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EPA

Agricultural NPS Control of Phosphorus in the New York State, Lake Ontario Basin

Volume II — Fertilizer Trials on Organic Soils in the Lake Ontario Drainage Basin

FOREWORD

The U.S. Environmental Protection Agency (USEPA) was created because of increasing public and governmental concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimony to the deterioration of our natural environment.

The Great Lakes National Program Office (GLNPO) of the U.S. EPA was established in Chicago, Illinois to provide specific focus on the water quality concerns of the Great Lakes. The Section 108(a) Demonstration Grant Program of the Clean Water Act (PL 92-500) is specific to the Great Lakes drainage basin and thus is administered by the Great Lakes National Program Office.

Several demonstration projects within the Great Lakes drainage basin have been funded as a result of Section 108(a). This report describes one such project supported by this office to carry out our responsibility to improve water quality in the Great Lakes.

We hope the information and data contained herein will help planners and managers of pollution control agencies to make better decisions in carrying forward their pollution control responsibilities.

Director
Great Lakes National Program Office

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AGRICULTURAL NONPOINT SOURCE CONTROL OF PHOSPHORUS IN THE NEW YORK STATE LAKE ONTARIO BASIN

VOLUME 2. FERTILIZER TRIALS ON ORGANIC SOILS IN THE LAKE ONTARIO DRAINAGE BASIN

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D I S C L A I M E R

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ABSTRACT

There are approximately 2.3 million hectares of cropland in New York. Cultivated organic soils comprise about 12,000 hectares or 0.5% of the total cropped land. The organic soils are used exclusively for intensive vegetable production with onions being the primary crop. About 50% of these soils are located within the Lake Ontario drainage basin. Unlike their mineral soil counterpart, there is essentially no soil test correlation data for use in estimating the fertilizer requirements of crops grown on organic soils. Hence, growers apply fertilizer based on recommendations that are not well correlated with crop response. The excessive use of fertilizer, coupled with elevated nutrient levels in the soil will result in poor nutrient utilization, an increase in nutrient enrichment of drainage water, and an economic loss to the farmer.

A comprehensive field study was conducted to evaluate the yield response of onions across a broad range of N, P, and K fertilizer inputs and to correlate the level of response with soil testing parameters. A primary objective was to develop an estimate of P loss in drainage water to the Lake Ontario drainage basin and how this loss is influenced by P fertilizer management.

Two years of research data at 12 different locations showed that the probability of obtaining a yield increase greater than 5% due to added N, P, K, or micronutrient fertilizers occurred in 70, 43, 57, and 20 percent of the cases, respectively. A first approximation of the soil test level for P and K, above which a fertilizer response is unlikely, was 80 and 260 ppm, respectively.

Estimates of field losses of P to the Lake Ontario drainage basin in 40 cm of tile drainage water ranged from 8 to 19 kg/ha as the soil test P level increased from 40 to 100 ppm. If average field losses were 16 kg/ha/year, then roughly 96 mt of P would be lost from cultivated organic soils in the Lake Ontario drainage basin. However, this number may be useless in estimating P loading into Lake Ontario because the transport mechanism between the field and lake is not well understood.

Farmers would be eager to improve their fertilizer management if a change would benefit them economically. Farmers are concerned about environmental quality, and they would be willing to make sacrifices to improve water quality even if a change could not be economically justified. However, before changes are made they must be assured that a shift in management will have a beneficial effect and others outside of the farming community are sharing proportionately in the cost for improvement.

A concentrated research program will have to be maintained in order to develop an adequate data base for determining economic fertilizer rates and to define the transport mechanism of P movement in water courses.

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ACKNOWLEDGEMENTS

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SECTION 1.

INTRODUCTION

New York State has approximately 240,000 hectares of organic soils, 12,000 of which are developed for intensive vegetable production. New York vegetable production ranks favorably on the national level in production and diversity as well as in its reputation to provide consumers with high quality products. Recently, the farmers ability to remain competitive has been challenged by economic and environmental constraints; namely, an unfavorable ratio of production cost to product value and social pressures for improved water quality from agricultural watersheds. Agricultural scientists are equally challenged to develop crop production systems that reduce input costs, increase yield and crop quality, and maintain environmental compatibility.

One of our current interests is to increase the efficiency of nutrient utilization by vegetables grown on organic soils. The traditional method of applying fertilizer on these soils is to preplant broadcast all of the N, P and K and foliar feed micronutrients where necessary. The rate of application is usually not correlated with the probability of a crop response. Growers adhere to this method of application because of familiarity and speed in getting the job done. The practice is not an efficient way to manage plant nutrients, and farmers are reluctant to change unless revised methods prove to be more cost effective.

JUSTIFICATION

Increased fertilizer efficiency on organic soils in the Lake Ontario drainage basin would lead to: a) reduction in phosphorus discharges from muckland into drainage waters, which eventually reach Lake Ontario; a prime concern of the joint agreement between the U.S. and Canada; and b) reduced inputs of N, P and K from fertilizer with less cost to the growers.

The excessive use of P is of special concern because leaching of P can lead to a degradation of water quality in streams and lakes receiving drainage water. Leaching of P from organic soils is several orders of magnitude larger than that from mineral soils. The magnitude of P loss from organic soils depends on the amounts of mineralization and fertilization that has occurred, and on the ability of the soil to absorb P. The farmer has little control over mineralization and soil absorption of P. However, crop recovery of applied P can be markedly increased with improved fertilizer management and result in reduced P discharges to the environment.

Several studies (Duxbury and Peverly, 1978; Erickson and Ellis, 1971; Hortenstine and Forbes, 1972; Miller, 1979) have shown that P concentrations in drainage water from organic soils can approach 10 ppm, with annual losses as high as 30 kg/ha. The magnitude of P loss from organic soils is markedly influenced by the amount of fertilizer added, and the ability of the soil to adsorb P. For soils with iron (Fe) plus aluminum (Al) less than 100 kg/ha (Cornell Soil Test) and with a constant rate of P addition, the available P content of the soil adjusts itself to the rate of fertilization, usually within 3 to 5 years. Iron plus Al control the soil test P values of soils having a sum for these two elements greater than 200 kg/ha. Leaching of P from organic soils is also related to their Fe and Al content (Cogger and Duxbury, 1984).

A minimum safe level of soil-test P for vegetable crop production is considered to be 50 kg/ha; however, the majority of cropped muck soils in New York have values greater than 50. The relationship of the reserve P supplying capacity of a soil to soil pH and to Fe plus Al content has not been investigated and is part of a research program currently being proposed. The inorganic P content of eight soils from the Elba muckland ranged from 35 to 60 percent of the total P (Cogger and Duxbury, 1984), which indicates the importance of understanding how the inorganic pool behaves with respect to P release.

Present fertilizer P additions are usually around 50 kg/ha (about 100 kg P_2O_5). Mineralization of soil organic P is in the range of 20 to 50 kg/ha of P per year depending on the organic P content of the soil. Crop removal of P is about 25 kg/ha for onions, so the sum of P added and that mineralized is about three times that needed by the crop.

Although the primary focus of this study was directed towards P, excessive additions of N and K can also lead to enrichment of drainage water with these elements resulting in water degradation and an economical loss to the farmer. Demonstration of optimal N, P, K, and micronutrient applications is more likely to result in a lasting change in fertilizer practices by farmers than a study focused on P alone.

OBJECTIVE

The objective of this research program was to ascertain the yield response of onions across a broad range of N, P, and K inputs and to correlate the level of response with soil testing parameters. A second objective was to develop an estimate of P loss in drainage water to the Lake Ontario drainage basin and how this loss is influenced by fertilizer P management.

SECTION 2.

CONCLUSIONS

At present, New York does not have a soil test correlation data base to estimate nutrient requirements of crops grown on organic soils. Hence, growers apply fertilizer based on recommendations that are not well correlated with crop response. A high rate of fertilization, coupled with an elevated nutrient level in the soil, will result in poor efficiencies in nutrient utilization, an increase in nutrient discharge in drainage water, and an economic loss to the grower.

This study showed that the probability of a yield increase (> 5%) due to added N, P, K, or micronutrient fertilizers occurred in only 70, 43, 57, and 20 percent of the cases, respectively. Excessive fertilization in previous years, resulting in high nutrient levels in the soil, was responsible for the low yield response level.

An important aspect of this research program was to begin to develop a soil test correlation data base for formulating fertilizer recommendations that are based on the most current research technology. A first approximation of the soil test level for P and K, above which a fertilizer response is unlikely, was 80 and 260 ppm, respectively (160 and 520 kg/ha by the Cornell soil test index). Fertilizer additions above these levels will result in unwanted nutrient loss. Our estimate of P loss to the Lake Ontario Drainage Basin for an average of 40 cm of drainage water ranged from 8 to 19 kg/ha per year as the soil test P level increased from 40 to 100 ppm. Estimated P loss at the 80 ppm soil test P level was 16 kg/ha.

A rough estimate of P loss from the 6,000 hectares of cultivated organic soils in the Ontario drainage basin is 96 mt (16 kg/ha x 6,000 ha). Unfortunately, this number cannot be directly used for estimating P loading into Lake Ontario because the effects of stream transport between the field and lake on P loading and availability is not well understood.

SECTION 3.

RECOMMENDATIONS

Due to the lack of historic data, the results of this two-year study represent a relatively small sampling of a large population. With broadcast fertilization, our predicted loss of P from organic soils is high at soil test P levels needed for maximum crop production and points to a need for further research in the area of efficiency of fertilizer use. Critical soil test levels, at which there is a low probability of a fertilizer response, must be defined more accurately. Additional data may reveal that a critical soil test level below the established 80 and 260 ppm for P and K, respectively, may be acceptable.

Apart from rates of application, the timing and method of fertilizer placement for enhancing nutrient recycling, across a broad spectrum of soil test levels, needs further documentation. In particular, we believe that a switch from broadcast to banded P application could lead to a substantial reduction in subsoil P levels and P leaching, while maintaining sufficient P in the surface soil for maximum crop production. It may, however, take a 3 to 5 year study to determine that this approach is having the desired effect because of high soil test P levels throughout the soil profiles on almost all of the muck farms in N.Y. On some farms where available P is well buffered, it could take as long as 10 years to reach a new steady state situation after a switch in fertilizer practice is made. Nevertheless, with sufficient data, appropriate management practices can be devised to benefit the grower as well as receiving waters of the state.

A second major need is to adequately define the fate of soluble P after it leaves the farm. All of the drainage water from organic soils in NY State is subject to stream transport before it reaches Lake Ontario. The effect of stream transport on the loading and bio-availability of P reaching Lake Ontario must be established in order to assess the real impact of a reduction in P loss from the farm or water quality in the lake.

An approximation of the cost of a research program to accomplish the fertilizer management objectives is on the order of 1.0 to 1.5 million dollars over the next ten years. Identifying nutrient transport phenomena would likely cost at least as much. If it were well documented that the P in drainage water from organic soils reaches Lake Ontario in bio-available form the reduction in P loading to the lake by elimination of agricultural use of much soils would be well known and unquestioned. By this statement, we mean that essentially zero loss of P from muck soils would result if the muck farms were abandoned and allowed to revert to natural wetlands which were perpetually flooded. This could be accomplished, at least in part, by 1) paying farmers not to farm, or 2) development of programs to transfer the muckland vegetable production to mineral soils where P losses would be very much less.

SECTION 4.

METHODS

Fourteen experimental sites were selected within the Lake Ontario drainage basin. Figure 1 shows the approximate geographical location of these areas and their proximity to the lake. Site selection was made on the basis of obtaining as large a cross section in soil test P values as possible. Secondary consideration was given to obtaining a range in soil pH, K, Al, Fe, and Mn values.

In 1984, twelve of the fourteen sites were used. The following year eleven sites were prepared, nine of which appeared in the exact physical location as the previous year (Table 1). Two sites were lost each year due to crop failures.

Ten fertilizer treatments were applied at each location and replicated three times (Table 2). Nine of the fertilizer rates were designed primarily to evaluate crop response to added P. Various rates of N,K and micronutrients were applied to evaluate crop yields in the presence or absence of fertilizer P. The tenth fertilizer treatment was the farmers rate and thus varied with site. Farmers fertilizer rates are shown in Appendix tables A7-A27. The rate of N shown in Table 2 was higher in 1984 than in 1985 due to the unusually wet weather that occurred after fertilization in 1984. It was felt that N losses due to leaching or denitrification during this period may limit growth, hence, an additional 67 kg/ha N was applied to most of the treatments as an early summer topdressing.

The procedure used to establish each experimental site each year follows: After the field was tilled by the farmer, the experimental area (41 x 18 m) was located from permanent reference points, and the individual plots (4.6 x 6 m) staked. Soil samples were collected from the check, NK, and NPK treatments at depths of 0-25, 25-50, and 50-90 cm. Each soil sample by depth was a composite of four corings and replicated three times. The fertilizer treatments (except the starter rate and micronutrients) were applied by broadcasting. The farmer then broadcast his fertilizer over the remainder of the field and planted onions over the entire field. Two of the cooperating farmers inadvertently applied a summer topdressing of N over our entire plot area. Therefore, some of the N rates in Appendix tables A7-A27 may be different then the standard treatments shown in Table 2. The additional N did not affect our objectives since the primary emphasis was on P.

After onion emergence, the starter fertilizer treatment was applied in a band, placed 5 cm to the side of the row and 4 cm deep. The micronutrient addition (Table 2) was made by injecting the appropriate solution in a band approximately 5 cm to the side of the row and 2.5 cm deep. Sulfuric acid was added to the spray tank to ensure that the micronutrients remained in solution. The final solution contained 0.1 N H_2SO_4.

In 1985 an additional experiment (Table 1, location 15) was established to focus more closely on the effect of P placement on onion yield in the presence of adequate N and K. Three rates of broadcasted P were applied prior to planting at rates of 0, 135 and 270 kg/ha of P_2O_5. At the same time, 85 and 170 kg/ha of N and K_2O, respectively were broadcasted over all treatments. The plots were then harrowed and planted with onions.

Immediately after emergence, fertilizer P was applied in a band 5 cm to the side of the row and 4 cm deep at a rate of 0, 22, 44, or 88 kg/ha of P_2O_5 applied factorially over each broadcasted rate. An additional 85 kg/ha of N was topdressed over all plots. The micronutrient mix described in Table 2 (excluding Fe and Mn) was band applied to all treatments.

Soil samples taken from all locations were analyzed for pH, P, K, Ca, Mg, Fe, Mn, and Al by adding 5 g of soil to 50 ml of a sodium-acetate extract buffered at pH 4.8 (Greweling and Peech, 1965). Results were reported in micrograms of nutrient per gram of soil (ppm on a weight basis). Selected samples were analyzed in 1984 for boron (B) by hot water extraction and P by water extraction. Bulk density samples were collected from each location in 1984.

The farmers maintained normal cultural practices in the plot area in terms of weed and insect control. Crop growth was monitored throughout the growing season. 9.75 m of row (four rows 2.4 m long) was harvested from each of the treatments. The harvested sample was graded, weight recorded, and dry matter determined. Onion yields were adjusted to ten percent dry matter. In 1984, yield included bulbs equal to or greater than 1.87 cm and in 1985 yield was calculated to include bulbs measuring greater than or equal to 4.2 cm in diameter.

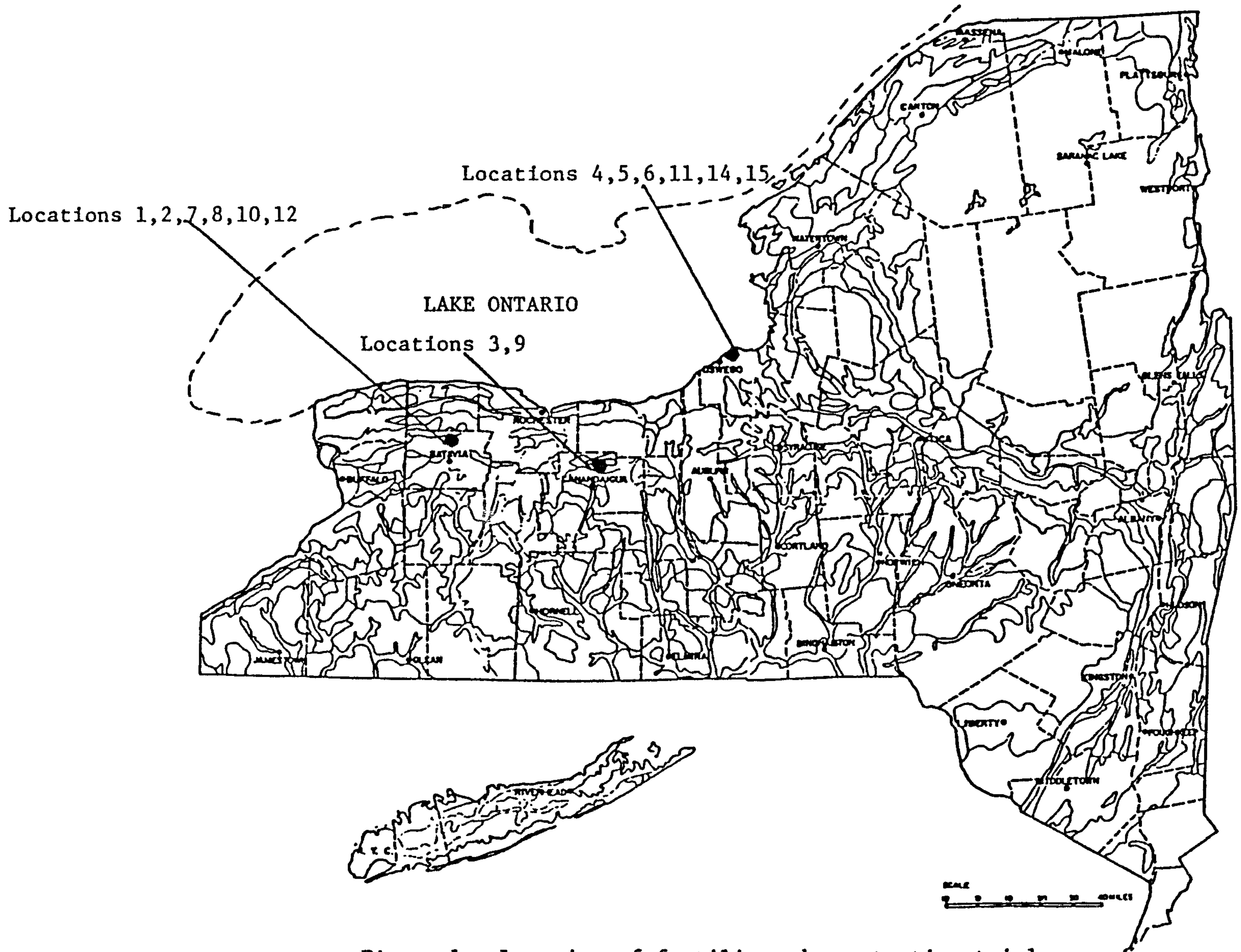

Figure 1. Location of fertilizer demonstration trials, 1984-85.

Table 1. Experimental locations.

Location Nos.	Farm	Year(s)	Area
1	Grinell-West	84,85	Elba
2	Grinell-East	84,85	Elba
3	Sacheli	84	Potter
4	Coulter-Old	84,85	Oswego
5	Jacobson	84,85	Oswego
6	Jacobson-Bonocorsi	84,85	Oswego
7	Kasmer	84,85	Elba
8	Smith	84,85	Elba
9	Palermo	84	Potter
10	Baldwin-Pops	84,85	Elba
11*	Coulter-New	84	Oswego
12	Baldwin-Shellar	84,85	Elba
14*	Coulter-New	85	Oswego
15	Coulter-P	85	Oswego

*Newly cleared muckland locations 11 and 14 were in the first and second year of production, respectively.

Table 2. Fertilizer treatments for 1984-85.

Treatment	1984 Fertilizer rate, kg/ha			1985 Fertilizer rate, kg/ha		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
1	0	0	0	0	0	0
2	13	13	13	13E	13	13
3	67E*	0	0	0	0	0
4	67L	0	0	67E	0	0
5	0	135	67	0	135	67
6	67E + 67L	0	67	67E	0	67
7	67E + 67L	135	0	67E	135	0
8	67E + 67L	135	67	67E	135	67
9	67E + 67L	135	67+M**	67E	135	67+M**
10	Farmers Rate			Farmers Rate		

*E = early, preplant L = late, onions ≅ 4 cm tall

**M = micronutrients in kg/ha

1. soil pH 5.8-6.3 : Fe=3, Mn=6, Cu=2, Mo=0.5, Zn=3, B=0.1
2. soil pH < 5.8 : Fe and Mn not added
3. soil pH > 6.3 : Mn increased to 11

SECTION 5.

RESULTS AND DISCUSSION

SOIL ANALYSIS

The initial 1984 soil test levels at each location were generally favorable for crop production with the exception of a low P value at site 11 in 1984 (Appendix tables A1-A3). Although our intent was to establish fertilizer trials across a broad range of soil test levels, it was difficult to find areas with low nutrient levels because of the liberal amounts of fertilizer applied by the farmers in the past.

The differences in the initial (1984) soil test values among plots at a given site were small. This was expected since the soil samples were taken prior to our fertilizer application and were essentially replicates. Differences in soil test values between locations reflect the varying fertilizer practices used by the cooperating farmers in the past. Soil test values for soil samples collected in 1985 (Appendix tables A4-A6) did not necessarily reflect the fertilizer treatments applied in 1984. This is not surprising since soil testing does not usually detect short-term changes but rather long-term trends, i.e., the soil has some capacity to buffer nutrient levels in the short-term.

YIELD RESPONSE

Onion yields at each location are shown in Appendix tables A7-A16 for 1984, and in Appendix tables A17-A24 for 1985. These data can be used for comparing yields and bulb size (grade) across a large range in fertilizer rates. Specific crop response, as it relates to soil test levels, will be discussed later.

The spring of 1984 was extremely wet, and farmers had difficulty planting onions on time and in obtaining uniform stands. Due to the large amount of variation experienced among all of the fertilizer treatments in 1984, only two of the 10 locations showed any significant response in yield to changes in fertilizer rate (Appendix tables A7-A16). Significantly greater yields were attained at location 10 from additions of nitrogen and from a combination of N and P at location 11. At the latter location, the quantity of non-marketable onions (less than 4.2 cm in diameter) was greatest where no N was applied. This quantity dropped significantly with the addition of as little as 13 kg/ha of N. Applied P at location 11, resulted in more than a doubling in yield where adequate amounts of N were present.

The 1985 growing season by comparison was very good. However, considerable variation in crop yield still existed between replicates of fertilizer treatments. Onion yield and grade were significantly influenced by N, P, and K at 4 of the 8 locations (Appendix tables A17-A24).

A large cross-section of fertilizer rates were applied on soils that had large differences in initial fertility levels. Therefore, it is not surprising to experience a lot of variation in yield, particularly when there are interactions between N, P, and K. A more appropriate method of analyzing these data would be to focus on the effect that a particular nutrient has on plant growth at various soil test levels. An understanding of the relationship between crop response due to adding a nutrient and the soil test level for that nutrient is important for developing fertilizer recommendations that are economically and environmentally advantageous.

The response of onions to N, P, K, or micronutrient additions when the element in question is accompanied by addition of an adequate amount of the others, is presented in Tables 3, 4, 5, and 6 for 1984 and 1985, respectively. The data in these tables are the singular effects of a nutrient taken from the treatments in Appendix tables A7-A24.

At several locations, N was inadvertently applied as a summer topdress over the plots by the farmer, hence, a zero rate of N is not always present. In almost all cases, yield trend increased and the percentage of small onions decreased at the higher N rate (Tables 3 to 6). However, this increase was only significant in three of the 15 comparisons.

Calculations of the amount of N mineralized annually, based on long-term subsidence rates leads to values in the range of 500-1000 kg/ha of N depending upon soil subsidence rate and N content. This amount is far in excess of crop uptake yet most crops, and all vegetable crops, grown on muck soils in New York respond to N fertilizer additions because the surface soil has been leached free of inorganic N early in the growing season. Young seedlings, with limited root systems, are growing in a volume of soil which contains very little inorganic N, hence the response to fertilizer. As soils warm up and mineralization of soil organic N proceeds, inorganic N accumulates to levels sufficient to sustain maximum crop yield. In general, no crop response is seen in fertilizer N additions made after mid-June. Even so, growers commonly topdress N on onions at the end of June.

With reference to Tables 3 to 6, there was a significant response to adding P in two of the 15 experiments. It is interesting to note that both experiments occurred on the same farm (locations 11 and 14) and appeared on a newly cleared soil. The probability of a yield or grade response was generally greatest at the lower soil test P levels. For an unknown reason, the yield at site 4 in 1984 was reduced when fertilizer P was added. Adding K did not significantly increase yield at any of the locations.

The addition of micronutrients was responsible for a significant yield increase in one of the 15 experiments. In general, most of the soils studied have been treated with micronutrients in the past, therefore, short-term residual effects may be preventing micronutrient responses where one or more of these nutrients are normally required.

Table 3. Response of onion yield and grade to additions of N and P_2O_5, 1984.

	N					P_2O_5						
Location	Treatment $N-P_2O_5-K_2O$ [1]	Yield, t/ha	Grade, % [2] S	M	L	Treatment $N-P_2O_5-K_2O$ [1]	Soil Test, [3] ppm P1	P2	Yield, t/ha	Grade, % S	M	L
4	0-135-67	45.4	40	43*		135-0-67	72	4.7	60.4*	19*	77*	
	135-135-67	46.8	30	61		135-135-67			46.8	30	61	
5	78-135-67	72.9	30	62		212-0-67	68	3.4	63.2	30	61	
	212-135-67	71.1	28	63		212-135-67			71.1	28	63	
8	0-135-67	39.5	30	60		135-0-67	77	5.5	37.7	26	63	
	135-135-67	40.2	21	69		135-135-67			40.2	21	69	
9	28-135-67	33.2	31	55		162-0-67	148	6.9	35.3	33*	56	
	162-135-67	36.0	25	66		162-135-67			36.0	25	65	
10	0-135-67	28.5*	17	73		135-0-67	118	6.9	39.5	13	79	
	135-135-67	41.9	10	78		135-135-67			41.9	10	78	
11	0-135-67	15.8*	30	5*		135-0-67	17	0.6	19.5*	48	8	
	135-135-67	41.2	45	27		135-135-67			41.2	45	27	
12	0-135-67	57.6	25	68		135-0-67	162	8.3	61.3	21	73	
	135-135-67	59.5	24	70		135-135-67			59.5	24	70	

[1] kg/ha.
[2] S = 4.0-5.0 cm; M = 5.0-7.3 cm; L = 7.3+ cm diameter.
[3] Soil test P1 = NaAC extract; P2 = Water extract.

*Denotes a significant difference @ 5% level.

Table 4. Response of onion yield and grade to additions of K_2O and micronutrients, 1984.

Location	K_2O						Micronutrients				
	Treatment $N-P_2O_5-K_2O$[1]	Soil test, ppm	Yield, t/ha	Grade, %[2] S	M	L	Treatment[3] $N-P_2O_5-K_2O$[1]	Yield, t/ha	Grade, % S	M	L
4	135-135-0	378	51.3	28	62		135-135-67-M	46.8	30	61	
	135-135-67		46.8	30	61		135-135-67+M	55.7	32	61	
5	78-135-0	113	64.0	31	59		212-135-67-M	71.1	28*	63*	
	212-135-67		71.1	28	63		212-135-67+M	71.1	38	51	
8	135-135-0	122	36.9	23	68		135-135-67-M	40.2	21	69	
	135-135-67		40.2	21	69		135-135-67+M	40.8	23	65	
9	28-135-0	228	35.9	29	57		162-135-67-M	36.0	25	65	
	162-135-67		36.0	25	65		162-135-67+M	36.5	29	62	
10	135-135-0	372	42.0	7	77		135-135-67-M	41.9*	10	78	
	135-135-67		41.9	10	78		135-135-67+M	44.8	11	78	
11	135-135-0	133	39.0	52	18		135-135-67-M	19.5	45	27	
	135-135-67		41.2	45	27		135-135-67+M	46.3	46	29	
12	135-135-0	515	59.5	22	70		135-135-67-M	59.5	24	70	
	135-135-67		59.5	24	70		135-135-67+M	51.7	23	68	

[1] kg/ha.
[2] S = 4.0-5.0 cm; M = 5.0-7.3 cm; L = 7.3+ cm diameter.
[3] Without (-M) and with (+M) micronutrients.

*Denotes a significant difference @ 5% level.

Table 5. Response of onion yield and grade to additions of N and P_2O_5. 1985.

	N					P_2O_5					
	Treatment[1]	Yield,	Grade, %[2]			Treatment[1]	Soil test,	Yield,	Grade, %		
Location	$N-P_2O_5-K_2O$	t/ha	S	M	L	$N-P_2O_5-K_2O$	ppm	t/ha	S	M	L
1	28-135-67	28.2	52	48	-	95-0-67	103	36.2	42	58	-
	95-135-67	32.9	44	55	-	95-135-67		32.9	44	55	-
2	28-135-67	76.2	53*	47*	-	95-0-67	117	32.4	34	65	1
	95-135-67	32.3	32	66	2	95-135-67		32.3	32	66	2
4	0-135-67	72.1	21	77	2	67-0-67	90	87.9	10	87	3
	67-135-67	82.1	6	78	16	67-135-67		82.1	6	78	16
5	45-135-67	56.1	19	81*	-	112-0-67	76	61.7	21*	79*	-
	112-135-67	59.1	11	89	-	112-135-67		59.1	11	89	-
6	45-135-67	56.3	41	59	-	112-0-67	38	55.5	45	55	-
	112-135-67	67.1	33	67	-	112-135-67		67.1	32	67	-
7	0-135-67	54.7	52*	48*	-	67-0-67	137	63.3	36	64	-
	67-135-67	64.4	42	58	-	67-135-67		64.4	42	58	-
8	0-135-67	37.5	62	38	-	67-0-67	59	36.8	50	50	-
	67-135-67	36.9	51	49	-	67-135-67		36.9	51	49	-
14	0-135-67	37.3*	55	45	0	67-0-67	78	61.0*	27	72	1
	67-135-67	72.4	22	77	1	67-135-67		72.4	22	77	1

[1] kg/ha.
[2] S = 4.0-5.0 cm; M = 5.0-7.3 cm; L = 7.3+ cm diameter.

*Denotes a significant difference @ 5% level.

Table 6. Response of onion yield and grade to additions of K_2O and micronutrients, 1985.

	K_2O						Micronutrients				
Location	Treatment $N-P_2O_5-K_2O$[1]	Soil test, ppm	Yield, t/ha	Grade, %[2] S	M	L	Treatment[3] $N-P_2O_5-K_2O$[1]	Yield, t/ha	Grade, % S	M	L
1	95-135-0	186	26.4	53	46	-	95-135-67-M	32.9	44	55	-
	95-135-67		32.9	44	55	-	95-135-67+M	31.6	41	58	-
2	95-135-0	193	31.8	39	59	2	95-135-67-M	32.3	32	66	2
	95-135-67		32.3	32	66	2	95-135-67+M	30.9	44	56	0
4	67-135-0	285	82.3	8	89	3	67-135-67-M	82.1	6	78	16
	67-135-67		82.1	6	78	16	67-135-67+M	83.7	6	85	9
5	112-135-0	226	56.4	18*	82*	-	112-135-67-M	59.1	11	89	0
	112-135-67		59.1	11	89	-	112-135-67+M	58.9	8	90	2
6	67-135-0	200	63.5	33	67	-	67-135-67-M	67.1	33	67	-
	67-135-67		67.1	33	67	-	67-135-67+M	64.6	34	66	-
7	67-135-0	260	59.7	45	55	-	67-135-67-M	64.5	42	58	-
	67-135-67		64.5	42	58	-	67-135-67+M	59.1	47	53	-
8	67-135-0	73	27.9	55	45	-	67-135-67-M	36.9	51	49	-
	67-135-67		36.9	51	49	-	67-135-67+M	34.3	44	56	-
14	67-135-0	413	59.0	25	75	0	67-135-67-M	72.4	22	77	1
	67-135-67		72.4	22	77	1	67-135-67+M	68.8	23	76	1

[1] kg/ha.
[2] S = 4.0-5.0 cm; M = 5.0-7.3 cm; L = 7.3+ cm diameter.
[3] Without (-M) and with (+M) micronutrients.

*Denotes a significant difference @ 5% level.

SOIL TEST CORRELATIONS

The major objective of soil test correlation studies is to determine the critical soil test level where the addition of the nutrient produces a crop response. Once this level is determined, with a reasonable degree of confidence, the next step is to estimate how much of the nutrient should be added if the soil test value is less than optimal. The amount added should produce economical crop responses and be environmentally acceptable.

Figures 2 and 3 show the relationship between the soil test value for P and K on check plots and the percent yield increase, due to the application of P or K, expressed as a percent of the yield in the check plot. Using a 5 percent yield increase as an arbitrary baseline, a first approximation of the critical soil test values for P and K, above which a crop response is unlikely, is 80 and 260 ppm (ug/g), respectively.

Some refinement is needed in the way the critical level is determined. This is obvious from the outlying data point in Figure 3. In 1985, the yield at location 14 increased 23 percent due to adding fertilizer K at a soil test value of 413 ppm; a contradiction to the previous stated critical level of 260 ppm. The only unusual characteristic of the soil at this location was its low bulk density due to being recently cleared for production. Because muck soils can differ greatly in their bulk density (Table 7), a correction for the weight of soil in a given volume has to be made to weight the soils evenly.

To convert parts per million from a weight per unit weight basis (ug/g) to a weight per unit volume basis (ug/cm^3) use equation (1) and the bulk density measurements in Table 7.

$$ug/cm^3 = ug/g * (BD/.33) \qquad (1)$$

where:

ug/cm^3 = parts per million on a weight per unit volume basis
ug/g = parts per million on a weight per unit weight basis
BD = soil bulk density in gms/cm^3

Using equation (1) to replot the data in Figures 2 and 3 showed that the critical soil test level for P and K remained at 80 and 260 ppm (ug/cm^3), respectively. However, the outlying data point in Figure 3 fell in place after correcting for bulk density (Figure 5). These critical levels should be used with caution because of the limited amount of data used in their development. The soil test values in ug/cm^3 can be multiplied by 2 to convert to an index used by the Cornell soil test laboratory, called lb/ac.

A fertilizer rate experiment for P was established in 1985 to estimate how much P should be added for optimal yield when soil test P was below the critical level. A newly cleared muck soil, in its first year of production was selected because of its low soil P level (location 15). Three rates of P (0, 135, and 270 kg/ha of P_2O_5) were applied as a preplant broadcast application in an attempt to establish three soil test levels at the same location; the initial level plus two elevated levels. Different rates of banded P (0, 22, 44, and 88 kg/ha of P_2O_5) were superimposed over each rate of broadcasted P in order to develop a response curve to banded P at each soil test value. Soil samples were taken prior to the preplant broadcast P application and about 10 weeks later, in mid-row to avoid band placed P, to quantify the change in the soil test level.

Initially, soil test P was higher on the plots which would receive zero P than on the ones which would be broadcast at the 135 and 270 kg rates (Table 8). As expected, ten weeks later P decreased in the zero broadcast treatment and increased at the higher broadcasted rates reflecting the addition of P. Soil pH, Mg and Ca decreased with time but K increased at the later sampling due to the application of 168 kg/ha of K_2O just prior to planting. Ironically, the higher initial soil test levels were associated with the check treatment (zero broadcast P).

Yield response to broadcast and banded P is shown in Table 9. There was essentially no relationship between yield and grade with rate and placement of P. One would have expected a positive and consistent yield increase to banded P at the two lower broadcasted P rates, in light of the critical soil test level established earlier (80 ppm of P). There was undoubtedly a lot of variation in this newly cleared soil perhaps due to micro-environmental effects of past plant and animal life, tree and stump removal, and land smoothing effects on soil mixing and compaction, but the reasons for lack of response to banded P are uncertain.

Table 7. Topsoil bulk density and organic matter content by location, 1984.

Location		Bulk density gm/cm³	Organic matter %
1	Grinell-west	0.44	72
2	Grinell-east	0.41	78
4	Coulter-old	0.28	84
5	Jacobson	0.31	83
6	Jacobson-Bon	0.29	83
7	Kasmer	0.34	81
8	Smith	0.32	84
10	Baldwin-Pops	0.49	75
11,14	Coulter-new	0.20	90

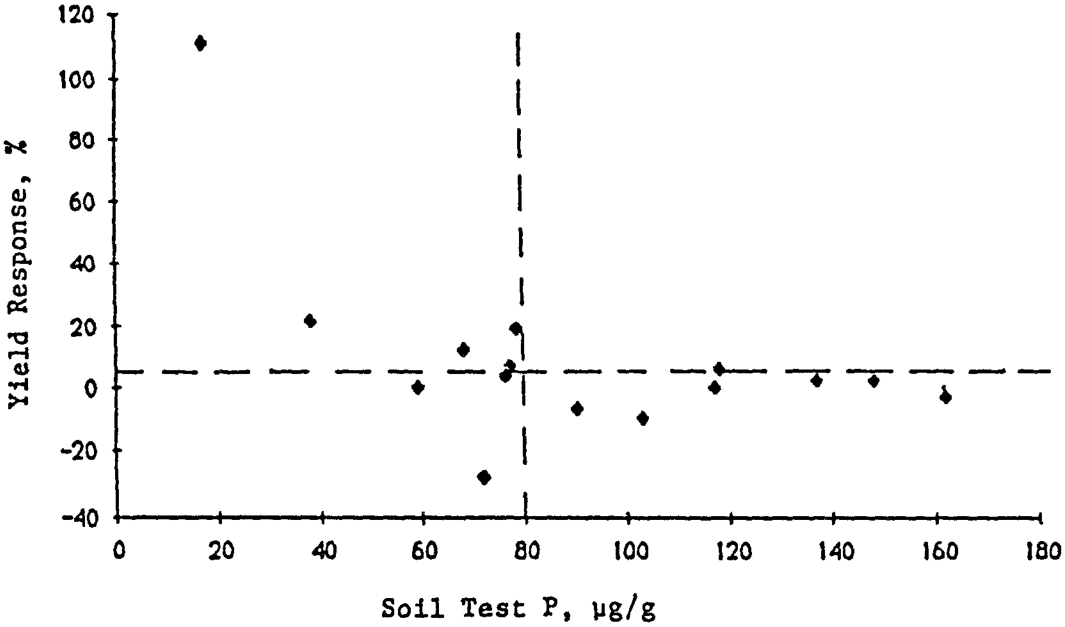

Figure 2. Response of onions to fertilizer P (0 vs 135 kg/ha P_2O_5) at various soil test levels.

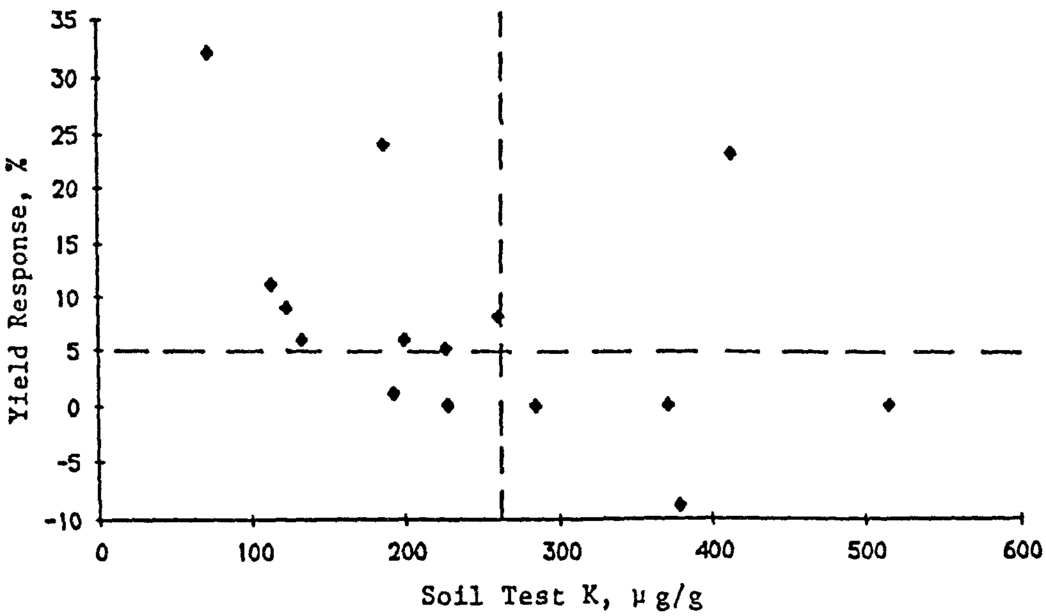

Figure 3. Response of onions to fertilizer K (0 vs 67 kg/ha K_2O) at various soil test levels.

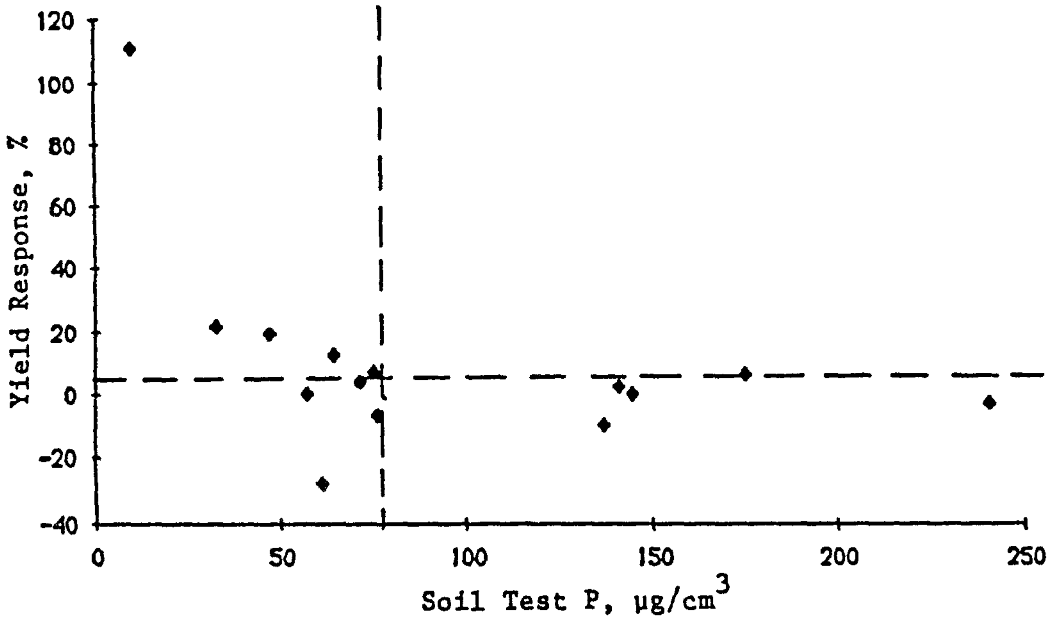

Figure 4. Response of onions to fertilizer P (0 vs 135 kg/ha P_2O_5) at various soil test levels, corrected for bulk density.

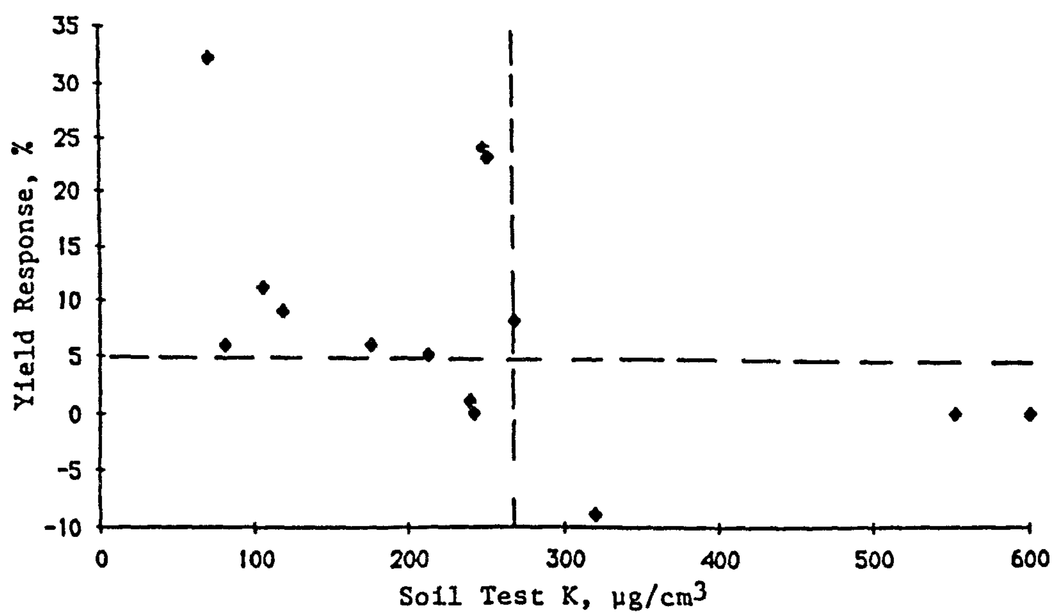

Figure 5. Response of onions to fertilizer K (0 vs 67 kg/ha K_2O) at various soil test levels, corrected for bulk density.

Table 8. Soil test parameters measured before and after a broadcasted P application, 1985.

Treatment P_2O_5, kg/ha	Time[1]	Soil Test Values, ppm pH	P	K	Mg	Ca
0 broadcast - 0 band	May 15	5.7	57	210	1733	8367
	Aug 2	5.1	37	316	1387	7300
135 broadcast - 0 band	May 15	5.6	31	170	1700	7767
	Aug 2	5.2	69	313	1380	7133
270 broadcast - 0 band	May 15	5.5	35	137	1666	7333
	Aug 2	5.2	97	250	1326	7200

[1]84 and 168 kg/ha of N and K_2O respectively, was applied shortly after the May 15 sampling.

Table 9. Yield and grade of onions as affected by P placement, 1985.

P_2O_5, kg/ha Broadcast	Band	Yield, t/ha[1]	Grade, % 4-5 cm	5-7.3 cm	7.3+ cm
0	0	50.5	27	72	1
	22	46.0	31	69	0
	44	41.9	31	69	0
	88	55.7	29	71	0
		avg. 48.5			
135	0	58.2	27	73	0
	22	50.9	30	70	0
	44	59.1	32	68	0
	88	47.4	27	73	0
		avg. 53.9			
270	0	42.6	42	58	0
	22	42.4	30	70	0
	44	47.9	25	75	0
	88	47.2	27	72	1
		avg. 45.0			
	LSD[1]	ns	ns	ns	ns

[1]Least significant difference @ 5% level, ns = not significant.

IMPLICATIONS FOR WATER QUALITY

Soil samples collected in 1984 were analyzed for both sodium acetate-acetic acid (pH 4.8) extractable P (Cornell soil test extractant) and water extractable P. The latter parameter has been shown by Cogger and Duxbury (1984) to be a good indicator of ortho-phosphate P concentration in drainage water from muck soils at high flow, which is when most of the P is leached from organic soils. Figures 6-8 show that the two extractable P parameters are measurably well correlated with each other at each soil depth (R^2 values between 0.60 and 0.79). The linear regression equations also show that the slope of the lines is very similar for all three soil depths. Inspection of the graphs reveals that almost all the outlying data points have values for water-extractable P lower than predicted by the regression equations, and that more data points deviate at the deepest soil depth. These patterns are obtained because sodium acetate-acetic acid extracts more P than does H_2O from those soils that have one or more of the following: 1) free $CaCO_3$, 2) high Fe and Al content, and 3) higher than normal mineral content. We conclude, however, that soil test P is, in general, a good predictor of the P leaching potential for soils and the regression equations obtained can be used to estimate actual P concentrations in drainage water. Soil test P values will overestimate P loss from some soils but importantly, our evidence indicates that soil test P will not underestimate P loss from organic soils.

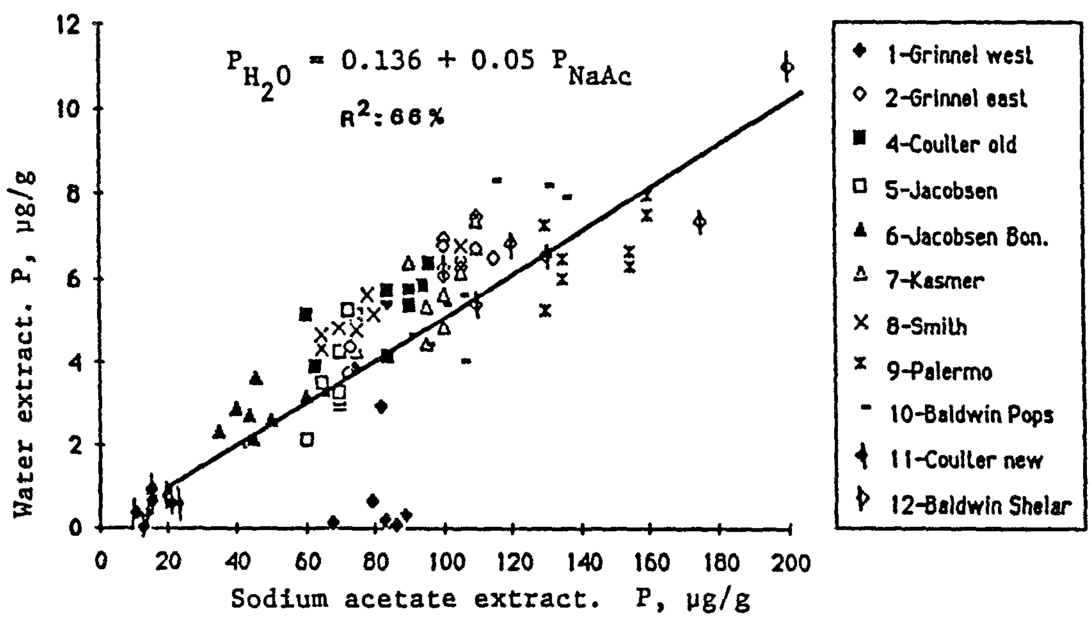

Figure 6. Relationship between sodium acetate extractable soil P and water extractable soil P at the 0-25 cm depth, 1984.

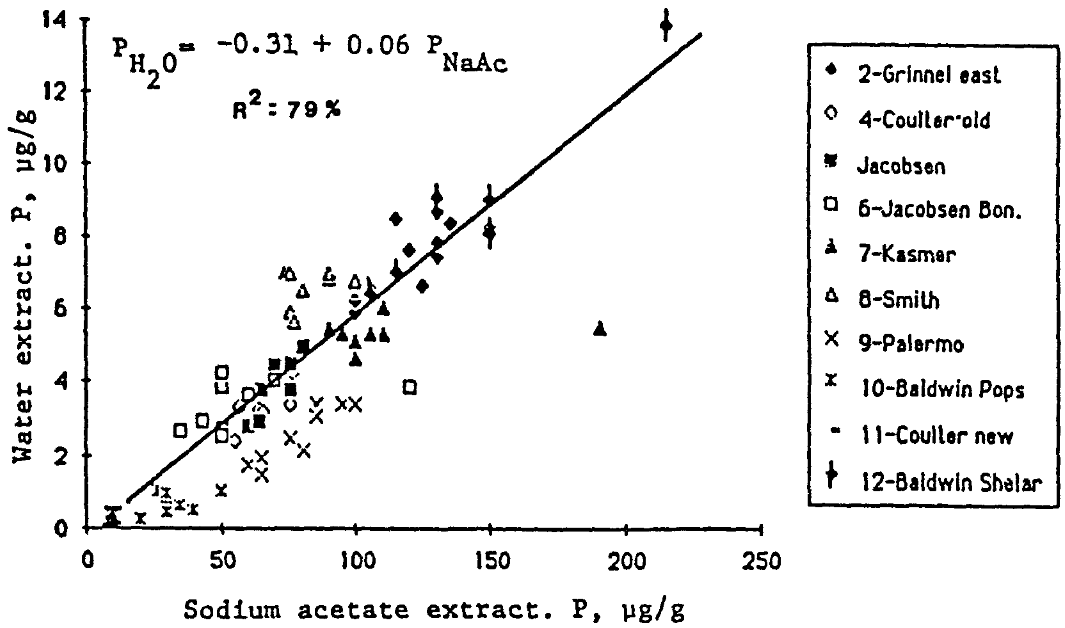

Figure 7. Relationship between sodium acetate extractable soil P and water extractable soil P at the 25-50 cm depth, 1984.

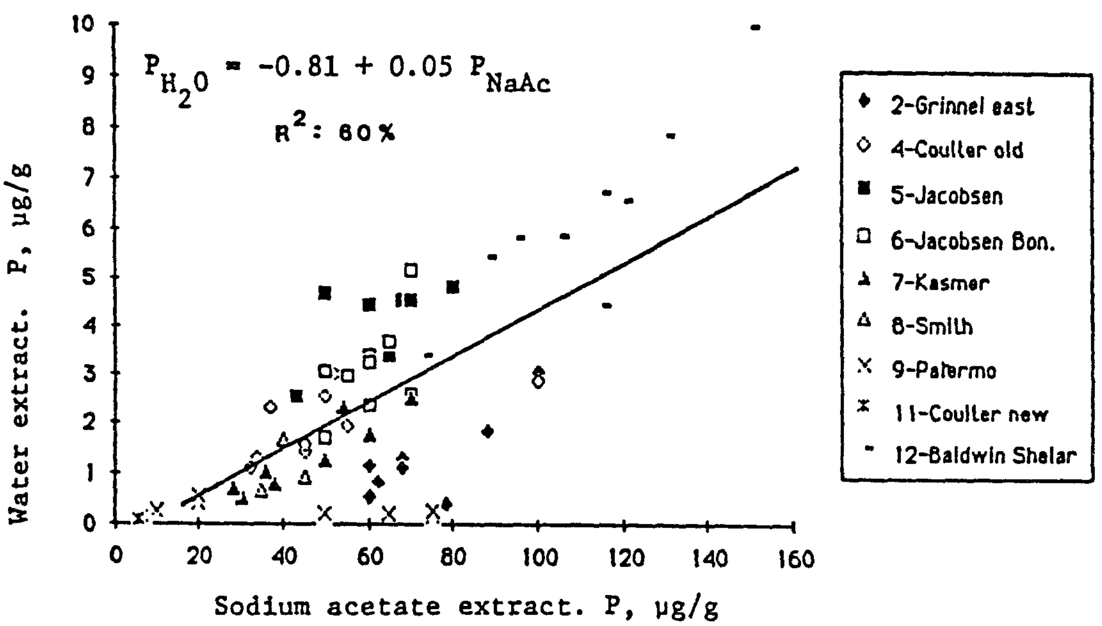

Figure 8. Relationship between sodium acetate extractable soil P and water extractable soil P at the 50-90 cm depth, 1984.

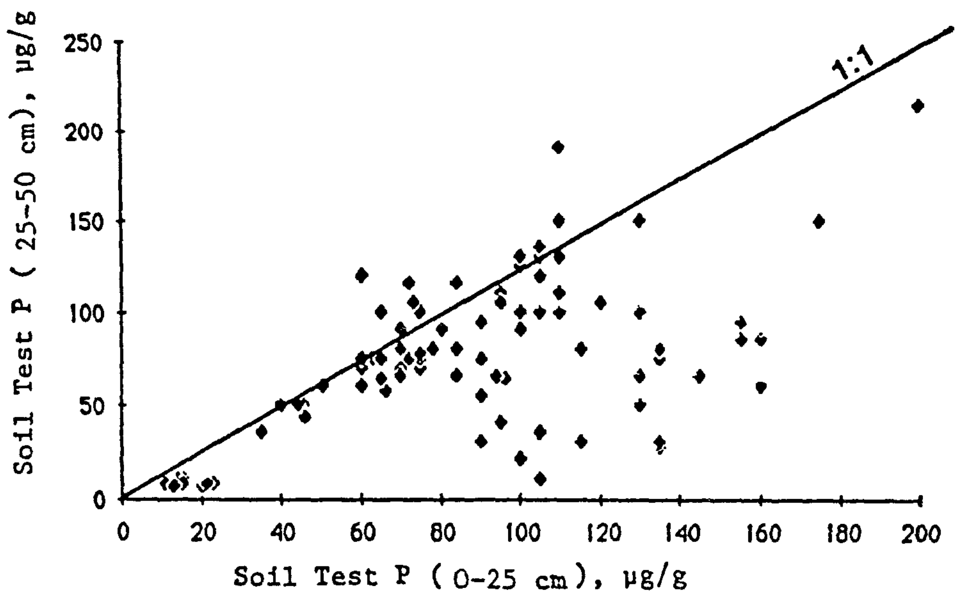

Figure 9. Relationship of sodium acetate extractable soil test P between the 0-25 and 25-50 cm depths for all locations, 1984.

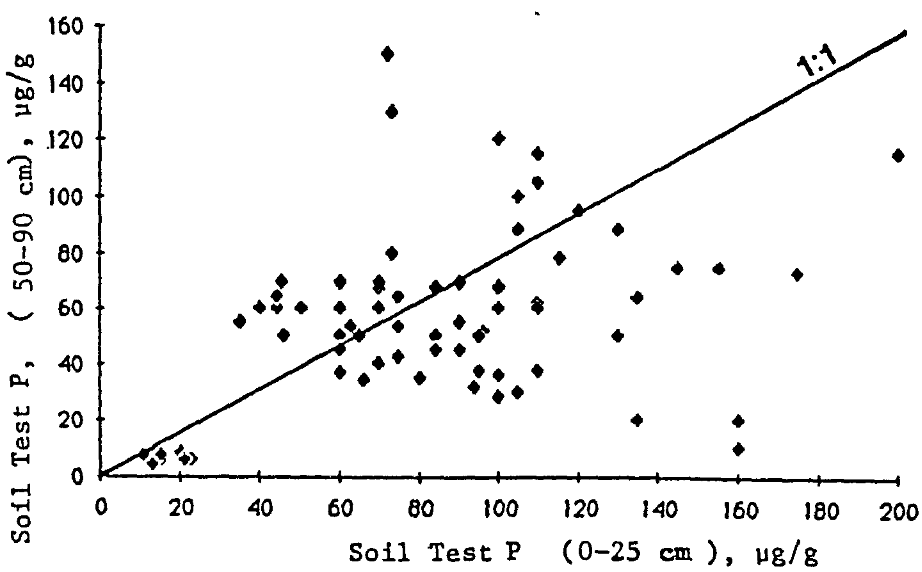

Figure 10. Relationship of sodium acetate extractable soil test P between the 0-25 and 50-90 cm depths for all locations, 1984.

We also looked for trends of soil test P with depth on the assumption that values lower in the profile may be more relevant to P leaching, but found no consistent trend. For example, the values of soil test P for the surface soil (0-25 cm) are plotted against those for the 25-50 cm depth in Figure 9. Many of the soil samples deviated from the 1:1 line (Figure 9) and values for the 25-50 cm depth could be similar to, higher, or lower than those for the surface soil. Similar results were obtained with other depth combinations (Figure 10). The lack of a consistent trend in soil test P with depth is probably a reflection of both past and present fertilizer use. The ideal situation for environmental quality would be to have higher soil test P values in surface soil where most of the plant roots are, and lower soil test P values in the subsoil.

Table 10 shows how soil test P data can be coupled with drainage water yield to estimate annual leaching losses of P from organic soils. Our experience in the Elba and Smith Lima areas (2 years) is that drainage water yield is between 30-46 cm per year. If we widen this to 25-50 cm the data in Table 10 predict annual P losses from 11-22 kg/ha of P at the critical soil test P value for crop production (80 ppm). The predicted losses of P are, of course, high (Table 10) and point to a need for further research to:

1) Define the critical soil test level for broadcast fertilizer more closely, i.e., is 80 ppm really the critical value or is it lower. More data may reveal that a lower level is acceptable.

2) Determine rates of fertilizer use for banded P application. Since banded P is used more efficiently we would expect to be able to reduce fertilizer P applications considerably as well as background soil test P levels. This would also mean that less fertilizer P is necessary to maintain maximum economic production; hence, a reduction in leaching of P. The lowering of extractable P in the subsoil is an important goal as this would substantially lower P leaching.

   For example, at our only low P site (No. 11 in 1984 and No. 14 in 1985) on the Coulter farm, subsoil soil test P values were <10 ppm in 1984 and <20 ppm in 1985. Estimated P loss is 3.2 kg/ha at the 10 ppm soil test P level and 50 cm of H_2O, compared to 20.4 kg/ha at the 80 ppm soil test P level.

3) Develop ways in which to reduce the amount of water draining from organic soils. In some organic soil areas, there is lateral movement of water derived from surrounding mineral soils, especially during the spring months when all soils are generally saturated with water. Use of perimeter ditches to divert this water would reduce P loss from organic soils. It is also likely that the concentration of P in drainage water is affected by the hydraulic properties of the soil, i.e., by the rate and pathway of water movement through the soil. Soil hydraulic properties can be influenced by management.

Table 10. Estimated annual leaching loss of P for organic soils.

Soil test P $NaCH_3COOH$, pH 4.8	Calculated P* concentration in drainage water	Estimated annual P loss for various amounts of drainage water (cm)		
		25	50	75
(ppm)	(ppm)		(kg/ha)	
10	0.6	1.6	3.2	4.8
40	2.1	5.3	10.5	15.8
60	3.1	7.8	15.7	23.5
80	4.1	10.3	20.4	30.9
100	5.1	12.9	25.8	38.6

*Calculated using regression equation $P_{H_2O} = 0.136 + 0.05\ P_{NaAc}$ obtained for surface soils.

Fertilizer Management

Due to the lack of an adequate soil test correlation data base for organic soils in New York, farmers must base their fertilizer rates on past experience or the experience of others. Our observations over the past several years have been that fertilizer is generally applied in excess of crop requirements. Additionally, fertilizer is applied inefficiently as a preplant broadcast application in mid- to late-April which can lead to excessive nutrient losses.

A study of fertilizer practices on mineral soils which minimize nutrient loss by Bouldin et al., 1971, showed that peak stream-flow and the peak quantity of nitrate N carried by stream-flow occurred in March with additional losses in April. The peak quantity of P carried by stream-flow occurred in April. Hence, fertilizer applications in excess of crop requirements coupled with applications during peak soil drainage periods result in undesirable nutrient loss, poor nutrient recovery by the crop, and an added expense to the farmer.

Onion growers are not unique in the way they manage fertilizer nor should they be singled out as poor stewards of the soil. Fertilizer management on a vast majority of farms could be improved, particularly livestock and poultry farms where nutrient surpluses are common. Currently we are able to offer more definitive guidelines for fertilizer management for mineral soils than for organic soils because historically, our research emphasis has been directed towards the much larger mineral soil areas.

Research data on mineral soils has shown that plant recovery of applied nutrients (less nutrient loss) is increased when the majority of N is applied after peak drainage periods in April and P is applied in a band in close proximity of the seed at planting. For example, N is about 65% as efficiently used when applied as a preplant broadcast application for corn as compared to a post plant sidedress incorporation in late June. Approximately twice as much P is needed for corn (at low soil test P) when applied as a preplant broadcast application as compared to band placement at planting. Therefore, timing and placement of fertilizer in addition to the rate can substantially influence nutrient loss.

Cooperative Extension has recently sponsored several meetings for onion growers. The farmers were very interested in our findings and equally receptive to our suggestions and recommendations. Growers will be eager to change their fertilizer management program if the following two criteria are met: 1) research data must show that the change will benefit the crop and therefore, make them more money, and 2) the change will improve water quality.

More research will be needed to develop an adequate data base to define economic fertilizer rates and to define the transport mechanism of P movement into Lake Ontario. Our research experience on mineral soils will be helpful in developing interim fertilizer recommendations for organic soils until the needed data is collected. The acceptability of a management change by farmers will be a function of economics. The cost of fertilizer is a very small percentage of the cost incurred in growing onions. Fertilizer costs approximately 2 to 6 percent of the total. A change in practice, i.e., reducing the rate of application to match the crop requirement, may not change the economic picture very much. The savings in fertilizer may be more than offset by the cost of additional equipment for band placing fertilizer, reduced speed in getting the job done during the critical planting period, and the added cost of multiple fertilizer applications.

The primary unanswered question at this point is how much the P loading into Lake Ontario would be reduced if growers improved their fertilizer management. At present, this cannot be documented until researchers can better understand the transport phenomena from the field to the lake. Undoubtedly, an improvement in management will be beneficial to water quality.

Since farmers are generally very conscientious and are concerned about environmental quality they will be willing to do their part in improving water quality even if they cannot justify it economically. However, before this occurs they must be assured that a change in management will have a beneficial effect and others outside of the farming community are sharing proportionately in the cost for improvement.

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A P P E N D I X

Table A1. Soil test values at each experimental location for the 0-25 cm depth (1984).

Location	Treatment[1]	Nutrient, ppm[2]											
		pH	P1	P2	K	Mg	Ca	Mn	Fe	Al	Zn	Cu	B
1	0-0-0	6.7	84	1.1	157	623	29400	24	12	20	15	<1	2.0
	135-0-67	6.3	80	2.0	170	550	29700	33	16	25	15	"	
	135-135-67	6.0	80	1.5	198	503	19467	23	16	26	14	"	
2	0-0-0	5.5	101	6.3	205	1046	13600	17	7	20	7	"	2.8
	135-0-67	5.4	105	6.9	182	1018	13900	15	<5	20	8	"	
	135-135-67	5.4	102	6.4	183	1045	13233	12	"	19	7	"	
3	0-0-0	5.9	85	-	206	910	12333	11	6	23	3	"	3.9
	135-0-67	5.8	93	-	223	940	12000	12	<5	21	7	"	
	135-135-67	5.8	87	-	201	847	12000	11	"	21	3	"	
4	0-0-0	5.7	72	4.7	378	1916	11073	22	"	13	8	"	1.9
	135-0-67	5.6	80	5.2	390	1800	10346	24	"	18	4	"	
	135-135-67	5.7	90	5.3	390	1786	10420	22	"	13	5	"	
5	0-0-0	5.8	68	3.4	113	1043	10000	22	8	46	11	"	2.7
	135-0-67	5.7	70	3.9	132	983	10333	38	6	43	12	"	
	135-135-67	5.7	71	4.3	108	926	10333	24	8	39	12	"	
6	0-0-0	5.5	53	3.0	230	1166	12000	9	<5	13	4	"	2.9
	135-0-67	5.5	41	2.3	230	1150	12000	9	"	17	4	"	
	135-135-67	5.5	47	2.8	227	917	12333	9	"	13	4	"	
7	0-0-0	5.7	107	6.5	208	1650	15666	7	"	9	6	"	2.3
	135-0-67	5.7	90	5.6	172	1600	15000	9	"	8	6	"	
	135-135-67	5.7	97	4.9	166	1633	15333	8	"	9	6	"	
8	0-0-0	5.4	77	5.5	122	767	14333	13	"	11	13	"	2.3
	135-0-67	5.4	70	4.7	112	750	14333	13	"	10	12	"	
	135-135-67	5.4	74	5.1	121	743	14000	14	"	11	13	"	
9	0-0-0	5.8	148	6.9	228	1033	16333	9	6	9	5	"	4.6
	135-0-67	5.8	138	6.2	200	1033	16333	8	5	10	5	"	
	135-135-67	5.8	148	6.6	187	1000	16333	10	7	11	5	"	
10	0-0-0	5.4	118	6.9	372	773	13333	33	14	22	21	"	3.4
	135-0-67	5.3	113	6.3	337	747	13333	41	14	24	22	"	
	135-135-67	5.4	105	5.6	362	800	12667	42	13	22	21	"	
11	0-0-0	5.5	17	0.6	133	1373	10000	37	6	5	3	"	2.0
	135-0-67	5.4	13	0.4	142	1350	9766	39	10	7	4	"	
	135-135-67	5.4	19	0.7	173	1333	9700	37	10	7	5	"	
12	0-0-0	5.5	162	8.3	515	1050	13533	15	<5	9	8	"	2.1
	135-0-67	5.6	110	6.1	307	1066	13633	11	"	9	8	"	
	135-135-67	5.4	92	4.9	303	1066	13033	12	"	9	8	"	

[1] kg/ha of N-P_2O_5-K_2O. Soil samples taken prior to fertilizer application.
[2] P1 = P extracted with NaAC, P2 = P extracted with water.

Table A2. Soil test values at each experimental location for the 25-50 cm depth (1984).

Location	Treatment[1]	Nutrient, ppm[2]										
		pH	P1	P2	K	Mg	Ca	Mn	Fe	Al	Zn	Cu
1	0-0-0	--										
	135-0-67	--										
	135-135-67	--										
2	0-0-0	5.4	105	7.0	206	1261	14000	17	6	14	5	<1
	135-0-67	5.4	128	7.3	230	1173	14066	15	6	17	6	"
	135-135-67	5.4	122	7.7	223	1238	14066	14	5	15	5	"
3	0-0-0	5.5	60	-	161	1066	13000	12	9	21	3	"
	135-0-67	5.5	39	-	110	1096	13000	9	13	21	2	"
	135-135-67	5.6	61	-	143	1050	12667	9	6	19	2	"
4	0-0-0	5.8	69	3.6	193	2093	10693	21	<5	13	3	"
	135-0-67	5.6	69	3.9	227	1993	10233	21	"	13	2	"
	135-135-67	5.7	66	3.5	235	1820	11000	21	"	13	2	"
5	0-0-0	5.8	68	3.6	111	986	10666	22	8	32	6	"
	135-0-67	5.8	71	4.1	175	1056	10666	22	6	33	7	"
	135-135-67	5.8	70	4.1	133	843	10333	19	6	33	7	"
6	0-0-0	5.3	80	4.0	128	1216	12333	7	<5	8	2	"
	135-0-67	5.4	45	3.0	99	1116	12000	7	"	10	3	"
	135-135-67	5.3	51	3.0	88	1200	12333	6	"	8	2	"
7	0-0-0	5.8	133	5.1	181	2333	19333	6	"	7	4	"
	135-0-67	5.8	105	5.2	168	1983	15000	7	"	6	4	"
	135-135-67	5.8	102	5.6	163	1983	15333	6	"	4	4	"
8	0-0-0	5.4	83	6.5	95	983	13333	9	"	13	16	"
	135-0-67	5.4	89	6.3	102	1020	13667	9	"	11	13	"
	135-135-67	5.3	82	6.8	87	983	13000	33	"	13	17	"
9	0-0-0	5.6	82	2.7	98	1200	16667	6	10	12	4	"
	135-0-67	5.7	73	2.2	86	1210	16333	5	7	11	2	"
	135-135-67	5.7	82	2.7	92	1200	16000	7	8	11	2	"
10	0-0-0	5.1	37	0.6	197	750	11000	22	210	48	13	"
	135-0-67	4.8	27	0.6	137	700	6333	26	442	71	11	"
	135-135-67	4.9	27	0.5	138	733	9000	16	369	65	10	"
11	0-0-0	5.5	9	0.1	80	1383	10000	43	9	5	2	"
	135-0-67	5.4	8	0.3	92	1366	10000	47	7	5	2	"
	135-135-67	5.4	7	0.3	136	1350	9667	44	10	5	3	"
12	0-0-0	5.2	155	9.4	225	1350	13433	11	<5	8	7	"
	135-0-67	5.3	128	7.9	152	1283	13500	11	"	7	7	"
	135-135-67	5.2	123	7.5	133	1233	13566	11	"	8	7	"

[1]kg/ha of N-P_2O_5-K_2O. Soil samples taken prior to fertilizer application.
[2]P1 = P extracted with NaAC, P2 = P extracted with water.

Table A3. Soil test values at each experimental location for the 50-90 cm depth (1984).

Location	Treatment[1]	Nutrient, ppm[2]										
		pH	P1	P2	K	Mg	Ca	Mn	Fe	Al	Zn	Cu
1	0-0-0	--										
	135-0-67	--										
	135-135-67	--										
2	0-0-0	5.8	78	1.2	146	1833	13867	8	11	8	5	<1
	135-0-67	5.7	74	1.7	170	1766	14333	6	11	9	3	"
	135-135-67	5.8	76	1.5	175	1853	15667	6	6	8	2	"
3	0-0-0	5.4	7	-	67	1626	15667	9	7	14	2	"
	135-0-67	5.4	6	-	52	1613	15333	6	6	12	1	"
	135-135-67	5.4	8	-	54	1650	15000	12	<5	28	2	"
4	0-0-0	5.6	38	1.7	180	1826	12000	26	"	9	6	"
	135-0-67	5.6	44	1.6	208	1730	10606	23	"	7	9	"
	135-135-67	5.6	52	2.5	225	1753	10467	25	"	10	1	"
5	0-0-0	5.6	62	3.4	99	1116	10666	25	"	11	2	"
	135-0-67	5.6	54	3.9	118	1183	10666	35	"	13	1	"
	135-135-67	5.8	70	4.2	91	1027	11333	19	"	14	2	"
6	0-0-0	5.0	60	3.4	54	973	13000	7	"	4	1	"
	135-0-67	5.0	60	3.0	52	1283	12333	8	"	6	2	"
	135-135-67	5.0	60	3.0	76	1417	13000	7	"	4	1	"
7	0-0-0	6.1	42	1.0	101	1983	13000	5	"	13	24	"
	135-0-67	6.1	51	1.8	83	2173	13666	6	"	10	21	"
	135-135-67	6.1	38	0.9	77	2033	12000	5	"	10	17	"
8	0-0-0	4.8	45	0.8	88	1050	9000	13	140	36	17	"
	135-0-67	4.7	40	1.7	110	920	9000	16	130	37	14	"
	135-135-67	4.4	35	0.6	65	850	7000	11	170	52	15	"
9	0-0-0	5.2	48	0.2	62	1266	13333	8	28	17	1	"
	135-0-67	5.0	53	0.3	53	883	12000	9	33	18	1	"
	135-135-67	5.0	45	0.2	59	1183	12000	10	33	19	1	"
10	0-0-0	--										
	135-0-67	--										
	135-135-67	--										
11	0-0-0	5.5	7	0.1	42	1550	11000	43	<5	5	1	"
	135-0-67	5.4	6	0.1	46	1433	10700	42	"	5	1	"
	135-135-67	5.4	7	0.1	51	1467	10933	41	"	4	1	"
12	0-0-0	5.4	98	4.6	156	1800	12633	7	12	12	12	"
	135-0-67	5.4	110	6.4	114	1866	13000	8	6	8	11	"
	135-135-67	5.3	123	7.8	128	1700	13000	9	7	11	12	"

[1] kg/ha of N-P_2O_5-K_2O. Soil samples taken prior to fertilizer application.
[2] P1 = P extracted with NaAC, P2 = P extracted with water.

Table A4. Soil test values at each experimental location for the 0-25 cm depth (1985).

Location	Treatment[1]	Nutrient, ppm					
		pH	P	K	Mg	Ca	Zn
1	0-0-0	6.9	87	186	567	37333	10
	67-0-67	6.5	103	246	450	27000	10
	67-135-67	6.1	92	223	417	21333	13
2	0-0-0	5.4	112	193	967	14000	8
	67-0-67	5.4	117	193	900	13333	9
	67-135-67	5.5	117	200	1000	14000	8
4	0-0-0	5.8	96	285	1850	12000	5
	67-0-67	5.7	90	255	1650	12000	5
	67-135-67	5.8	110	285	1650	12000	6
5	0-0-0	5.9	81	226	1133	11667	12
	67-0-67	5.9	76	270	1133	11667	11
	67-135-67	5.8	82	273	1033	11333	11
6	0-0-0	5.7	50	200	1366	14666	5
	67-0-67	5.6	38	183	1200	10100	4
	67-135-67	5.6	51	197	1200	14333	5
7	0-0-0	5.7	157	260	1567	17666	6
	67-0-67	5.8	137	177	1533	17000	6
	67-135-67	5.7	150	207	1600	17667	6
8	0-0-0	5.7	66	73	800	14333	12
	67-0-67	5.6	59	83	833	15333	12
	67-135-67	5.7	72	77	800	14000	14
10	0-0-0	5.5	123	303	833	13333	24
	67-0-67	5.4	117	253	800	13000	23
	67-135-67	5.4	120	347	833	13000	22
14	0-0-0	6.2	69	413	1700	11000	4
	67-0-67	6.2	78	400	1667	11000	4
	67-135-67	6.0	63	320	1733	10667	4

[1]kg/ha of N-P_2O_5-K_2O. Soil samples taken prior to fertilizer application.

Table A5. Soil test values at each experimental location for the 25-50 cm depth (1985).

Location	Treatment[1]	Nutrient, ppm					
		pH	P	K	Mg	Ca	Zn
1	0-0-0	6.8	90	145	450	24500	8
	67-0-67	5.8	83	185	425	16500	11
	67-135-67	5.5	77	170	400	15000	9
2	0-0-0	5.5	100	213	1133	14333	5
	67-0-67	5.5	108	220	1100	14333	6
	67-135-67	5.5	117	220	1233	15000	5
4	0-0-0	5.8	59	155	1900	12000	1
	67-0-67	5.7	62	170	1650	11500	1
	67-135-67	5.8	57	155	1450	12000	5
5	0-0-0	5.9	64	127	1100	12333	4
	67-0-67	5.9	64	160	1233	12000	4
	67-135-67	5.9	73	173	1033	12000	6
6	0-0-0	5.3	48	80	1100	13667	2
	67-0-67	5.2	43	80	1133	13667	2
	67-135-67	5.3	57	87	1067	9433	1
7	0-0-0	5.9	108	140	1866	17000	4
	67-0-67	5.9	115	140	1966	17333	5
	67-135-67	5.8	120	150	1966	18000	4
8	0-0-0	5.3	82	90	933	13333	16
	67-0-67	5.3	67	77	1000	12333	17
	67-135-67	5.2	78	80	900	11667	17
10	0-0-0	5.1	32	123	766	9500	10
	67-0-67	4.9	29	103	667	8500	10
	67-135-67	5.1	30	153	767	8633	11
14	0-0-0	5.8	10	147	1700	10633	<1
	67-0-67	5.7	7	107	1733	11000	"
	67-135-67	5.8	8	440	1867	11000	"

[1]kg/ha of N-P_2O_5-K_2O. Soil samples taken prior to fertilizer application.

Table A6. Soil test values at each experimental location for the 50-96 cm depth (1985).

Location	Treatment[1]	Nutrient, ppm					
		pH	P	K	Mg	Ca	Zn
1	0-0-0	--					
	67-0-67	--					
	67-135-67	--					
2	0-0-0	5.6	91	193	1366	14666	5
	67-0-67	5.6	84	200	1533	14000	4
	67-135-67	5.6	88	223	1500	14333	4
4	0-0-0	5.8	49	195	1550	12000	1
	67-0-67	5.9	38	190	1350	11500	1
	67-135-67	5.7	47	215	1400	12000	2
5	0-0-0	5.8	55	140	1233	12000	3
	67-0-67	5.7	63	217	1166	11666	4
	67-135-67	5.7	66	190	1133	12333	4
6	0-0-0	5.4	49	99	1433	15333	2
	67-0-67	5.4	49	97	1333	14000	2
	67-135-67	5.4	71	133	1267	14333	2
7	0-0-0	6.1	53	103	2066	14667	15
	67-0-67	6.1	57	97	2167	16000	13
	67-135-67	6.1	74	100	2200	15667	14
8	0-0-0	5.0	38	70	1033	8300	13
	67-0-67	4.7	47	80	900	9500	13
	67-135-67	4.7	49	67	833	7267	11
10	0-0-0	--					
	67-0-67	--					
	67-135-67	--					
14	0-0-0	5.9	16	160	1600	10666	<1
	67-0-67	5.9	11	113	1667	11000	"
	67-135-67	5.9	20	163	1767	11000	"

[1]kg/ha of N-P_2O_5-K_2O. Soil samples taken prior to fertilizer application.

Table A7. 1984 Onion yields. Location 2, Grinell-East.

Fertilizer, kg/ha[1] $N-P_2O_5-K_2O$ & M	Yield t/ha	Grade, % 2-4 cm	4-5 cm	5-7.3 cm	7.3+ cm
90L-0-0	9.9	25	38	37	0
13E,90L-13-13	13.4	9	23	68	0
67E,90L-0-0	9.4	5	15	73	7
157L-0-0	7.4	3	12	75	10
90L-135-67	10.5	20	37	43	0
67E,157L-0-67	7.8	2	14	83	1
67E,157L-135-0	13.6	3	8	84	5
67E,157L-135-67	7.3	2	7	82	9
67E,157L-135-67+M	7.4	8	17	75	0
Farm 135E,90L-135-135	12.3	3	9	87	1
LSD	ns	8	13	19	0

[1]E = early (preplant), L = late (summer topdress), M = micronutrients, LSD = least significant difference, ns= not significant @ 5%.

Table A8. 1984 Onion yields. Location 4, Coulter-Old.

Fertilizer, kg/ha[1] N-P_2O_5-K_2O & M	Yield t/ha	Grade, % 2-4 cm	4-5 cm	5-7.3 cm	7.3+ cm
0-0-0	48.2	12	33	55	0
13E-13-13	54.9	8	34	58	0
67E-0-0	53.7	6	26	67	0
67L-0-0	56.1	6	25	69	0
0-135-67	45.4	17	40	43	0
67E+67L-0-67	60.4	5	19	76	0
67E+67L-135-0	51.3	10	28	62	0
67E+67L-135-67	46.8	9	30	61	0
67E+67L-135-67+M	55.7	7	31	61	0
Farm 135-135-135+M	56.3	6	25	69	0
LSD	ns	5	11	15	0

[1]E = early (preplant), L = late (summer topdress), M = micronutrients, LSD = least significant difference, ns= not significant @ 5%.

Table A9. 1984 Onion yields. Location 5, Jacobson.

Fertilizer, kg/ha[1] N-P_2O_5-K_2O & M	Yield t/ha	Grade, % 2-4 cm	4-5 cm	5-7.3 cm	7.3+ cm
0-0-0	68.2	10	36	54	0
13E-13-13	67.9	11	34	55	0
67E-0-0	76.0	10	34	56	0
67L-0-0	73.3	8	32	59	0
0-135-67	73.0	8	30	62	0
67E+67L-0-67	63.2	9	30	61	0
67E+67L-135-0	63.9	10	31	59	0
67E+67L-135-67	71.1	9	28	63	0
67E+67L-135-67+M	71.3	10	38	51	0
Farm 90E,78L-50-226	72.1	9	33	58	0
LSD	ns	ns	ns	ns	0

[1]E = early (preplant), L = late (summer topdress), M = micronutrients, LSD = least significant difference, ns= not significant @ 5%.

Table A10. 1984 Onion yields. Location 6, Jacobson-Bonocorsi.

Fertilizer, kg/ha[1] $N-P_2O_5-K_2O$ & M	Yield t/ha	Grade, % 2-4 cm	4-5 cm	5-7.3 cm	7.3+ cm
0-0-0	50.6	20	43	37	0
13E-13-13	44.7	20	43	37	0
67E-0-0	56.3	15	48	37	0
67L-0-0	57.2	15	51	33	0
0-135-67	54.8	19	49	32	0
67E+67L-0-67	58.7	14	49	37	0
67E+67L-135-0	57.0	15	40	45	0
67E+67L-135-67	--	-	-	-	0
67E+67L-135-67+M	54.3	14	45	41	0
E Farm 84E,73L-84-168	56.5	14	42	44	0
LSD	ns	ns	ns	ns	0

[1]E = early (preplant), L = late (summer topdress), M = micronutrients, LSD = least significant difference, ns= not significant @ 5%.

Table A11. 1984 Onion yields. Location 7, Kasmer.

Fertilizer, kg/ha[1] $N-P_2O_5-K_2O$ & M	Yield t/ha	Grade, % 2-4 cm	4-5 cm	5-7.3 cm	7.3+ cm
0-0-0	45.7	6	10	64	20
13E-13-13	47.2	6	12	67	15
67E-0-0	32.8	3	5	62	30
67L-0-0	33.5	3	12	85	0
0-135-67	53.8	7	16	75	2
67E+67L-0-67	38.8	1	3	55	41
67E+67L-135-0	45.9	3	7	56	34
67E+67L-135-67	35.3	2	7	46	45
67E+67L-135-67+M	45.1	1	3	62	34
Farm 179E-179-179+M	54.4	2	9	83	6
LSD	ns	3	ns	ns	ns

[1]E = early (preplant), L = late (summer topdress), M = micronutrients, LSD = least significant difference, ns= not significant @ 5%.

Table A12. 1984 Onion yields. Location 8, Smith.

Fertilizer, kg/ha[1] $N-P_2O_5-K_2O$ & M	Yield t/ha	Grade, %			
		2-4 cm	4-5 cm	5-7.3 cm	7.3+ cm
0-0-0	40.8	10	31	57	0
13E-13-13	37.0	9	32	57	0
67E-0-0	41.5	11	30	57	0
67L-0-0	36.6	10	27	62	0
0-135-67	39.5	9	30	60	0
67E+67L-0-67	37.7	9	26	63	1
67E+67L-135-0	36.9	8	23	68	0
67E+67L-135-67	40.1	8	21	69	0
67E+67L-135-67+M	40.8	6	23	65	2
Farm 135E-90-179+M	43.8	7	21	70	0
LSD	ns	ns	ns	ns	ns

[1]E = early (preplant), L = late (summer topdress), M = micronutrients, LSD = least significant difference, ns= not significant @ 5%.

Table A13. 1984 Onion yields. Location 9, Palermo.

Fertilizer, kg/ha[1] $N-P_2O_5-K_2O$ & M	Yield t/ha	Grade, % 2-4 cm	4-5 cm	5-7.3 cm	7.3+ cm
28L-0-0	42.0	9	35	55	0
13E+28L-13-13	32.8	6	22	70	0
67E+28L-0-0	37.0	7	31	62	0
95L-0-0	32.4	10	27	60	0
28L-0-135	33.3	12	31	55	0
67E+95L-0-67	35.3	9	33	56	0
67E+95L-135-0	35.9	11	29	57	0
67E+95L-135-67	36.0	8	25	65	0
67E+95L-135-67+M	36.5	8	29	62	0
Farm 84E+28L-118-135	40.4	11	27	61	1
LSD	ns	ns	ns	ns	ns

[1]E = early (preplant), L = late (summer topdress), M = micronutrients, LSD = least significant difference, ns= not significant @ 5%.

Table A14. 1984 Onion yields. Location 10, Baldwin-Pops.

Fertilizer, kg/ha[1] $N-P_2O_5-K_2O$ & M	Yield t/ha	Grade, % 2-4 cm	4-5 cm	5-7.3 cm	7.3+ cm
0-0-0	27.9	4	13	74	9
13E-13-13	29.2	5	23	69	3
67E-0-0	32.2	3	13	75	9
67L-0-0	38.4	2	15	77	6
0-135-67	28.5	4	17	73	6
67E+67L-0-67	39.5	2	13	79	6
67E+67L-135-0	42.0	2	7	77	14
67E+67L-135-67	41.9	3	10	78	9
67E+67L-135-67+M	44.8	3	11	78	8
Farm 112E-112-168	39.9	3	11	76	10
LSD	8.3	ns	ns	ns	ns

[1]E = early (preplant), L = late (summer topdress), M = micronutrients, LSD = least significant difference, ns= not significant @ 5%.

Table A15. 1984 Onion yields. Location 11, Coulter-New.

Fertilizer, kg/ha[1] $N-P_2O_5-K_2O$ & M	Yield t/ha	Grade, % 2-4 cm	4-5 cm	5-7.3 cm	7.3+ cm
0-0-0	4.7	92	8	0	0
13E-13-13	22.1	33	61	6	0
67E-0-0	31.2	60	30	102	0
67L-0-0	7.7	52	31	17	0
0-135-67	15.8	65	27	5	0
67E+67L-0-67	19.5	44	48	8	0
67E+67L-135-0	39.0	30	52	17	0
67E+67L-135-67	41.2	28	45	27	0
67E+67L-135-67+M	46.3	25	46	29	0
Farm 157E-151-151+M	46.9	25	31	43	0
LSD	24.0	32	21	ns	0

[1]E = early (preplant), L = late (summer topdress), M = micronutrients, LSD = least significant difference, ns= not significant @ 5%.

Table A16. 1984 Onion yields. Location 12, Baldwin-Shellar.

Fertilizer, kg/ha[1] $N-P_2O_5-K_2O$ & M	Yield t/ha	Grade, % 2-4 cm	4-5 cm	5-7.3 cm	7.3+ cm
0-0-0	58.4	5	23	71	1
13E-13-13	56.0	7	18	73	2
67E-0-0	60.8	5	18	74	3
67L-0-0	60.7	6	25	68	1
0-135-67	57.6	6	25	68	1
67E+67L-0-67	61.3	5	21	73	1
67E+67L-135-0	59.2	6	22	70	2
67E+67L-135-67	59.5	5	24	70	1
67E+67L-135-67+M	51.7	7	23	68	2
Farm 112E-112-168	61.5	5	19	74	2
LSD	ns	ns	ns	ns	ns

[1]E = early (preplant), L = late (summer topdress), M = micronutrients, LSD = least significant difference, ns= not significant @ 5%.

Table A17. 1985 Onion yields. Location 1, Grinell-West.

Fertilizer, kg/ha[1] $N-P_2O_5-K_2O$	Yield t/ha	Grade, % 4-5 cm	5-7.3 cm	7.3+ cm
28L-0-0	28.1	47	53	0
13E,28L-13-13	35.2	43	56	1
67E,28L-0-0	34.5	47	53	0
28L-135-67	28.2	52	48	0
67E,28L-0-67	36.3	42	58	0
67E,28L-135-0	26.4	54	46	0
67E,28L-135-67	32.9	44	56	0
67E,28L-135-67+M	31.6	41	59	0
Farm 135E,28L-135-135	37.9	40	60	0
LSD	ns	ns	ns	1

[1]E = early (preplant), L = late (summer topdress), M = micronutrients, LSD = least significant difference, ns= not significant @ 5%.

Table A18. 1985 Onion yields. Location 2, Grinell-East.

Fertilizer, kg/ha[1] $N-P_2O_5-K_2O$	Yield t/ha	Grade, % 4-5 cm	5-7.3 cm	7.3+ cm
28L-0-0	19.2	54	46	0
13E,28L-13-13	24.5	54	46	0
67E,28L-0-0	27.0	40	59	1
28L-135-67	26.2	53	47	0
67E,28L-0-67	32.4	34	65	1
67E,28L-135-0	31.8	40	58	2
67E,28L-135-67	32.3	32	66	2
67E,28L-135-67+M	31.0	44	56	0
Farm 135E,28L-135-135	37.9	36	64	0
LSD	ns	ns	ns	ns

[1]E = early (preplant), L = late (summer topdress), M = micronutrients, LSD = least significant difference, ns= not significant @ 5%.

Table A19. 1985 Onion yields. Location 4, Coulter-Old.

Fertilizer, kg/ha[1] $N-P_2O_5-K_2O$	Yield t/ha	Grade, % 4-5 cm	5-7.3 cm	7.3+ cm
0-0-0	80.5	12	85	3
13E-13-13	57.6	8	72	19
67E-0-0	83.6	9	88	3
0-135-67	72.1	20	78	2
67E-0-67	87.9	10	87	3
67E-135-0	84.9	8	89	3
67E-135-67	82.1	6	78	16
67E-135-67+M	83.7	6	85	9
Farm 151E-151-151+M	85.7	8	89	3
LSD	15.9	ns	10	ns

[1] E = early (preplant), M = micronutrients,
LSD = least significant difference, ns= not significant @ 5%.

Table A20. 1985 Onion yields. Location 5, Jacobson.

Fertilizer, kg/ha[1] $N-P_2O_5-K_2O$	Yield t/ha	Grade, % 4-5 cm	5.0-7.3 cm	7.3+ cm
45L-0-0	56.9	27	73	0
13E,45L-13-13	--	--	--	-
67E,45L-0-0	54.3	17	83	0
45L-135-67	55.9	20	80	0
67E,45L-0-67	61.7	21	79	0
67E,45L-135-0	56.5	18	82	0
67E,45L-135-67	59.0	11	89	0
67E,45L-135-67+M	--	--	--	-
Farm 112E,45L-112-112	59.9	16	84	0
LSD	ns	4	4	0

[1]E = early (preplant), L = late (summer topdress), M = micronutrients, LSD = least significant difference, ns= not significant @ 5%.

Table A21. 1985 Onion yields. Location 6, Jacobson-Bonocorsi.

Fertilizer, kg/ha[1] $N-P_2O_5-K_2O$	Yield t/ha	Grade, % 4-5 cm	5.0-7.3 cm	7.3+ cm
45L-0-0	45.3	48	52	0
13E,45L-13-13	57.2	38	62	-
67E,45L-0-0	49.1	44	56	0
45L-135-67	56.3	41	59	0
67E,45L-0-67	55.5	45	55	0
67E,45L-135-0	63.5	33	67	0
67E,45L-135-67	67.1	33	67	0
67E,45L-135-67+M	64.4	34	66	-
Farm 112E,45L-112-112	61.4	30	70	0
LSD	10.3	12	12	ns

[1]E = early (preplant), L = late (summer topdress), M = micronutrients, LSD = least significant difference, ns= not significant @ 5%.

Table A22. 1985 Onion yields. Location 7, Kasmer.

Fertilizer, kg/ha[1] $N-P_2O_5-K_2O$	Yield t/ha	Grade, % 4-5 cm	5.0-7.3 cm	7.3+ cm
0-0-0	65.5	42	58	0
13E-13-13	60.4	50	50	0
67E-0-0	59.0	37	63	0
0-135-67	54.7	52	48	0
67E-0-67	63.4	36	64	0
67E-135-0	59.7	45	55	0
67E-135-67	64.5	42	58	0
67E-135-67+M	59.1	47	53	0
Farm 168E-168-168+M	63.0	43	57	0
LSD	ns	ns	ns	ns

[1]E = early (preplant), M = micronutrients,
LSD = least significant difference, ns= not significant @ 5%.

Table A23. 1985 Onion yields. Location 8, Smith.

Fertilizer, kg/ha[1] $N-P_2O_5-K_2O$	Yield t/ha	Grade, %		
		4-5 cm	5.0-7.3 cm	7.3+ cm
0-0-0	30.4	69	31	0
13E-13-13	24.8	75	25	0
67E-0-0	28.3	63	37	0
0-135-67	37.5	62	38	0
67E-0-67	36.8	50	50	0
67E-135-0	27.9	55	45	0
67E-135-67	36.9	51	49	0
67E-135-67+M	34.3	--	--	-
Farm 135E-90-179+M	53.7	28	72	0
LSD	14.4	ns	29	ns

[1]E = early (preplant), M = micronutrients,
LSD = least significant difference, ns= not significant @ 5%.

Table A24. 1985 Onion yields. Location 14, Coulter-New.

Fertilizer, kg/ha[1] $N-P_2O_5-K_2O$	Yield t/ha	Grade, % 4-5 cm	5.0-7.3 cm	7.3+ cm
0-0-0	27.1	62	38	0
13E-13-13	35.8	55	45	0
67E-0-0	56.3	33	67	0
0-135-67	37.3	55	45	0
67E-0-67	61.0	27	72	1
67E-135-0	59.0	25	75	0
67E-135-67	72.5	22	77	1
67E-135-67+M	68.8	23	76	1
Farm 90E-90-270+M	75.0	10	87	3
LSD	21.9	21	21	1

[1]E = early (preplant), M = micronutrients,
LSD = least significant difference, ns= not significant @ 5%.

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16. ABSTRACT

There are approximately 2.3 million hectares of cropland in New York. Cultivated organic soils comprise about 12,000 hectares or 0.5% of the total cropped land. The organic soils are used exclusively for intensive vegetable production with onions being the primary crop. About 50% of these soils are located within the Lake Ontario drainage basin. Unlike their mineral soil counterpart, there is essentially no soil test correlation data for use in estimating the fertilizer requirements of crops grown on organic soils. Hence, growers apply fertilizer based on recommendations that are not well correlated with crop response. The excessive use of fertilizer, coupled with elevated nutrient levels in the soil will result in poor niutrient utilization, an increase in nutrient enrichment of drainage water, and an economic loss to the farmer.

A comprehensive field study was conducted to evaluate the yield response of onions across a broad range of N, P, and K fertilizer inputs and to correlate the level of response with soil testing parametes. A primary objective was to develop an estimate of P loss in drainage water to the Lake Ontario drainage basin and how this loss is influenced by P fertilizer management.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTIONS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field Group
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Phosphorus	Mucklands		
Nitrogen	Cropland		
Nutrients	Potassium		
Water Quality	Sediment		

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