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Fertilizer and Lime Rates Influence Highbush Blueberry Growth and Foliar Elemental Content During Establishment[1]

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Abstract. Nitrogen and P fertilization increased growth of 1 and 2 year-old highbush blueberry plants (*Vaccinium corymbosum* L., cv Wolcott) at 2 locations in eastern North Carolina. The influence of K upon growth during the years of establishment was not conclusive. Dolomitic lime application prior to establishment raised soil pH from 3.7 and 3.9 to 4.5 and depressed growth.

The influence of treatments upon the foliar contents of N, P, K, Ca, Mg, Fe, Cu, Mn, and Zn was determined. A direct relationship existed between the rate of N, P, or K and the content of these elements in the foliage. The only effects noted from lime application were an increase in P and Ca and decrease in Fe foliar level at one location. Variations in foliar elemental content, induced by treatments, were usually similar at both locations. The level of certain elements in the foliage, however, varied widely with location.

Several studies have been reported concerning the influence of nutrition upon blueberry yield under field conditions. Results of greenhouse nutritional studies with blueberries have also been reported. Recent reviews by Cain and Eck (6) and Ballinger (3) have summarized such data. Most of the data, however, were obtained from studies with controlled greenhouse conditions, or from field plantings, where plant response from the application of specific fertilizer ratios or nutrients was ascertained. In the field Beckwith (4) and Johnston (9) found N alone was not sufficient to significantly increase yield. Beckwith (5) also obtained good responses from the application of 2 different complete fertilizers. The apparent responses from the application of a complete fertilizer of various grades or amounts without systematic comparisons of rates of N, P, and K is of limited value. It does not assure that the optimum level of any element was supplied or that all elements supplied were even needed. Data relative to the influence of variations of N, P, K and lime upon plant growth during the years of establishment and ultimate production are absent. Our study was undertaken to determine the influence of 3 rates of N, P, and K, with and without lime, upon the growth and yield of blueberry bushes from the time of planting through productive years of the plantings. We report here the experimental results during the years of establishment on newly cleared land.

Materials and Methods

Two experiments were initiated in the spring of 1965 on newly cleared and drained land, one in Duplin County and the other in Pender County, North Carolina. Soils at both locations were primarily Leon fine sand (sandy siliceous aeric Haploquod) with the more poorly drained portions of the fields gradating to Lynn Haven find sand (sandy, siliceous typic Haploquod). The soil test results of samples taken prior to treatment application and establishment of the planting for both locations are presented in Table 1.

Table 1. Chemical analysis[a] of soils used in blueberry field experiments.

	Ca	K	Mg	CEC	OM	pH	P
	meq/100 gm soil				%		ppm
Duplin County	.98	.065	.39	15.4	8.2	3.7	3.0
Pender County	.72	.053	.36	11.9	7.1	3.9	2.2

[a]Analysis performed by Soil Test Division, North Carolina Department of Agriculture.

Treatments consisted of 3 levels of N, P, and K from NH_4NO_3, concentrated superphosphate, and KCl respectively, each with or without lime, in factorial combination with 2 replications. A basal rate of fertilization consisting of N-75, P-22, and K-42 lbs/acre was selected to approximate the amount normally used by growers in North Carolina (N-75, P_2O_5-50, and K_2O-50 lbs/acre). Treatments for each element included the basal rate and one higher and one lower rate. The high rate was double the basal rate, the low was 30 lbs. of N/acre and zero for P and K. Only 1/4 of the above rates were applied the first year in split applications and the amount was increased an equal increment each year until the fourth year when the full amount was applied. Sufficient dolomitic lime was applied in the lime treatment and mixed into the soil prior to establishment to raise soil pH from the original 3.7 in Duplin County and 3.9 in Pender County to pH 4.5 at both locations. All cultural practices, except fertilization, were done by the cooperating grower in accordance with the practices normally employed by the grower. Experimental plots consisted of 9 bushes spaced 4 feet apart in the row with 10 feet between rows. Plots were arranged in blocks of 18 as described by Li (10) with 2 replications and separated by a guard bush within the row. One year old 'Wolcott' rooted cuttings were transplanted in March, 1965, and the first of 2 annual fertilizer applications was made in May.

Measurements of growth were made by weighing the prunings removed each winter. The youngest mature leaves were sampled in August each year and elemental analysis determined by the North Carolina State University service laboratory as follows: N by Kjeldahl, P colormetrically by vanadate molybdate, K by flame spectroscopy, and Ca, Mg, Fe, Zn, Cu,

[1]Received for publication May 18, 1970. Paper number 3162 of the Journal Series of the North Carolina State University Agricultural Experiment Station, Raleigh, North Carolina, 27607.

J. Amer. Soc. Hort. Sci. 96(2):184–186. 1971.

and Mn by atomic absorption.

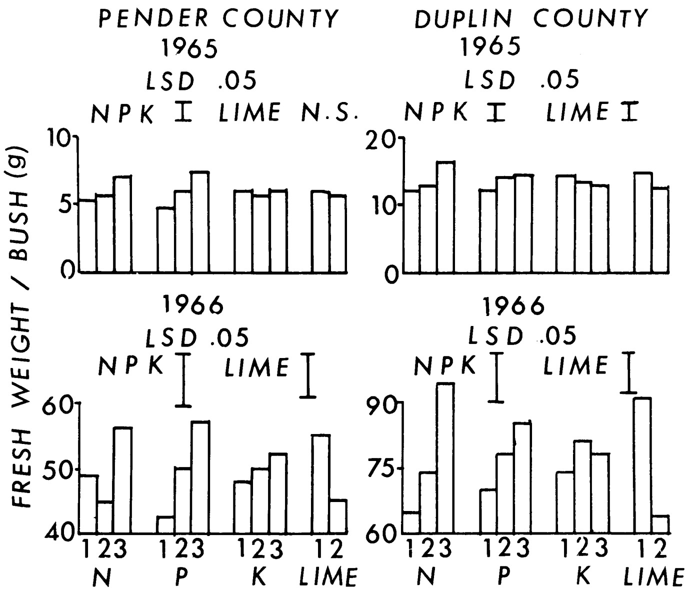

Fig. 1. The influence of N, P, K, and lime upon top growth of blueberries at two locations in N. C. Fertilizer rates 1965 were N 7.5, 12.5, 25; P O, 5.5, 11; K O, 10.5, 21; 1966 rates were N 7.5, 17.5, 35; P O, 11, 22; K O, 21, 42. Both locations limed prior to establishment; Pender County, 1800 and Duplin County, 3000 lbs/A.

Results

Nitrogen and P fertilization increased growth during the first year at both locations (Fig. 1). The application of lime resulted in a reduction in growth in the year of establishment in Duplin County, but had no influence in Pender County. The response to K was not conclusive and trends varied with location. The differences in weight of pruned wood in 1965 may be attributed to the difference in pruning carried out at the 2 locations. Plants were pruned to ground level in Duplin County while only a small portion of the previous years growth was removed in Pender County.

In the second year (1966), the influence of treatments was similar to those noted the first year except lime application was detrimental to top growth at both locations (Fig. 1).

The influence of treatment upon elemental content of the foliage in most cases was much less than differences that may be attributed to location (Tables 2 and 3).

Nitrogen fertilization resulted in an increase in the foliar level of N, K, and Fe and a decrease in the foliar level of Mn at both locations and in lower Mg levels at one location. The influence of N application upon foliar content of Ca, P, Cu, and Zn varied between locations and was not conclusive.

Phosphorus fertilization increased P foliar levels at both locations and decreased the foliar level of K, Mn, and Cu at one location. The first increment of P lowered the foliar N level at one location, but N content at the high rate of P was not different from that of the low rate. The foliar levels of Ca, Mg, Fe, and Zn were not influenced by P application.

Table 2. Influence of the application of N, P, K, and lime rates upon the elemental content of blueberry foliage in Duplin County, North Carolina (1966).

Fertilizer Rate		N	P	K	Ca	Mg	Fe	Cu	Mn	Zn
Lb/A				%				(ppm)		
N	7.5	1.44	.081	.25	.32	.124	48	9.8	119	13.4
	17.5	1.50	.086	.26	.31	.109	51	7.7	113	11.5
	35.0	1.55	.080	.30	.31	.111	58	8.7	91	13.6
P	0	1.54	.077	.30	.30	.118	53	10.4	121	13.5
	11	1.46	.084	.25	.34	.114	53	7.9	117	14.1
	22	1.50	.086	.26	.30	.112	50	7.9	84	10.9
K	0	1.49	.083	.24	.35	.114	48	7.7	119	11.7
	21	1.50	.082	.28	.29	.114	54	9.8	101	12.2
	42	1.51	.082	.30	.31	.115	54	8.7	103	14.7
Lime	0	1.50	.080	.26	.30	.119	54	8.3	99	12.5
	1800	1.50	.084	.28	.33	.110	50	9.2	116	13.2
LSD 0.05 (N, P, K)		.07	.005	.031	.049	.014	8.4	1.8	21.8	3.3
LSD 0.05 (Lime)		NS	.004	NS	NS	NS	NS	NS	NS	NS

Table 3. Influence of N, P, K, and lime rates upon elemental content of blueberry foliage in Pender County, North Carolina (1966).

Fertilizer Rate		N	P	K	Ca	Mg	Fe	Cu	Mn	Zn
Lb/A				%				(ppm)		
N	7.5	1.74	.094	.39	.36	.173	32	9.8	142	22.0
	17.5	1.78	.091	.39	.38	.173	32	10.5	135	21.8
	35.0	1.89	.089	.44	.33	.169	40	9.9	110	22.4
P	0	1.81	.085	.42	.35	.172	35	9.8	136	23.4
	11	1.80	.090	.40	.37	.166	35	10.8	126	22.0
	22	1.79	.098	.40	.36	.178	34	9.7	125	20.8
K	0	1.80	.089	.34	.35	.189	35	9.5	130	24.0
	21	1.80	.093	.42	.37	.171	35	9.9	146	22.1
	42	1.81	.091	.46	.35	.155	34	10.8	112	20.1
Lime	0	1.82	.092	.42	.34	.167	39	9.9	126	21.4
	3000	1.79	.091	.40	.38	.177	30	10.3	132	22.7
LSD 0.05 (N, P, K)		.056	.008	.049	.027	.015	4.4	2.0	26.5	3.69
LSD 0.05 (Lime)		NS	NS	NS	.022	NS	3.6	NS	NS	NS

Potassium fertilization increased K foliar levels at each location, decreased foliar levels of Mg, Mn, and Zn at one location, but exerted little influence on these elements at the other.

Lime application was associated with a decrease in the foliar level of Fe and an increase in P and Ca at one location. In each case there was a trend of a similar influence at the other location. Lime tended to increase foliar levels of other micronutrients at both locations.

Discussion

The influence of N fertilization upon growth as measured by amount of prunings removed was similar at both locations. The only exception was that the response was not linear in Pender County the second year. It was evident that breakdown of soil organic matter was not sufficient to supply the N required for maximum growth and that growth was increased by the use of supplemental N. It is apparent that factors other than level of organic matter must be considered in determining the amount of N supplied by organic matter in these soils.

Soil chemical analysis prior to initiation of the experiment indicated very low soil P values at both locations. Both soils have a very low capacity to retain P. Soil tests can account for only a small portion of the P applied, and laboratory leaching experiments indicate rapid movement of P through them (unpublished data). Low P fixation on Leon fine sands in Florida has been reported by Hortenstine (8). The favorable influence of P upon growth suggests that supplemental P is necessary in these soils for proper plant development during the years of establishment.

The influence of applied K appeared to vary with years at each location and was not conclusive.

The overall influence of lime was detrimental at both locations and supports earlier work by Bailey (1) who reported a 55% reduction in growth from lime application. The pH of 4.1 measured in limed plots after the second growing season was well above pH 3.2 suggested by Merrill (11) to be the lower limit for blueberry growth. The data does not support Harmer's (7) findings of an optimum pH range from 4 to 5.2 and recommendation of liming when the pH was below this range.

The increase in foliar N content resulting from N application observed at both locations was less than expected. The percent increase was less than the increase in growth as measured by weighed prunings. Thus, the total N in the foliage was much greater than indicated by the foliar N content.

The increase in foliar Fe content resulting from N fertilization was evident regardless of the lime application. Based on the available literature, Cain and Eck (6) estimated 60 ppm Fe as the deficiency level for blueberry. All values of foliar Fe concentration in this study were below the estimated deficiency level. From these data one could suggest that by increasing the N application, Fe content of the plant might be increased from a deficient to a sufficient level.

The increase in K level of the plant as N supply was increased was not expected. At the low pH in the plantings most of the available N would probably be in the ammonium form and thus would compete with the K ion for entry into the plant. However, if the K^+ ion was replaced on the exchange complex by the NH_4^+ ion, then this reaction would increase K in the soil solution and result in higher K uptake. The decrease in Mn at both locations could be explained by dilution associated with the increased growth resulting from N application. Variations in the level of Fe and other elements resulting from N application cannot be accounted for by dilution or competitive ion effects.

The level of P in the plant even after P fertilization was still rather low. However, with the consistent increase in growth resulting from P application, the total content of P would be somewhat greater than indicated by percent P. The tendency of foliar Zn content to decrease from P fertilization was similar to that noted with other crops (12). Whether the decrease in Mn at both locations and of Cu and K at one location should be attributed to dilution resulting from the increase in growth or as a direct relationship to P supply requires further study.

Changes in the content of cations induced by K fertilization were as expected for K foliar levels at both locations. However, at one location K application depressed foliar Mg, but not Ca, while at the other Ca, but not Mg, was depressed. The foliar content of each of these elements is near or below the estimated deficiency level for blueberries (6). The failure of K fertilization to lower the Mg content in Duplin County may be related to the low elemental contents of cations in the foliage. However, the facts that the cation content of blueberry foliage is much lower than that of other crops (2) and that they are grown on soils in which the cation exchange capacity is predominantly a pH-dependent rather than a permanent charge may also influence the relative availability and ultimate uptake of these ions.

The effect of K application upon Mn foliar content was similar to that observed from the application of N and P. Since growth was not increased to the extent that it was with N and P, dilution could not account for the decrease. More information is needed on the influence of treatments upon Mn content. The decrease in Zn levels at one location contrasts sharply with the trend for K application to increase Zn at the other location.

The detrimental influence of lime upon growth was not accompanied by consistant changes in foliar element contents; with the exception of Fe, lime application tended to increase the foliar content of micronutrients. Previous work in similar soils (13) showed an increase in Cu foliar content as a result of lime application, probably associated with an increased rate of organic matter breakdown and resultant increase or release of Cu. However, with an increase in pH the availability of the micronutrient would probably be decreased. Thus, the level of a given micronutrient in the foliage would be dependent upon the inherent supply in the soil, its rate of release from organic matter breakdown, and its availability after release as influenced by pH or other factors.

It is apparent that elemental content varied widely with location and was also greatly influenced by treatments. It is also evident that slight differences in soils may change the nature of the response to a given treatment. Finally, the differences in cultural practices used by the cooperating growers may have influenced the foliar content of individual elements and also their relationship to each other.

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