EFFECT OF K FERTILIZATION ON YIELD AND LEAF NUTRIENT CONCENTRATIONS OF POTATOES GROWN ON A SANDY SOIL[1]

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Abstract

A large percentage of winter and spring potatoes (*Solanum tuberosum*, L.) grown in the USA is produced in northeast Florida (NEF) on sandy soils with low cation exchange capacity. Maintaining adequate K nutrition is a major concern. A study was conducted on an Elzey fine sand (sandy, siliceous, hyperthermic Typic Humaquept) in NEF to relate yield and leaf K to soil and fertilizer K levels. In 1981, Mehlich-I soil K in the 0-15 cm depth averaged 73 mg/kg. Yields of 35 t/ha were obtained without any K fertilization and no response to K sidedressed at rates up to 70 kg/ha was obtained. In the following three years, soil K prior to fertilization was <40 mg/kg. In 1982 and 1983, significant differences in yield were obtained as a result of K fertilization at planting at rates up to 186 kg/ha. In 1984, no yield differences were obtained with K fertilizer rates ranging from 94 to 280 kg/ha. Differences in maximum tuber yields from year to year were related to the number of growing-degree days accumulated between planting and harvest. Yield-leaf K relationships for leaf samples taken late in the season showed that the critical leaf K concentration for 35 t/ha yields was no more than about 20 g/kg; that for yields approaching 40 t/ha was no more than about 45 g/kg. The results of this study indicated that current K fertilizer recommendations are higher than necessary for the yields being obtained by most NEF potato growers.

Resumen

Un gran porcentaje de papas de invierno y de primavera (*Solanum tuberosum* L.), cultivadas en los Estados Unidos de América, se produce en el noreste de Florida (NEF) en suelos arenosos con baja capacidad de intercambio de cationes. El mantener una adecuada nutrición con *K* es de principal importancia. Se condujo un estudio en arena fina Elzey (un típico Humaquept

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arenosos, silicoso e hipertérmico) en NEF, para encontrar la relación del rendimiento y del *K* foliar con los niveles de *K* en el suelo y en el fertilizante. En 1981, el *K* en el suelo, extraído con Mehlich-I a una profundidad de 0-15 cm, promedió 73 mg/kg. Se obtuvieron rendimientos de 35 t/ha sin ninguna aplicación de *K*, no habiéndose obtenido respuesta alguna al abonamiento potásico con dosis de hasta 70 kg/ha. En los siguientes tres años, el *K* del suelo antes de la aplicación del fertilizante fue < 40 mg/kg. En 1982 y 1983, se obtuvieron diferencias significativas en el rendimiento como resultado de la aplicación de *K* al momento del sembrío, en dosis de hasta 180 kg/ha. En 1984, con dosis de *K* variando de 94 a 280 kg/ha, no se obtuvieron diferencias en rendimiento. Las diferencias, de año en año, en los rendimientos máximos en tubérculos, estuvieron relacionados con el número de grados-crecimiento día (Growing-degree days) acumulado entre siembra y cosecha. Las relaciones entre los rendimientos y el contenido foliar de *K*, para las muestras de hojas tomadas al final de la temporada, mostraron que la concentración crítica de *K* en las hojas, para rendimientos de 35 t/ha, no era sino de alrededor de 20 g/kg, y que para rendimientos cecanos a las 40 t/ha no era mayor de 45 g/kg. Los resultados de este estudio indicaron que las cantidades recomendadas actualmente para fertilizar con *K*, son más altas de lo necesario, para los rendimientos que vienen obteniendo los productores de papa del noreste de Florida (NEF).

Introduction

Potassium is required by plants for translocation of sugars and synthesis of starch. Since potato (*Solanum tuberosum*, L.) tubers are high in starch, this crop has a relatively high requirement for K. The K content of raw fresh tubers has been reported to range from 3.7 to 5.4 g/kg depending on the season, the cultivar, and the rate and timing of N and K fertilization (2, 9).

Myre, *et al.* (18) obtained yields of 35 to 40 t/ha in NEF using only 66 kg K/ha at planting plus another 27 kg K/ha sidedressed at 40 days. However, McCubbin (17) later recommended 108 kg K/ha in conjunction with a seeding rate of 2.8 t/ha for NEF potatoes grown on sandy soils. Neither of these studies attempted to relate the K fertilizer response to initial soil test K level. MacKay, *et al.* (15) found that potato yields were poorly correlated with either exchangeable soil K or K saturation for soils in Nova Scotia. The authors reported that near maximum yields were obtained with 168 kg K/ha, regardless of soil K level. Giroux and Lierop (8) stated that statistically significant yield increases occurred on soils in Quebec only when exchangeable K was <140 kg/ha. They recommended 175 kg K/ha for these conditions. Others have reported little or no response of potatoes to K fertilization for medium to heavy textured soils with exchangeable K levels at 200 kg/ha or more (4, 14, 24). Harrison, *et al.* (10) obtained a yield response by potatoes on a Hagerstown silt loam when the K saturation increased from 2 to 5%.

Efforts have been made to relate the fertility status of the potato crop to K concentration in various plant parts (6, 14, 16, 24). However, the critical concentration depends on the plant part being sampled and time of sampling. Since the growth rate of potatoes in NEF varies considerably from year to year due to climatological differences, growing degree-days (GDD) (25) may be a good parameter on which to base critical nutrient concentrations. Hartz and Moore (11) obtained a fair correlation between potato yields and a modified GDD parameter. Others have also applied the GDD concept when estimating crop maturity (3, 7, 19, 23) but no attempts have been made to use it for estimating critical nutrient concentrations.

Very little data have been published on the K requirements of potatoes grown on sandy soils in NEF since the late 1950's and none that relates potato yields to soil and leaf K. This paper summarizes the results of a four-year study designed to provide information about those relationships.

Materials and Methods

This study was initiated in 1981 on an Elzey fine sand (sandy, siliceous, hyperthermic, Typic Humaquept) located near Hastings, Florida. The site had been in potato production for more than 70 years and the soil tested very high in P but only medium in K (Table 1). Using commonly accepted definitions of soil test ratings (22), yield responses to fertilizer K but not P would be expected if the ratings are correctly calibrated.

'Atlantic' potatoes were planted 4 Feb 1981 in 8-row plots 9.1 m long with a 102 cm row spacing. Nitrogen at 140 kg/ha and a complete micronutrient mix at 22 kg/ha were applied at planting in two bands 20 cm apart, one on each side of the seed piece. Fertilizer P was not applied since the soil test P value was considered very high (Table 2) and previous studies had shown no response to fertilizer P at these soil P levels (20, 21). Potassium was sidedressed at 0, 23, 47, and 70 kg/ha along with 56 kg N/ha 35 days after planting. These treatments will be referred to as the K81 treatments. The sources of N and K were NH_4NO_3 and K_2SO_4, respectively. The K treatments were arranged in a randomized complete block design with four replications. Leaf samples consisting of the fourth leaf below the bud were taken at 57, 64, 78, and 85 days after planting. The leaf sampled in this study corresponded to the second leaf below the "flat top" as described by Fong and Ulrich (6). Tubers were harvested 104 days after planting.

In 1982, the plots were split and fertilized with either 93 or 186 kg K/ha at planting. These treatments will be referred to as the K82 treatments. A sidedress application of 56 kg N and 47 kg K/ha was made to all plots 35 days after planting. All other fertilizer and cultural practices were the same as those in 1981 except that 28 kg Mg/ha as $MgSO_4$ were included in the

TABLE 1. — *Mean squares from analysis of variance for the effect of K treatments on preplant soil K, tuber yield,, and leaf K near midseason.*

Year	Source of Variation	df	Variable		
			Soil K‡	Yield	Leaf†
1981	Blocks	3	223.53	4.42	0.417
	K81	3	62.53	25.14	1.102**
	Error	9	59.75	10.61	0.101
1982	Blocks	3	8.50	42.17	1.495
	K81	3	56.50	5.62	0.287
	Error (a)	9	28.50	10.31	0.413
	K82	1	4.50	90.56**	5.281**
	K81 x K82	3	45.83	3.20	0.643
	Error (b)	12	96.83	8.08	0.509
1983	Blocks	3	60.66	54.59	0.592
	K81	3	24.00	256.90	0.055
	Error (a)	9	65.11	118.47	0.144
	K82	1	625.00**	2.72	2.066**
	K81 x K82	3	89.00	110.40	0.295
	Error (b)	12	126.33	74.26	0.207
	K83	1	16.00	734.41**	34.368**
	K83 x K81	1	25.00	40.25	0.147
	K83 x K82	3	40.00	8.26	0.000
	K83 x K81 x K82	3	14.33	47.56	0.561
	Error (c)	24	26.16	49.26	0.112
1984	Blocks	3	139.17	65.73	0.003
	K84	7	31.35	35.38	0.012*
	Error	21	59.92	32.13	0.004

*, ** indicate that treatment effects were significant at the 5 and 1% level, respectively.
† Data correspond to leaf samples taken at 64, 61, 65, and 61 days after planting in 1981, 1982, 1983, and 1984, respectively.
‡ Soil samples were taken before fertilizer was applied in the indicated year.

TABLE 2. — *Preplant soil test values and rainfall data for the potato study near Hastings, Florida.*

Year	pH	Mehlich-I Extractable Nutrient							Rainfall‡
		P	K	Ca	Mg	Cu	Mn	Zn	
		mg/kg							mm
1981	5.7	274VH†	73M	590	51H	4	3	7	1037
1982	5.8	304VH	34L	614	37H	4	3	8	1095
1983	5.9	272VH	32L	702	60H	—	—	—	1711
1984	6.4	333VH	39L	782	68H	3	4	8	1740

† Soil test ratings: VH-very high, H-high, M-medium, L-low.
‡ Cumulative rainfall for the last 11 months of the preceding year plus January of the indicated year.

fertilizer at planting. This was considered necessary because of the drop in soil test Mg between 1981 and 1982 (Table 2) and the desire to insure that Mg did not become limiting during the season. Leaf samples were taken at 45, 54, 61, and 75 days and tubers were harvested 102 days after planting.

In 1983, the plots were again split and fertilized with either 0 or 183 kg K/ha at planting. These treatments will be referred to as the K83 treatments. All other fertilizer and cultural practices were the same as in 1982. Leaf samples were taken at 58, 65, and 72 days and tubers were harvested 105 days after planting.

In December, 1983, dolomitic lime at the rate of 3.4 t/ha was applied uniformly to all plots. Because of the low residual effects of K fertilization at this site, the split-plot design was abandoned and a randomized complete block design was again used in 1984 in order to evaluate the effects of a wider range of K fertilizer rates. The following K treatments were applied: 47, 93, 140, 186, and 233 kg/ha at planting plus 47 kg K/ha sidedressed 35 days later and 93, 140, and 186 kg K/ha at planting plus 93 kg K/ha sidedressed 35 days later. These treatments will be referred to as the K84 treatments. Nitrogen at 56 kg/ha was included in the sidedressing. All other fertilizer and cultural practices were the same as in 1981. Leaf samples were taken at 54, 61, 68, 75, 82, and 89 days and tubers were harvested 97 days after planting.

Soil samples were taken from the plant bed in each plot every year just prior to fertilization. The soil samples were air-dried and screened through a 10-mesh sieve. A 5 g sample was then extracted with 20 cm^3 of the Mehlich-I extractant (0.05M HCl+0.0125M H_2SO_4) using a 5 minute shaking period. The extract was analyzed for P, K, Ca, Mg, Cu, Mn, and Zn every year except 1983 when Cu, Mn, and Zn were not measured. The pH of a 1:2 soil-water suspension was measured after a 30 minute equilibration.

Leaf samples were oven-dried at 70 C and finely ground. A 1 g sample was ashed and the ash dissolved in concentrated HCl. The sample was transferred to a 100 cm^3 volumetric flask, brought to volume with deionized water, and analyzed for P, K, Ca, and Mg every year. Copper, Mn, and Zn were determined on leaf samples in 1981 and 1982 only. Leaf K, Ca, and Mg were significantly affected by K treatments every year. Leaf P was never affected by K treatments and leaf Cu, Mn, and Zn were not affected in the two years they were measured. Therefore, only the leaf data for K, Ca, and Mg are presented in the tables. In general, leaf P was in the range of 3 to 5 g/kg at midseason every year; leaf Cu, Mn, and Zn concentrations were in the ranges of 5-20, 150-300, and 60-90 mg/kg, respectively.

The field in which the potatoes were grown was seep irrigated and drained through porous tile spaced 18 m apart and 61 cm deep. The water table was maintained approximately 20 cm below the alleys between rows throughout the season. The K concentration in the irrigation water used in this study varied from 10 to 14 mg/L. The soil was fumigated each year for control of nematodes and the crop was treated for disease and insect control as recommended in the current potato production guide for NEF.

Growing-degree days (25) were calculated each year for the period beginning at planting and ending at harvest using the following formula:

$$\mathrm{GDD}=\sum\left[\frac{\text{Daily Temp. Max. }(^{\circ}\mathrm{C}) + \text{Daily Temp. Min. }(^{\circ}\mathrm{C})}{2} - 10\right]$$

Negative values were counted as zero in the summation.

Analysis of variance was conducted on all data using the General Linear Models procedure of the Statistical Analysis System of Barr, *et al.* (1). The data were analyzed as a randomized complete block design in 1981. In 1982, the design was a split-plot with K81 treatments as main plots and K82 treatments as subplots. In 1983, the design was a split-split plot with K83 treatments as sub-subplots. In 1984, the design was treated as a randomized complete block. All possible interactions between K81, K82, and K83 treatments were evaluated where possible. However, no interactions were found to be significant at the 95% level. Therefore, only main effects of the K treatments are discussed in this paper. Results from analysis of variance for soil K, tuber yield, and leaf K concentration near midseason are given in Table 1.

Results

1981: The initial soil test K level was in the medium range (Table 2) according to current soil test interpretations for vegetables grown on sandy soil in Florida (22). A yield response by vegetable crops to fertilizer K at this soil test level is generally expected and 126 kg K/ha plus additional K at sidedressing is currently recommended for potatoes. However, as indicated in Tables 1 and 3, there was no yield response to K sidedressed at rates up to 70 kg/ha.

Potassium fertilization significantly increased leaf K at the first two sampling dates but not at the last two (Table 3). Leaf Mg was decreased significantly by K fertilization at all but the first sampling while leaf Ca was decreased significantly at the last sampling (Table 4). A decrease in Mg concentration in potato leaves as a result of K fertilization has also been reported by others (10, 13).

1982: The K81 treatments had no effect on extractable K in soil samples taken prior to planting in 1982 (Table 1). The soil test K level was low (Table 2) and the K fertilizer rates applied at planting in 1982 were one-half and one times the recommended rate for such situations. There was also no effect of K81 treatments on yield or leaf nutrient concentrations in 1982 (Table 1).

A small but highly significant yield response was obtained for the K82 treatments (Table 1) as well as significant increases in leaf K at all but the first

TABLE 3. — *Effect of K fertilization on leaf K concentrations and potato tuber yields near Hastings, Florida.*

Year	K Treatment	K Rate Planting	K Rate Sidedress	Yield	Sample Number‡ 1	2	3	4	5	6
		kg/ha	kg/ha	t/ha	g/kg					
1981	K81	0	0	35.5	59	28	20	15	—	—
		0	23	33.2	68	34	30	21	—	—
		0	47	36.8	68	35	28	22	—	—
		0	70	35.8	74	41	26	19	—	—
		LSD (.05)		NS	12	5	NS	NS	—	—
		CV (%)		5	9	9	18	21	—	—
1982	K82	93	47	37.4	48	38	42	30	—	—
		186†	47	39.3	52	44	51	45	—	—
		LSD (.05)		1.2	NS	4	6	4	—	—
		CV (%)		4	9	13	15	15	—	—
1983	K83	0	47	25.5	43	47	39	—	—	—
		186†	47	29.1	54	62	55	—	—	—
		LSD (.05)		2.0	2	2	2	—	—	—
		CV (%)		14	9	6	9	—	—	—
1984	K84	47	47	28.2	33	56	43	39	43	36
		93	47	28.0	34	54	44	43	43	37
		140	47	27.8	49	61	56	59	57	52
		186†	47	29.5	66	66	60	68	70	65
		233	47	30.3	68	66	60	69	67	71
		93	93	28.7	49	53	56	55	52	46
		140	93	28.9	59	60	61	65	59	61
		186†	93	31.0	70	66	60	71	70	67
		LSD (.05)		NS	11	10	10	9	11	11
		CV (%)		11	14	11	12	11	13	14

† Recommended K rates at planting based on soil test K level.
‡ Leaf samples were taken 4 times during the growing season in 1981 and 1982, 3 times in 1983, and 6 times in 1984.

sampling (Table 3). The K82 treatments significantly decreased leaf Mg in all four samplings (Table 4).

1983: The K81 treatments had no effect on any soil or plant variable measured in 1983 (Table 1). The K82 treatments resulted in a small but significant difference in soil test K determined prior to planting in 1983 (Table 1). The Mehlich-I extractable K values were 29 and 36 mg/kg for the 93 and 186 kg K/ha treatments, respectively. Both of these values are low and were averaged to give the value shown in Table 2.

The K82 treatments also resulted in small differences (2 to 3 g/kg) in leaf K at all three sampling dates in 1983 but the differences were significant at the second sampling only (Table 1). Leaf K concentrations in the second

TABLE 4. — *Effect of K fertilization on concentrations of Ca and Mg in potato leaves near Hastings, Florida.*

Year	K Treatment	K Rate Planting	K Rate Sidedress	Sample Number‡ 1 Ca	1 Mg	2 Ca	2 Mg	3 Ca	3 Mg	4 Ca	4 Mg	5 Ca	5 Mg	6 Ca	6 Mg
		kg/ha		g/kg											
1981	K81	0	47	5.0	5.7	9.1	10.1	13.7	14.0	15.6	17.4	—	—	—	—
		0	47	4.9	5.3	8.1	8.7	13.4	11.4	15.3	14.6	—	—	—	—
		0	47	4.6	5.0	7.9	8.8	12.5	12.4	14.4	14.5	—	—	—	—
		0	47	5.0	5.2	8.0	7.9	13.3	12.8	14.7	15.0	—	—	—	—
		LSD (.05)		NS	NS	NS	1.3	NS	1.4	0.9	1.3	—	—	—	—
		CV (%)		14	14	8	9	6	7	4	5	—	—	—	—
1982	K82	93	47	4.2	4.3	5.4	5.6	4.9	5.6	9.0	8.5	—	—	—	—
		186†	47	4.3	4.1	5.2	5.0	4.0	4.6	6.8	6.3	—	—	—	—
		LSD (.05%)		NS	0.2	NS	0.4	0.5	0.4	0.8	0.6	—	—	—	—
		CV (%)		12	7	14	10	14	11	13	11	—	—	—	—
1983	K83	0	47	8.8	7.0	9.8	8.8	8.3	8.3	—	—	—	—	—	—
		186†	47	7.4	4.7	8.4	6.3	6.1	5.4	—	—	—	—	—	—
		LSD (0.5)		0.7	0.3	0.6	0.4	0.7	0.6	—	—	—	—	—	—
		CV (%)		-16	10	12	9	19	16	—	—	—	—	—	—
1984	K84	47	47	27.7	24.8	8.3	7.4	9.4	8.6	18.0	17.8	13.6	13.2	19.8	19.8
		93	47	29.5	26.0	8.4	7.4	10.9	9.0	18.1	17.7	13.5	12.1	19.2	20.1
		140	47	25.0	19.1	7.4	6.3	9.4	8.0	16.1	13.5	11.1	9.9	17.1	14.3
		186†	47	22.0	14.6	7.2	5.8	9.0	7.4	13.6	10.8	10.4	8.8	15.1	11.9
		233	47	20.0	13.1	7.0	5.9	7.9	6.6	12.4	9.5	9.9	8.0	13.8	10.8
		93	93	25.5	20.9	6.9	6.3	9.4	8.0	15.9	13.8	11.8	10.2	17.2	15.6
		140	93	22.8	14.9	6.8	5.9	7.9	7.0	13.6	10.6	9.4	7.9	14.6	11.8
		186†	93	19.5	13.2	7.0	5.7	8.8	7.3	12.4	9.4	10.0	8.1	14.1	10.9
		LSD (0.5)		3.7	5.2	1.2	1.0	NS	1.5	2.5	3.4	2.0	2.0	1.9	3.8
		CV (%)		10	19	11	11	14	13	11	18	12	14	8	18

† Recommended K rates at planting based on soil test K level.

‡ Leaf samples were taken 4 times during the growing season in 1981 and 1982, 3 times in 1983, and 6 times in 1984.

sample were 53 and 56 g/kg K for the 93 and 186 kg K/ha treatments, respectively. The K82 treatments had no effect on tuber yields in 1983 (Table 1).

The K83 treatments significantly increased yields (Tables 1 and 3) although the yield levels were considerably lower than in 1981 and 1982. Potassium fertilization also significantly increased leaf K and significantly decreased leaf Ca and Mg at all three sampling dates (Table 3 and 4).

1984: Soil test K was again low prior to planting (Table 2) and a range of K fertilizer rates above and below the currently recommended rate was applied. As indicated in Tables 1 and 3, there were no yield differences among the eight K treatments.

Leaf K increased significantly while both leaf Mg and Ca decreased significantly with increasing rate of K applied (Tables 3 and 4). The behavior of leaf K over time varied with the K rate (Figure 1). At the lowest K rate, the maximum leaf K concentration occurred at the second sampling. The concentration decreased sharply between the second and third sampling followed by a slow decrease for the remainder of the season. At the highest K rate, leaf K was essentially constant over the entire season with the exception of sample three in which there was a drop in concentration coinciding with the sharp drop observed at the lower K rates. The cause for the drop in leaf K at the third sampling for all K rates is not known, but it was probably associated with either the initiation of tuber bulking or with an increase in the bulking rate. The behavior for the other K rates was intermediate between these extremes as indicated by the leaf data for the 140 kg K/ha treatment shown in Figure 1.

Leaf Mg reached a minimum value at the second sampling and generally increased with time for the remainder of the season (Figure 1). This behavior was essentially unaffected by the K rate. Leaf Ca behaved similarly to leaf Mg, reaching a minimum value at the highest K rate of 7 g/kg at the second sampling and increasing to 14 g/kg by the sixth sampling (Table 4).

An orthogonal comparison of the K84 treatment means in Table 3 showed that, for a given total amount of K applied, leaf K concentrations were the same whether 47 or 93 kg K/ha had been applied in the sidedressing.

Discussion

Although annual applications of K to potatoes had been made at this site for many years prior to the start of this study, the soil test K level was low every year but the first. The medium soil K status in 1981 probably resulted from the lower than normal rainfall that occurred at this site prior to sampling in 1981 (Table 2). Although the potential for leaching K was also low in the period preceding 1982, the low soil K status that year probably resulted from the low rates of K applied in 1981 and the relatively high amount of K removal estimated from the 1981 yield levels. It is obvious from

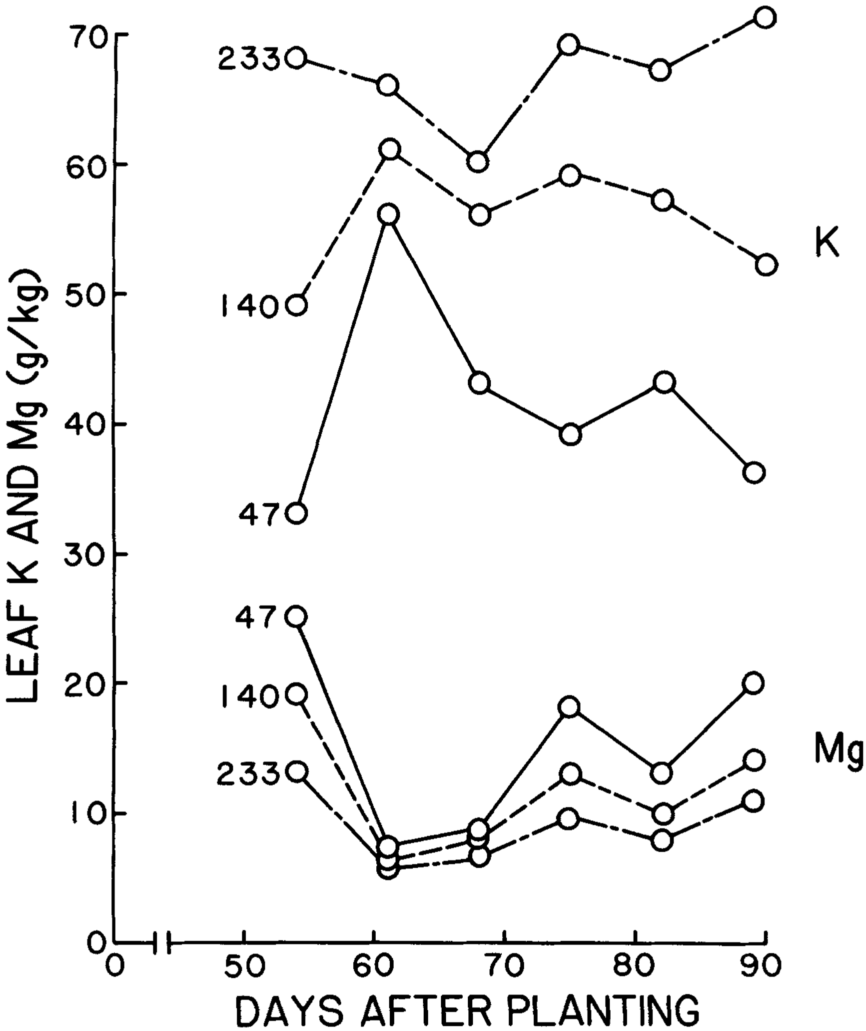

FIG. 1. Concentrations of K and Mg in potato leaves in 1984 as a function of days after planting for three rates of K applied at planting: 47, 140, and 233 kg/ha.

Table 2 that, in years with normal rainfall (i.e., 1700 mm), application of currently recommended K rates to potatoes will do little to increase K reserves in this sandy soil. Extractable K was also low in soil samples taken from beneath the plant beds in 1984 (data not shown), indicating that K was not accumulating in the subsoil at this site.

Lack of response to fertilizer K at this site in 1981 and 1984 suggests that current K recommendations may be too high for the yield levels that are being obtained by most NEF growers. The average potato yield in the

Hastings area for the period from 1981 to 1984 was less than 27 t/ha (5). The medium soil K status in 1981 produced yields of 35 t/ha without any supplemental K fertilization. Current recommendations for this soil K level call for 126 kg K/ha at planting plus additional K in a sidedressing. In 1984, the optimum fertilizer K rate at planting for 28 to 30 t/ha yields on soil with a low K status was no more than 47 kg/ha. The current recommendations call for 186 kg K/ha at planting. The fertilizer K response in 1982 suggests that current K recommendations may be valid only for yields approaching 40 t/ha. Although a significant yield response to fertilizer K occurred in 1983 at yields of 25 t/ha, the 1981 and 1984 data suggest that the 4 t/ha yield response could have been obtained with much less than 186 kg K/ha at planting.

Climatological differences from year to year in NEF, particularly in the early part of the season, can have marked effects on the growth rate of potatoes. Even when planted on the same date each year, a variation of 2 to 3 weeks in the time required for the crop to reach the early bloom stage is not uncommon. Differences in GDD between planting and harvest for the Hastings study are shown in Figure 2. Days on which leaves were sampled and tubers were harvested are indicated in the figure. Temperatures were highest early in the 1982 season, resulting in over 200 more GDD at harvest than in 1983. The data in Figure 3 suggest that tuber yields were correlated with GDD. These data represent the maximum yields obtained during each of the four years of this study plus maximum yields obtained on high fertility plots at this site in 1979 and 1980. Much of the variation in maximum yield at this site in the period from 1979 to 1984 appears to be explained by differences in GDD.

Figure 4 shows leaf K concentrations as a function of GDD for two K rates which had been replicated over time in this study. The soil test K ranged from 34 to 39 mg/kg in each case. From Figure 4, it is apparent that there were large differences in leaf K concentration from year to year for a given fertilizer K rate, soil K status, and GDD. Since K leaches in sandy soil, it might be assumed that the amount of rainfall between fertilization and leaf sampling would explain some of the variation in leaf K among years. The cumulative rainfall received between fertilization and sampling is indicated in Figure 4. It is apparent that these rainfall amounts cannot explain the differences in leaf K since higher rainfall amounts were in most cases associated with higher leaf K concentrations.

The use of GDD appears to be potentially useful when comparing leaf K data obtained over a period of years. This can be seen in Figure 4(B) where leaf K data from 1982 and 1984 are compared. Leaf sampling was initiated 9 days earlier in 1982 because of the warmer weather and more rapid plant growth. However, when leaf K concentrations are compared on a GDD basis, the changes in leaf K with time were very similar for the two years. The same trend appears in Figure 4(A) with the exception of the first

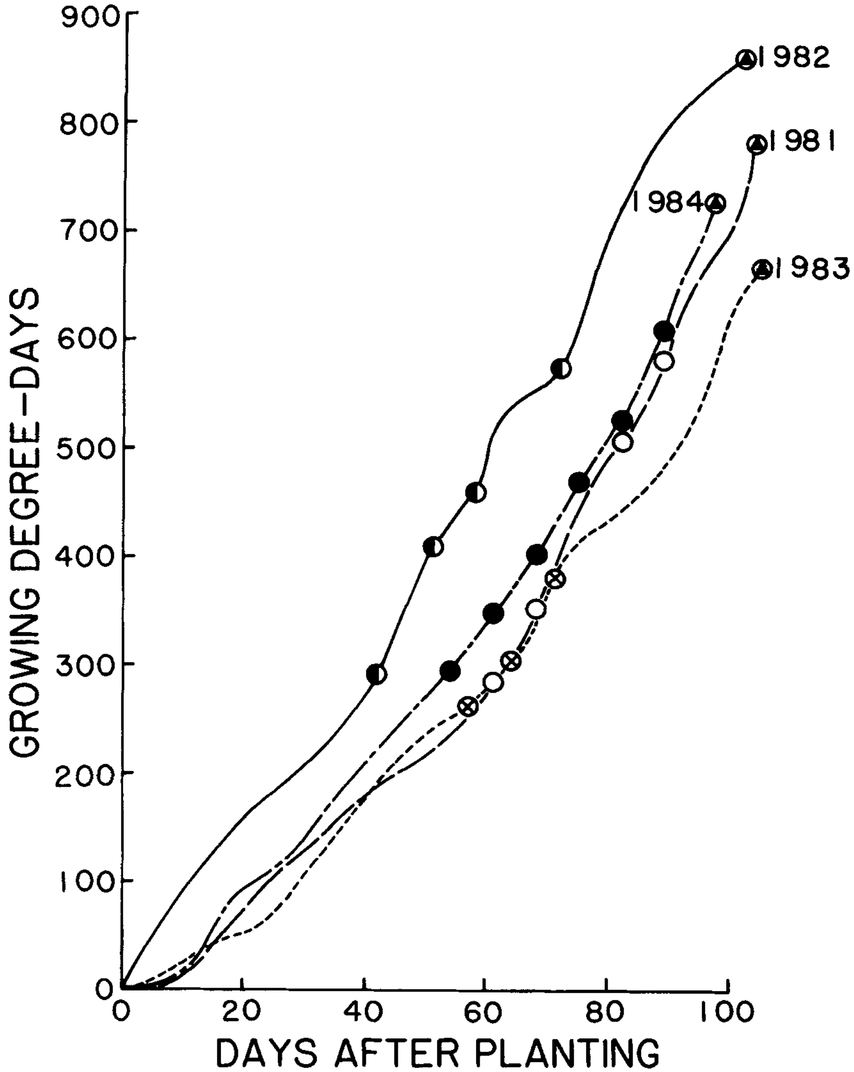

FIG. 2. Accumulation of growing degree-days between planting and harvest for the Hastings potato study. Symbols are used to indicate days when leaf samples were taken (O-1981, ◐-1982, ⊗-1983, and ●-1984) and when tubers were harvested (◓).

sample. The amount of data obtained in this study is insufficient to fully evaluate the potential for using GDD as a basis for comparing leaf K data. However, the results suggest that it is worth investigating further.

Tyler, *et al.* (24) considered leaf samples taken late in the season to be indicative of the K status of the potato crop. In order to determine whether a

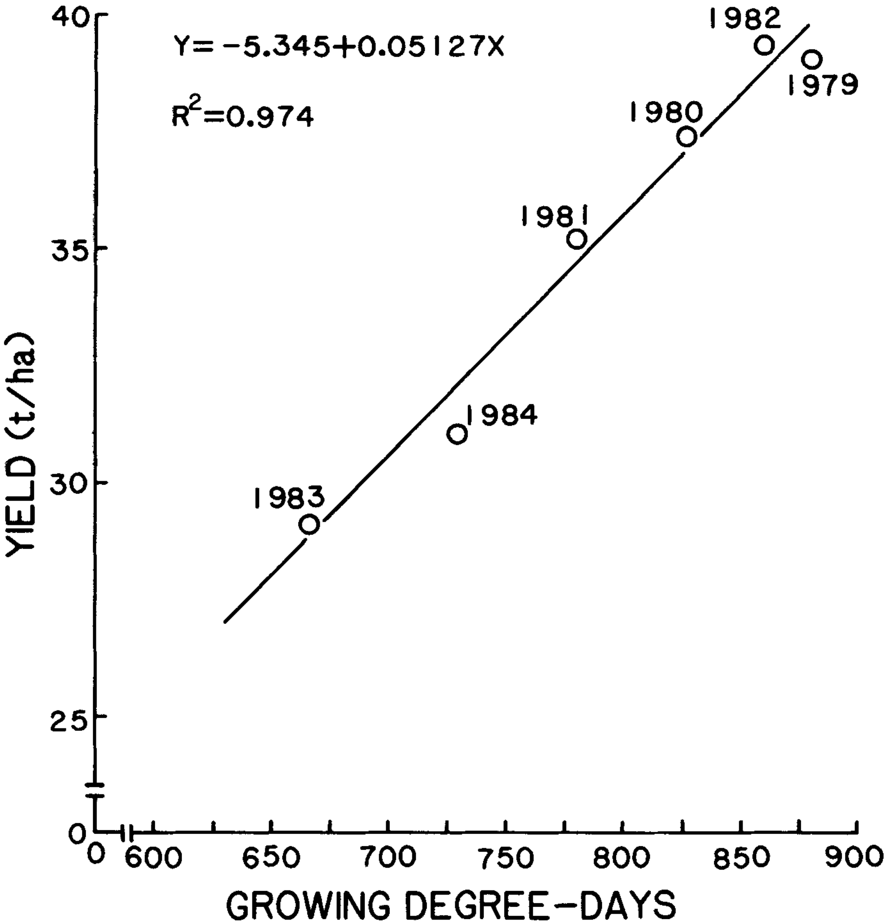

FIG. 3. Relation between maximum potato tuber yields and growing degree-days during a six year period at the Hastings potato site.

critical leaf K level could be determined from this study, yields were plotted against leaf K concentrations measured around 600 GDD (Figure 5). This corresponded to sample 4 in 1981 and 1982, and sample 6 in 1984 (Figure 2). The results show that yields were obviously not limited by K in 1984 since leaf K concentrations late in the season were generally higher than those measured in 1982 when yields approached 40 t/ha. The 1984 yields were obviously limited by other factors, the most likely of these being the number of GDD. Since GDD appears to have limited the yield response to K every year, with the possible exception of 1982, critical values for leaf K cannot be evaluated from these data. However, it is apparent from Figure 5 that the critical leaf K concentration for 35 t/ha yields is no more than about 20 g/kg

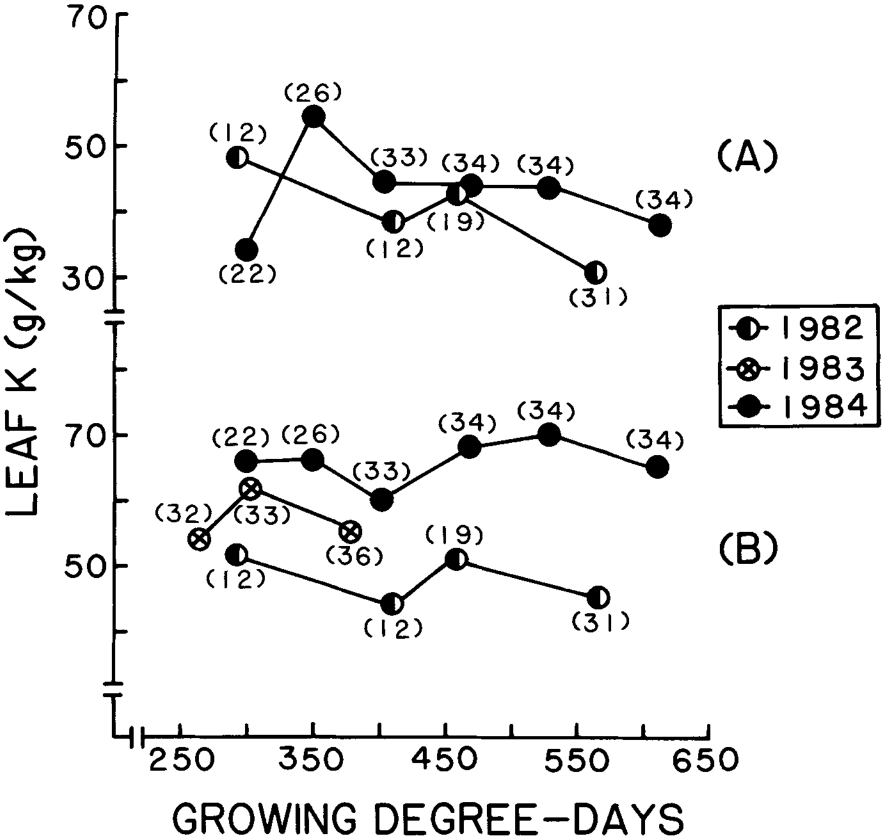

FIG. 4. Concentrations of K in potato leaves as a function of growing-degree days for two rates of K (A) 93, (B) 186 kg K/ha at planting. Both treatments included an additional 47 kg K/ha as sidedressing. Numbers in parentheses are the cumulative rainfall (cm) received between planting and sampling.

and, for yields approaching 40 t/ha, it is no more than about 45 g/kg. It is possible that higher yields would be obtainable at these leaf K levels if other factors such as GDD were not limiting. The yield-leaf K relationship in 1984 also supports the contention that current K fertilizer recommendations for potatoes in NEF are higher than necessary for the yields obtained by most NEF growers. The currently recommended K rates produced leaf K concentrations in 1984 in excess of 60 g/kg (Table 3).

The fact that K fertilization was often associated with a decrease in leaf Mg in this study suggests that Mg may have affected the yield response to K. However, the 1982 results suggest that Mg was not a limiting factor at any time in this study. In that year, both the highest yields and the lowest leaf Mg concentrations were obtained (Tables 3 and 4). Thus, lower yields were

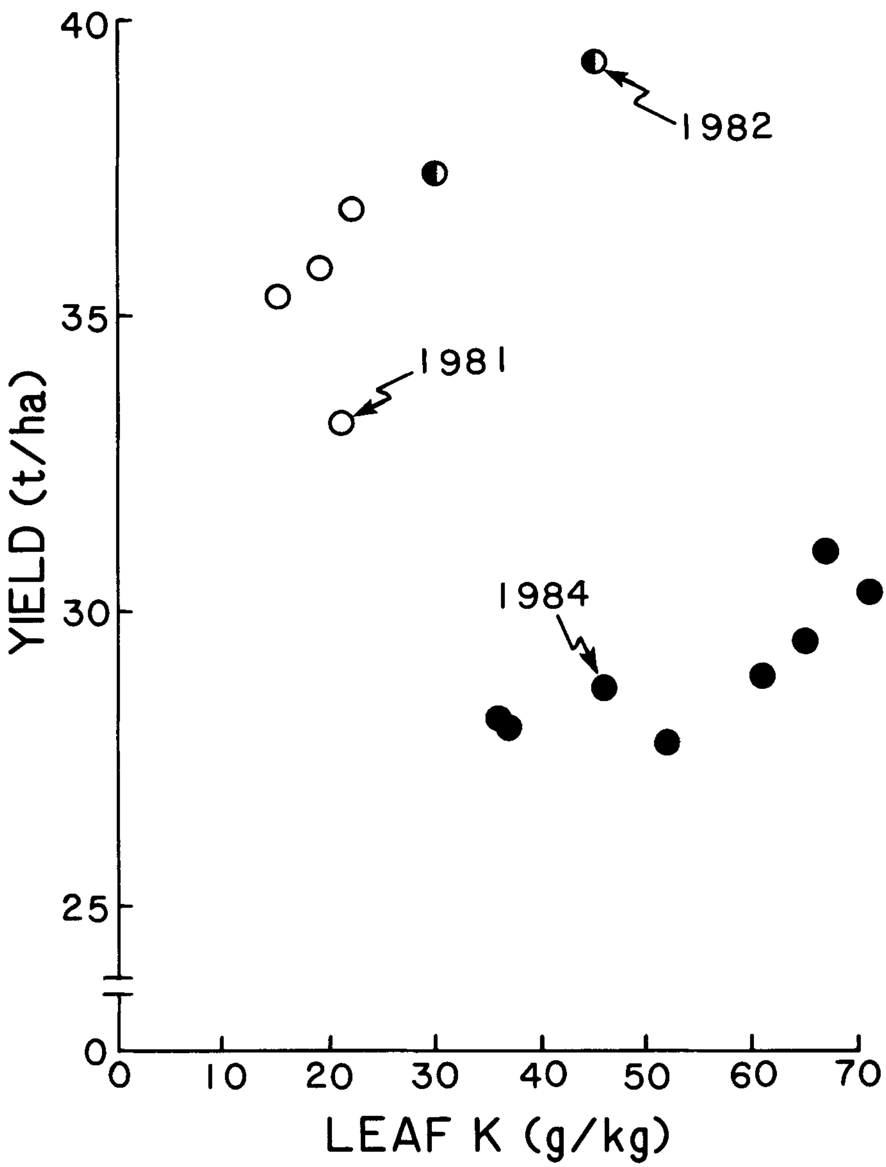

FIG. 5. Yield as a function of leaf K concentration measured around 600 GDD.

always associated with leaf Mg concentrations above the 1982 levels. Furthermore, leaf Mg concentrations were well above the 1.5 g/kg level in petioles that Hossner and Doll (13) associated with Mg deficiency in potatoes. They found that the Mg concentration in petioles increased with time in non-deficient plants while it decreased in deficient plants. Leaf Mg increased during the latter half of the season every year of this study (Table 4), further indicating that Mg was not a limiting factor. Holmes (12) found that, on soils giving a yield response to fertilizer Mg, K induced Mg deficiencies in potatoes were rare and were observed only with very high K rates.

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