retention after the high rainfall was similar to those values shown in Table 4. However, nitrate values were must higher ranging from 21 ppm in the unfertilized plots to 2,600 ppm where 90 percent of fertilizer at the higher rate was banded or 1,970 ppm were broadcast.

Soluble salt distribution for two fertilization patterns is illustrated in Figure 1. Observed distribution of broadcast placement varied probably due to crop utilization and salt movement by water and cultivation. Note the lower value at the bed center attributed to crop removal, and the increased level of soluble salts on the bed shoulders. Soluble salt levels were more variable across the bed than anticipated but considerably less than with banded placement. Migration of salts to the bed center occurred for the banded fertilizer but these values were lower than in

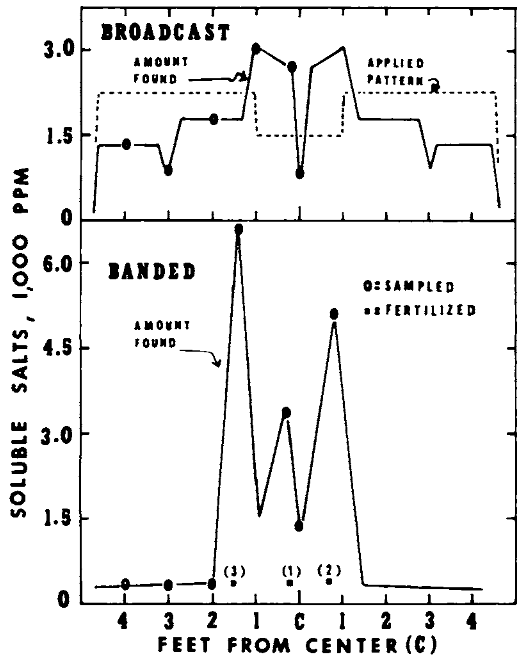

Figure 1.—Soluble salt levels to 9-inch depth found in mid-May 1970, from watermelon plots on Lakeland fine sand. Theoretical values are shown for broadcast application as dotted line with preplant distance shortened by bed formation. Locations for banded fertilizer are (1) preplant at 27,000 ppm, (2) first side-dressing, 13,500 ppm, and (3) second side-dressing, 13,500 ppm. Note fertilizer movement toward bed center.

the bands. Where banded fertilization was used note soluble salts moved to the bed center and values from bands are very much less than those applied. Salt crusts on the bed surface were observed above banded fertilizer and were found to be principally Ca and K nitrates.

Soil fertility found in samples taken diagonally across the bed at the fruiting stage from the Lakeland site (Table 4) were lower than those found on the Leon site at earlier stages (Table 3). Nitrate response was not significant for broadcast patterns but was for banded ones with highest values where 30 or 70 percent of the fertilizer was applied initially. Soil pH was slightly effected by fertilizer rates. Mean K values of 64 ppm compared to 33 ppm were found at the highest rate and lower rate, respectively. Soluble salts were 400 ppm higher at the 3,000 lb. rate; nitrate mean value was 41 ppm more at the higher rate. Placement differences for banded and broadcast were 56 and 41 ppm for K, and 1,020 compared to 811 for soluble salts, respectively. Cation ratios were much lower at harvest than at the early runner stage. Banded fertilization resulted in ratios of 0.69 and broadcast ratios averaged 0.50. At the lower rate the ratio was 0.42 compared to 0.76 at the higher one. These ratios indicated changes in K relative to Ca and Mg fluctuations. Significant correlations were found only between fruit yields and soluble salts ($r = .331$) and nitrate values ($r = .303$). Soil values correlated significantly with corresponding tissue values for Mg ($r = .334$), P ($r = .232$), and cation ratio ($r = .244$).

Tissue responses.

First tissue samples showed linear response in Ca, Mg, and P to rate of fertilizer applied on Leon fine sand and Lakeland fine sand, 1969. On the latter, K also increased linearly with percent fertilizer applied initially. In both soils, Ca was higher with broadcast applications. In 1970, at this growth stage, Mg decreased linearly and K curvilinearly with increase in percent fertilizer applied to Lakeland soil. On Leon soil, 3% Ca and 5.8% K values were maximum with 30% of the fertilizer applied initially. All above values were higher with broadcast fertilization.

Tissue samples at the early runner stage decreased linearly in Mg but increased linearly in P from the Leon soil. Tissue values for Mg from Lakeland soil were highest where 30% of the fertilizer was applied initially and with broadcast placement.

At the flowering stage, composition of whole above-ground plants (Table 5) showed the effect of percent fertilizer applied initially. There was a linear increase in Ca for Lakeland soil and highest Ca at the 30 percent applicaiton for the Leon soil in 1969. For the latter soil site, P values showed a complex linear and cubic response to percent applied and were higher from the banded fertilizer and the higher rate than broadcast or lower rate. In 1970, these samples from the Lakeland soil showed Ca content to be highest where 70 percent of the fertilizer was applied initially and from broadcast placement. At the lower rate, tissue contained 3.8% K compared to 4.2% K at the higher rate. Plants from the Leon soil, 1970, contained 0.52% Mg from banded compared to 0.46% Mg from broadcast placement. There was a linear increase in K content (Table 5) with increase in fertilizer applied. Phosphorus content showed a similar increase. Cation ratios were not affected by fertilization patterns. Tissue N from the Lakeland site exhibited a cubic response with highest amount from the highest initial application. Note an opposite effect occurred in 1970 for tissue N (Table 5). Note also the high levels obtained from the unfertilized plots. These plants looked healthy and were about one-third as large as fertilized ones but did not flower extensively nor produce marketable melons although several fruit were set on these plots. Apparently variations in growth of fertilized plants at this stage had little effect on fruit yields (6).

Table 5 - Main effect means for plant composition of Charleston Gray watermelons sampled at flowering stage from fertilization patterns and two soils.

Fertilizer 6-8-8 in 3 applications	Plant composition, %				
	Ca	Mg	K	P	N
			Lakeland site, 1969		
% applied	**				
10; 45; 45	2.93	1.62	5.71	0.57	4.18
30; 35; 35	3.29	1.71	5.41	0.59	4.12
50; 25; 25	3.41	1.73	5.45	0.57	4.06
70; 15; 15	3.22	1.61	5.47	0.56	4.12
90; 5; 5	3.49	1.59	5.25	0.57	4.44
Rate					
0	3.15	1.79	4.97	0.55	3.82
1500	3.17	1.66	5.36	0.57	4.25
3000	3.36	1.66	5.54	0.57	4.12
Placement	*	**			
Banded	3.12	1.72	5.48	0.59	4.15
Broadcast	3.40	1.59	5.42	0.55	4.22
			Leon site, 1969		
% applied	*			**	**
10; 45; 45	4.77	1.15	6.10	0.60	4.08
30; 35; 35	5.31	1.09	6.23	0.66	3.69
50; 25; 25	4.92	1.11	6.45	0.63	3.78
70; 15; 15	4.44	1.12	6.51	0.61	3.90
90; 5; 5	4.52	1.17	6.51	0.72	3.66
Rate				*	
0	4.43	1.29	5.94	0.57	4.05
1500	4.82	1.15	6.28	0.62	3.85
3000	4.80	1.11	6.43	0.67	3.79
Placement					
Banded	4.85	1.13	6.31	0.67	3.80
Broadcast	4.78	1.13	6.41	0.62	3.84
			Lakeland site, 1970		
% applied	**		*	*	
10; 45; 45	1.75	0.44	3.94	0.27	2.11
30; 35; 35	2.03	0.40	3.71	0.22	2.00
50; 25; 25	2.12	0.37	4.01	0.23	1.86
70; 15; 15	2.35	0.42	4.11	0.28	1.83
90; 5; 5	2.11	0.38	4.25	0.29	1.77
Rate			*		
0	2.06	0.48	3.24	0.30	1.69
1500	2.01	0.40	3.79	0.26	1.83
3000	2.13	0.41	4.21	0.26	2.00
Placement	*				
Banded	1.94	0.39	4.03	0.25	2.02
Broadcast	2.20	0.41	3.98	0.26	1.81

*Significant at 5% level. **Significant at 1% level. Details in text.

Mature leaf tissue taken 120 days after fertilization showed a few changes in composition attributable to fertilization (data not shown). Tissue from the Leon site, 1969, contained 2.86% K and 0.40% P at the higher fertilizer rate compared to 2.37% K and 0.37% P at the lower rate. In 1970, mature leaves from the Lakeland site increased from 3.1 to 4.6% Ca and from 0.47 to 0.65% Mg as the amount of fertilizer applied initially was increased. Similar tissue from the 1970 Leon site showed no significant influences of fertilizer treatment. Tissue composition at all growth stages correlated poorly with yields (6). This indicated tissue composition was not a reliable way of explaining yield differences from the different fertilizations. During vine growth and fruiting, tissue nutrients were not static but were subject to withdrawal into the fruit and to transfer to new vine growth. Onset of decreasing plant vigor at harvest of fruit also complicated the meaning of the foliar composition.

Since early growth and fruit yield responded to broadcast fertilization and to distributing the fertilizer evenly over three applications, it was surprising to find such poor correlations between soil determination values and yields. This may be explained by the tolerance of watermelon plants to a wide range of soil fertility. Also growth stimulation, as shown by the unfertilized compared to fertilized plants, was a function of quantity of nutrients available. Near the banded fertilizer, soluble salts were several times higher than the same fertilizer spread over much more soil by broadcast placement. Possibly some root injury to high salts did occur and this would not be recognized from the soil or tissue data. From this study, there was an advantage to uniform distribution of fertilizer in the whole bed area coinciding side-dressings *with thinning* and layby operations.

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NEMATODE CONTROL ON POTATOES BY SOIL FUMIGANTS, BAND AND IN-FURROW APPLICATIONS OF CONTACT NEMATICIDES

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ABSTRACT

The effects of soil fumigants and contact nematicides on nematode populations, emergence, yield, quality, specific gravity, and chipping quality of Sebago potatoes were compared during the 1969-70 growing season at Hastings, Florida. Row applications of D-D, Telone, Vorlex, and Dowfume W-85 applied 2 weeks before planting significantly reduced populations of sting (*Belonolaimus longicaudatus*), stunt (*Tylenchorhynchus claytoni*), and ring (*Criconemoides spp.*) nematodes. Yields and emergence were reduced by EDB (4.1 gal/acre in-the-row). Yield differences among remaining fumigants and checks were generally nonsignificant. Telone and D-D applied in another test with off-centered chisels one week before and at planting reduced emergence and yields. Granular formulations of Mocap, Dasanit, Furadan, and Nemacur (formerly Bay 68138) applied at planting both as 12-inch bands and in-furrow, and a liquid formulation of DuPont 1410 applied in 12-inch bands, significantly reduced populations of sting nematodes. Stunt nematode populations were reduced significantly only by band treatment. Yields were significantly increased by in-furrow, but not by band applications of granular materials. Both fumigants and granulars improved tuber quality. Specific gravity and potato chip color were not appreciably affected by any treatment.

Florida Agricultural Experiment Station Journal Series No. 3745.

INTRODUCTION

Several species of parasitic nematodes affect quality and quantity of potatoes produced in the Hastings, Florida area. Galls caused by root-knot nematodes (*Meloidogyne spp.*) can severely affect quality of tubers and drastically reduce crop value. This problem has been minimized by harvesting potatoes before spring temperatures favor rapid development of the parasites. Stubby root nematode (*Trichodorus christiei*, Allen) has been important in the disease cycle of corky ringspot disease as a vector of tobacco rattle virus (7). Resistant potato varieties such as Pungo, Plymouth, and Merrimack have been the best means of combating corky ringspot (2). In addition to *Meloidogyne spp.* and *T. christiei*, soils which have been cropped to potatoes for several years ("old land") have been found to contain high populations of sting (*Belonolaimus longicaudatus*, Rau), stunt (*Tylenchorhynchus claytoni*, Steiner), ring (*Criconemoides spp.*), sheath (*Hemicycliophora spp.*), and lance (*Hoplolaimus spp.*) nematodes. Although little work has been done to define the major nematode problems on potatoes in the Hastings area, striking increases in yield were reported by 2 chemical companies in fumigation tests performed independently by them during 1968-1970 (1, 6). Aside from these tests, nematicides had