WHAT GRID CELL SIZE IS BEST FOR P AND K SOIL TESTING IN MINNESOTA?

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ABSTRACT

A study to evaluate the best grid cell size and best soil sample system for immobile nutrients was conducted in South-Central Minnesota from 1993 to 1995. A corn/soybean cropping system was used. The soils at the research sites were formed in glacial till. Three grid cell sizes, 60 x 60 ft., 180 x 180 ft., and 300 x 300 ft. were evaluated. The sampling patterns included a mid-plot sample, a 60 x 60 ft. grid all-point pattern, and five to nine sample pattern. The smaller the grid cell the better the characterization of the soil for P and K. Economics of the cropping system will dictate the grid cell size used in most situations. The sampling pattern results indicate that a single mid-point soil sample is not a good characterization of soil P and K in a grid cell. The use of any pattern with at least five sample locations in the cell is as good as using soil from 25 locations. To get the most out of grid soil sampling, the person taking the sample should use their knowledge of soil science and of the field being sampled to get a sample which "best" reflects the grid cell.

INTRODUCTION

Precision soil sampling has become an issue in Minnesota. Many fertilizer dealers and consultants have invested in the variable rate technology (VRT) for application of phosphorus (P) and potassium (K) fertilizer. Variable rate application equipment require a condition map of the field to provide information on how much and where to apply fertilizer. As the use of VRT grows more questions arise about how to develop the condition map. Most consultants have adopted a grid system of soil sampling a field to meet this need.

As more grid soil sampling is done the following questions have been asked: 1. What is the best grid cell size for P and K soil testing? and 2. What is the best soil sampling pattern within a grid cell? The objective of this paper is to report progress that has been made in Minnesota on grid cell soil sampling research for making P and K fertilizer recommendations.

METHODS

A study was started with three locations in South-Central Minnesota on soils derived from glacial till to answer questions about using grid soil sampling,. These locations were established in farmer's fields in the soybean year of a corn-soybean rotation. One location

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(SB) was started in June 1993 and the others (RA and RM) in June 1994. For this paper, only SB and RA locations will be discussed. Soil samples to a six inch depth were taken on a 60 X 60 ft. grid and analyzed for pH, organic matter, Bray-P, sodium bicarbonate-P (Olsen-P), and potassium. The SB location was 360 feet wide and 1320 feet long accounting for an area of 10.9 acres which forms 132 - 60 X 60 ft grid cells. The RA site was 360 feet wide and 1140 feet long which is 9.4 acres in area and has 114 - 60 X 60 ft. grid cells. Soybean and corn were grown by the farmer cooperators as part of their bigger fields. At the end of the second year, corn grain yields were determined in 60 foot segments by a plot combine.

Soil data from one sampling time at each location was evaluated at three different grid cell sizes; 60 X 60 ft, 180 X 180 ft, and 300 X 300 ft. To compare grid cell sizes, a part of the sites were used to most nearly compare the same part of the site. At the SB site, 21 - 180 X 180 grid cells were used making the site size 360 ft X 1260 ft. and for each grid cell size. Four 300 X 300 grid cells were used or an area 300 ft X 1200 ft. At the RA location 12 - 180 X 180 ft grid cells and 3 - 300 X 300 ft grid cells were use for areas of 360 ft X 1080 ft. and 300 ft X 900 ft., respectively. Fertilizer recommendations for P and K were derived from University of Minnesota recommendations for a 150 bushel per acre corn yield goal.

DISCUSSION

Optimum Grid Cell Size

From an academic prospective, the smaller the grid cell sizes will provide a better documentation of the variation in a field. Current University of Minnesota research at two sites has looked at three grid cell sizes: 60 X 60 foot (0.1 acre), 180 X 180 foot (0.75 acre), and 300 X 300 foot (2 acre). For the actual soil test values, there are some differences in average values with changing grid cell sizes, Table 1. At the RA location, when using a standard single mid point sample, the Bray-P test was affected by cell size. The 300 X 300 foot soil test was considerable less than the smaller two grid sizes. At the SB location, Bray-P soil test values decreased with increasing grid cell size. The phosphate fertilizer recommendations for a 150 bu/A corn crop based on the Bray-P soil test are quite different when comparing a 60 X 60 foot grid cell to a 300 X 300 foot grid cell, Figures 1 and 2. At both locations the average recommended rate for all cells increased with increased cell size: (35 lb phosphate/A at RA and 7.9 lb phosphate/A at SB) (Table 1). For recommendation purposes, we suggest using the smallest grid cell size that is economically practical. Large cells should be used where this a small amount of variability in a field. If substantial variability is expected, use smaller grid cells.

Table 1. The Bray-P soil test values and phosphate fertilizer recommendations for a 150 bu/A corn crop as affected by size of grid cell at two locations in central Minnesota.

	RA		SB	
Cell dimensions	P soil test ave. of all cells	Phosphate recommendation ave. of all cells	P soil test ave. of all cells	Phosphate recommendation ave. of all cells
ft	- ppm -	- lb/A -	- ppm -	- lb/A -
60 X 60	16.4	34.6	27.7	23.3
180X 180	20.1	21.7	26.9	22.1
300 X 300	9.7	56.7	21.0	30.0

Sampling Pattern Within a Grid Cell

The sampling pattern used within the cell seems to make a substantial difference in the fertilizer recommendations, (Table 2). The use of a midpoint location produced different fertilization recommendations than if multi point (5 to 9 sampling locations in the grid cell) were used (Figure 3). In this study, the multi-point and all points sampling systems produced the same Bray-P test. The all points system required collection from within the 300 X 300 ft. grid on 60 X 60 ft. intervals, Figures 1 and 2. If possible a sampling pattern which would include at least five separate locations in the grid cell, should be used. Again this would increase the number of soil samples but the increased precision in the fertilizer

Table 2. Effect of three types of soil sample patterns on average Bray-P soil tests and phosphate fertilizer recommendations for a 150 bu/A corn crop in a Minnesota field when a 300 X 300 foot grid cell was used.

	RA		SB	
Sampling pattern	P soil test ave. of all cells	Phosphate recommendation ave. of all cells	P soil test ave. of all cells	Phosphate recommendation ave. of all cells
	- ppm -	- lb/A -	- ppm -	- lb/A -
Multi points*	16.7	19.2	30.4	15.0
All points**	16.7	18.3	28.8	15.0
Midpoint***	9.7	56.7	21.0	30.0

* Multi point samples have 5 to 9 soil samples taken in a pattern in the grid cell. Examples of the patterns are /, \, V, X, or Z.

** All points is the mean of all 25 individual soil samples (not a composite sample) in the 300 X 300 grid cell from a 60 X 60 foot grid pattern.

*** Midpoint pattern was one soil sample location in the middle of the 300 X 300 foot grid cell.

recommendations may be worth it. The midpoint sampling system allows an individual to return to a specific location each time a cell is sampled. With the improvement of global positioning system technology (GPS), the ability to return to the same place using 5 to 9 sampling areas should also be possible.

Tables 3 and 4 show the Bray-P soil test values for each of the 300 X 300 ft. grids at location RA and SB. The RA location had three cells while SB was larger with four cells. The comparison indicates that in two of three cells at RA the single midpoint value was less than the all points value which utilized 25 individual soil samples taken in the 300 X 300 ft. cell (Table 3). Because of this the phosphate recommendations are different between the two sampling systems at the RA site, Figure 1. At the SB site, three of four cells the midpoint value was less than the all point value (Table 4). Again the phosphate recommendations reflect these differences. Figure 2. In both locations, the Bray-P soil test value derived from a multi point sampling pattern which involved five to nine soil samples was similar to the all point value. In this study multi point patterns involved separate soil samples which were mathematically averaged and not composited.

Table 3. Bray-P soil test values for location RA for grid cell size 300 ft X 300 ft.

		Cell number West to East		
Sampling pattern	Number of soil samples	1	2	3
		- Bray-P soil test ppm -		
Multi point*	5 to 9	18.8	14.6	16.5
All points**	25	20.1	13.4	16.9
Midpoint***	1	26	2	1

* Multi point samples have 5 to 9 soil samples taken in a pattern in the grid cell. Examples of the patterns are /, \, V, X, or Z.

** All points is the mean of all 25 individual soil samples (not a composite sample) in the 300 X 300 grid cell from a 60 X 60 foot grid pattern.

*** Midpoint pattern was one soil sample location in the middle of the 300 X 300 foot grid cell.

Table 4. Bray-P soil test values for location SB for grid cell size 300 ft. X 300 ft.

Sampling pattern	Number of soil samples	Cell number West to East			
		1	2	3	4
		- Bray-P soil test ppm -			
Multi point*	5 to 9	7.5	41.5	45.2	27.2
All points**	25	5.7	41.1	40.9	26.7
Midpoint***	1	0	22	49	13

* Multi point samples have 5 to 9 soil samples taken in a pattern in the grid cell. Examples of the patterns are /, \, V, X, or Z.

** All points is the mean of all 25 individual soil samples (not a composite sample) in the 300 X 300 grid cell from a 60 X 60 foot grid pattern.

*** Midpoint pattern was one soil sample location in the middle of the 300 X 300 foot grid cell.

The research in this whole area of grid soil sampling is causing many more questions than it is answering. We do not have a standard "best" economical method to recommend at this time. What we do know is that to optimize soil sampling information, the person doing the soil sampling will have to use their practical knowledge of the field being sampled.

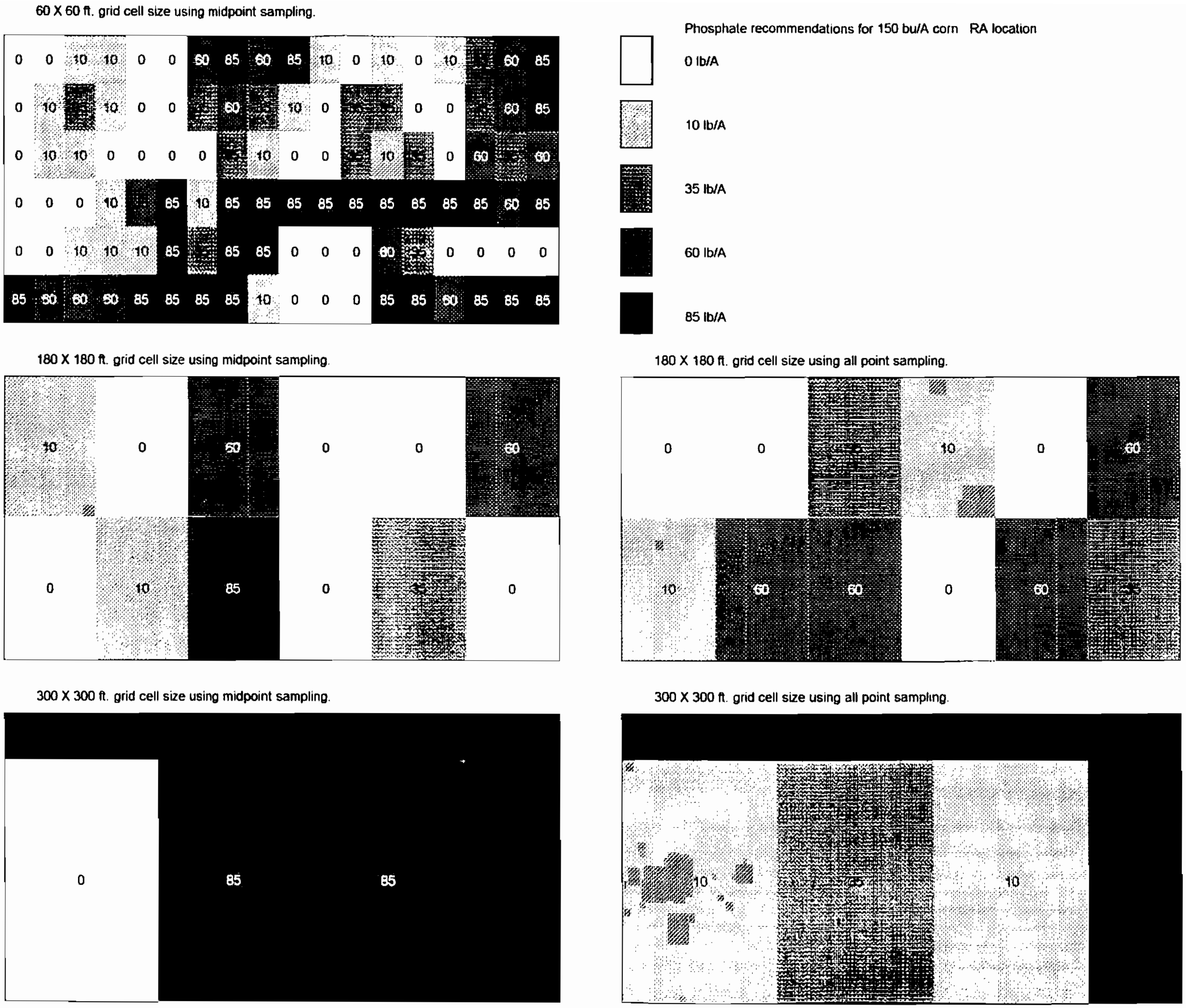


Figure 1. Phosphate recommendations for 150 bu/A corn at RA location for grid cell sizes of 60 X 60 ft., 180 X 180 ft., and 300 X 300 ft. and for sampling patterns of midpoint and all point.

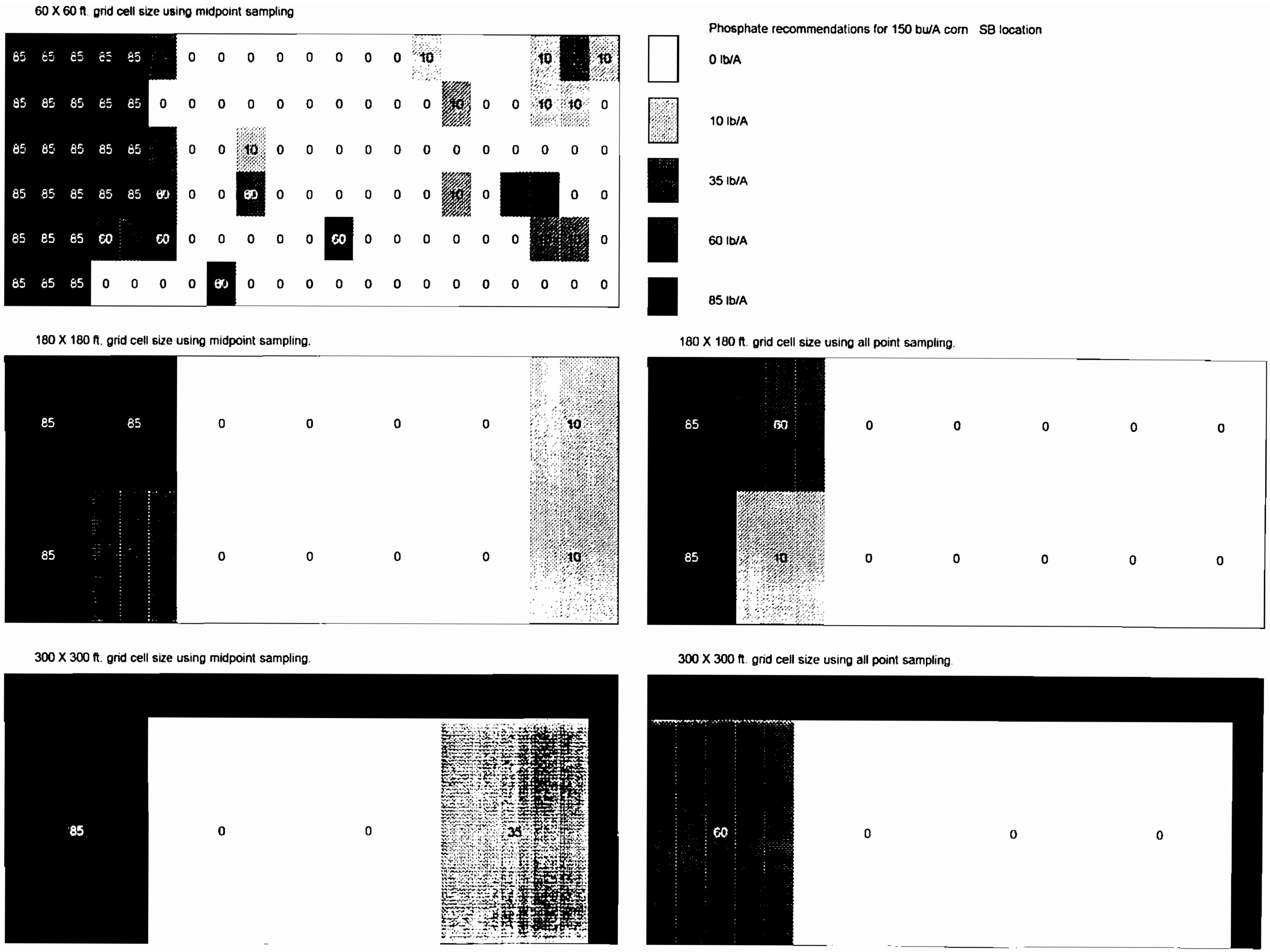
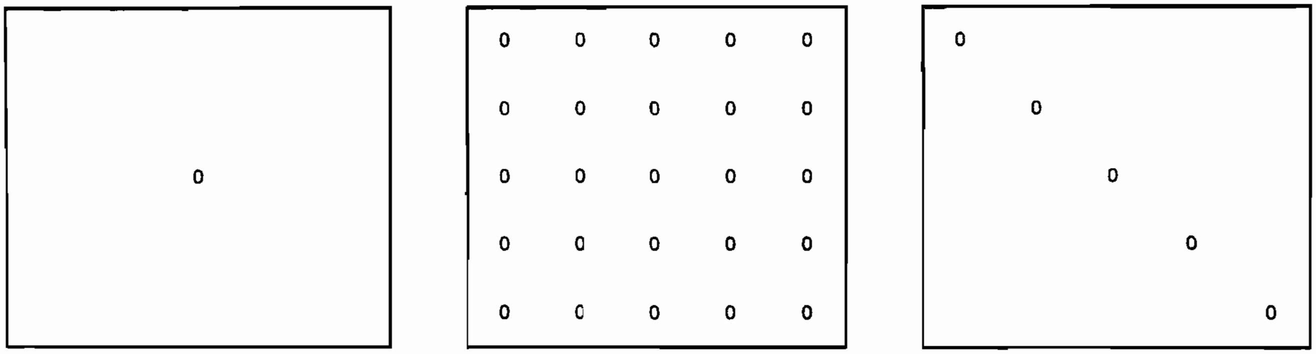


Figure 2. Phosphate recommendations for 150 bu/A corn at SB location for grid cell sizes of 60 X 60 ft., 180 X 180 ft., and 300 X 300 ft. and for sampling patterns of midpoint and all point.



Midpoint | All points | Multi point

Figure 3. Examples of Midpoint, all points, and multi point soil sampling patterns. The 0's are mark where the soil samples were taken.

Partial list of Soil Fertility Research Activities in Minnesota

Potato variety responses to nitrogen rate and timing on irrigated soils. -- Carl Rosen

Mapping yield variability in irrigated potato fields. -- Carl Rosen and Pierre Robert

Evaluation of liming materials for alfalfa production on acid sandy soils. -- George Rehm

Nitrogen use for grass-legume mixtures which include kura clover. -- George Rehm

Potassium sources for alfalfa production. -- George Rehm

White mold severity in edible beans as affected by nitrogen timing, fungicide use, and irrigation scheduling. -- Jerry Wright, Dick Meronuck, and George Rehm

Sources and rates of sulfur for spring wheat production. -- George Rehm

The effect of ammonium and nitrate nutrition on production of hard red spring wheat. -- George Rehm

Phosphorus management for spring wheat under increased residue systems. -- John Lamb, Albert Simms, Bobby Holder, and George Rehm

Management practices to improve root health of soybeans. -- Ward Stienstra and George Rehm

Use of zinc fertilizers for navy bean production. -- George Rehm

Phosphate fertilizer management for corn and soybean production in two contrasting tillage systems. -- George Rehm

Enhancing the role of fluid fertilizers in precision farming. -- George Rehm

The impact of starter fertilizers on root activity, and production of popular but different corn hybrids. -- Deborah Allan and George Rehm

More precision in fertilizer management. -- John Lamb, George Rehm, Gary Malzer, and Pierre Robert

Long term grain yield stability on sandy soils. -- John Lamb

Variable rate application of nitrogen fertilizer as a BMP. -- Gary Malzer, John Lamb, Pierre Robert, and Bruce Montgomery

Use of variable rate experiments for correlation and calibration of new soil tests. -- John Lamb, George Rehm, and Gary Malzer

Effect of manure applied prior to alfalfa establishment on corn's fertilizer N response for three year after alfalfa plowdown. -- Michael Schmitt, Craig Sheaffer, and Gyles Randall

Use of annual medics as a smother crop and N source in corn. -- Craig Sheaffer, Michael Schmitt, and Gyles Randall

Effect of anhydrous application patterns and time of application after planting on corn stands and yields. -- Michael Schmitt and Dale Hicks

Assessment of soil N tests in animal-based farming systems. -- Gyles Randall and Michael Schmitt

Nitrogen release from fall and spring-applied manure. -- Gyles Randall and Michael Schmitt

Partial list of Soil Fertility Research Activities in Minnesota (continued)

Residual effects of nitrogen applied to reed canarygrass. -- Gyles Randall and Michael Russelle

Manure application to reed canarygrass. -- Gyles Randall and Michael Schmitt

Nitrogen credit from winter-killed alfalfa. -- Michael Schmitt, Craig Sheaffer, and Gyles Randall

Corn response to phosphorus starter fertilizer with varying soil P tests. -- Gyles Randall

Alternate strip cropping systems for improved production and residue management. -- Tammiraj Iragavarapu and Gyles Randall

No-till management of continuous corn and corn-soybean rotation systems. -- Jeff Vetsch and Gyles Randall

Nitrogen and phosphorus movement into tile drainage systems as influenced by manure. -- Gyles Randall and Tammiraj Iragavarapu

Nitrate loss to drainage water as affected by crop rotation and N application. -- Gyles Randall

Fertilizer and manure N management for continuous corn on loess soils. -- Gyles Randall

Managing nitrogen inputs in an alfalfa-corn cropping system. -- Gyles Randall

Sweet corn processing waste as a nutrient source for corn. -- Vince Fritz, Gyles Randall, and Carl Rosen

Immobilization of N following peas as affected by sweet corn waste. -- Gyles Randall, Vince Fritz, and Carl Rosen

Swine manure application for soybeans. -- Michael Schmitt, Jim Orf, John Lamb, and Gyles Randall

Nitrogen Fertility Management. -- Dave Huggins and Gary Malzer

Precision Soil N Testing. -- Dave Huggins, George Rehm, and Sam Evans

Precision N-Serve Management. -- Gary Malzer, Dave Huggins, and Pierre Robert

Evaluataion of GPS and on-the-go yield monitoring. -- Dave Huggins and Pierre Robert

Evaluation of real-time soil moisture measuring device. -- Dave Huggins and Pierre Robert

Precision N Timing by Soil Condition. -- Dave Huggins and Pierre Robert

Site Specific Tillage. -- Pierre Robert and Dave Huggins

Nitrogen-Pesticide Movement. -- Gyles Randall, Dave Huggins, Michael Russelle, and Jim Anderson

Tillage and Nutrient effects on the water quality of tile drainage. -- Dave Huggins, John Moncrief, and Satish Gupta

Tile spacing, tillage, and N timing effects on water quality of tile drainage. -- Dave Huggins

Long-term N management effects on nitrate leaching potential. -- Dave Huggins and Gary Malzer

Yield-soil relationships across the landscape. -- Pierre Robert, B.R. Khakural, and Dave Huggins

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