FIELD VARIATION IN SOIL FERTILITY: ITS ASSESSMENT AND MANAGEMENT FOR POTATO PRODUCTION

by
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Where does field variation in soil fertility come from?

Research utilizing intensive soil sampling has shown that spacial variations in phosphorus and potassium soil test levels are very common in production fields (2,4,5,9,11,14). These variations result from natural soil development patterns as well as man-made causes. The latter develop due to land leveling, incorporation of smaller fields into larger fields for automated sprinkler irrigation purposes, cropping patterns and past fertility management practices.

What is the effect of fertility variability on potato production?

The spacial variability of phosphorus and potassium levels has been identified to be a cause for both yield and quality reductions in potato production (10,11,13). Underfertilization of low testing areas will result in localized yield and quality reduction as well as the reduction of overall uniform quality of the crop. Where phosphorus and potassium deficiencies contribute to early senescence of the crop, tuber size is reduced. Specific gravities will be lowered due to reduction in photosynthesis and carbohydrate storage. As irrigation for the remainder of the season proceeds, excessive moisture levels develop due to low evapo-transpiration in the senesced areas. These conditions then contribute to excessive enlargement of lenticels and the development of "elephant hide". The potential for soft rot development also increases. Predisposition to blackspot is greater in areas that have senesced early (10).

Past management programs.

Attempts to compensate for low fertility areas by increasing fertilizer application rates will result in overfertilization of the rest of the field. This usually does not cause problems with yield and quality with the exception that high potassium levels have been implicated in lowering of specific gravities (7,12). Overfertilization is not economically efficient.

Past programs to manage for fertility variability have been suggested (1,3,4,9,11,13). These have been difficult to implement due to difficulties in accurate soil mapping and lack of technology for making practical variable fertilizer applications in the field to compensate for fertility variations.

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New management programs.

With the advent of intensive statistical analysis programs made feasible by computer technology, accurate soil fertility mapping and the development of fertility management maps is now available to production agriculture (8,14). The technology for variable fertilizer application, in both ratio of nutrients and application rates, as dictated by computerized management maps, is also available to production agriculture (6).

A brief description of such management work will now be presented. Data from a 126 acre potato circle that has been managed with such a program will be used for illustration.

Fields are intensively grid sampled and the samples are analyzed for phosphorus and potassium. The soil test data is then statistically analyzed via computer programs to show projected soil test phosphorus and potassium levels at 50 ft. intervals within the field. These results are depicted by contour-type maps showing the areas of various soil test levels (figures 1 & 2). The numbers on the contour lines indicate the ppm for the soil test levels. Data from 100, 200 and 400 ft. grids indicate that results from a 200 ft. grid are adequate but significant detail is lost at 400 ft. (14). More research is being done on optimum grid spacing.

To assist in visualizing the various soil test levels the contour-type maps may be converted into three-dimensional images via computer as shown in figures 3 and 4.

The soil test data is further analyzed by computer programs to over-lay phosphorus data with potassium data. The results are then organized into fertility management zones. The zones are established by designating cut-off levels for the soil test data. Up to five fertility management zones may be developed which may also be depicted on a map as shown in figure 5 which in this case shows three management zones that are delineated by labeled contour lines of 10, 20 and 30. Again the map may be projected visually as a three-dimensional image as shown in figure 6. The computer program also gives the average soil test values for each of the management zones as well as the acreage for each zone.

Using more technology that is now available, the data for the management zone maps are stored in permanent computer chips. These chips may then be inserted into a computer that controls fertilizer application equipment for making variable applications in the field. This equipment which is now commercially available can make applications that vary in both ratio and rate of applied fertilizer nutrients (6).

A comparison of the efficiency of fertilizer application by conventional and variable management programs is made in table 1. The recommended rates of phosphorus and potassium are based on the soil test data from the whole field in the case of the conventional program and on the soil test data within the management zones in the case of the variable management program.

The percentages indicated are for acres either over (O) or under (U) fertilized using conventional fertilizer application on the 126 acre circle. The zones A, B and C correspond to the management zones shown in figure 5 which are the areas delineated by contour lines 10, 20 and 30 respectively.

The effects on fertilizer cost are shown in table 2. Often the total fertilizer costs appear to be about the same with the difference being that the fertilizer is optimally placed where it is most needed for crop production.

The additional cost for variable fertility management is shown in table 3. Where only phosphorus and potassium are being managed the cost tends to be at about $10 per acre on a 200 ft. grid sampling program.

Further study on the benefits of variable fertility management.

Economic returns of such programs need to be considered for both the fertilizer input and yield and quality returns. The most likely return for many fields will be improved quality for the crop due to increased uniformity across the field. In low-testing areas an increase in yield is likely. Often the overall increase in the grade of the potato crop will bring more return than increasing yield in some parts of the field.

Preliminary data indicates that the effects of a variable fertilizer application for potatoes will extend into several more growing seasons providing more uniform soil fertility for other crops in the rotation sequence.

In the light of increased environmental concerns about fertilizer useage, the use of variable fertility management technology should be considered strongly for better environmental management. Research needs to be carried out on variable nitrogen application. The concepts of yield goals and practices to provide for maximum economic returns and minimum environmental effects must be futher developed. There is a need to develop fertilizer recommendation philosophies to accommodate farming soils instead of fields.

Summary

Intensive soil sampling along with variable soil fertility management is one of the steps in the process of providing maximum economic returns to the grower while contributing to better environmental management.

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FIGURE 1

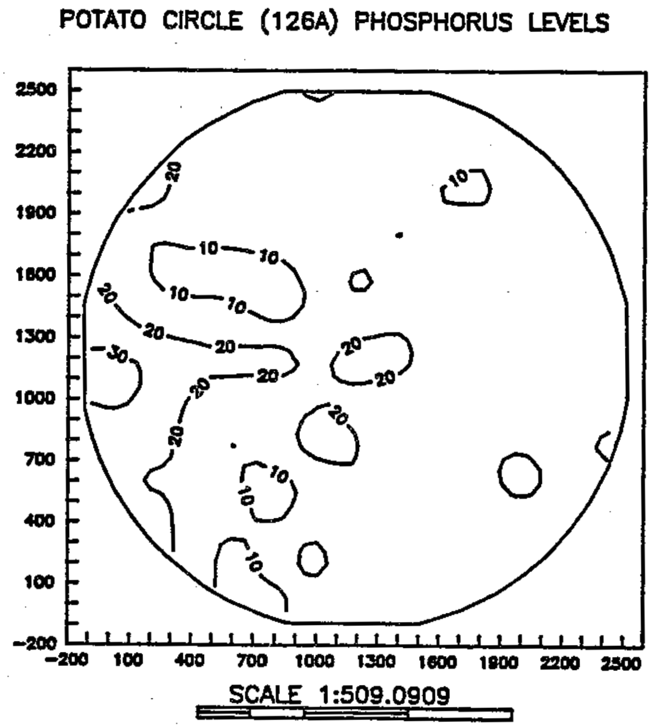
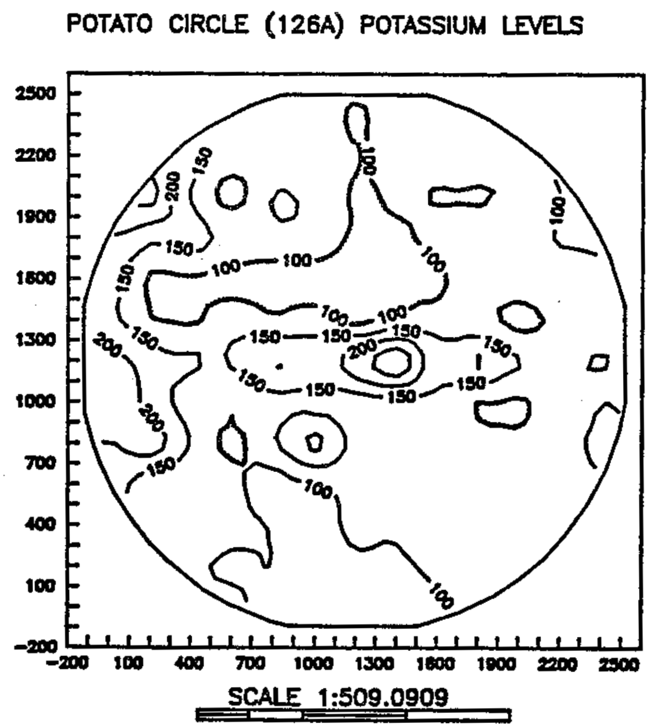
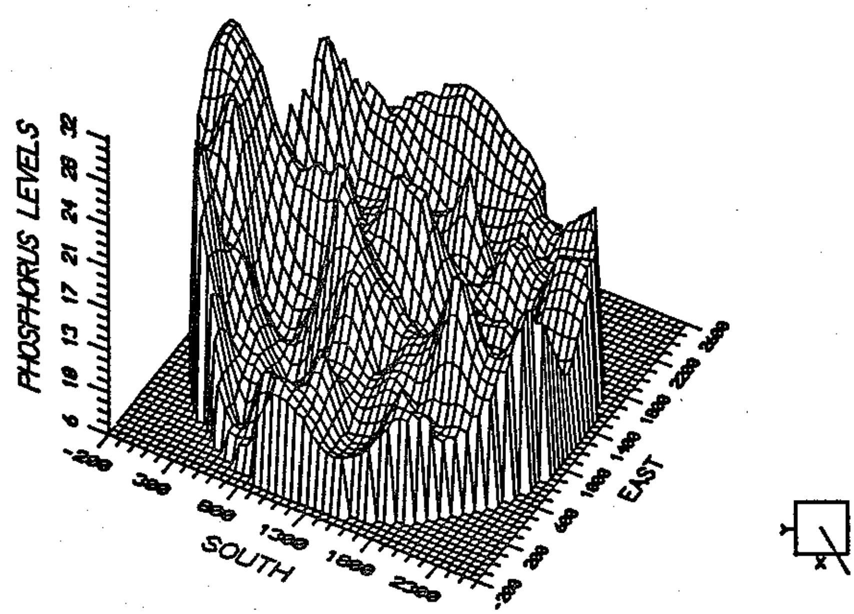


FIGURE 2



POTATO CIRCLE (126A) PHOSPHORUS LEVELS

FIGURE 3



POTATO CIRCLE (126A) POTASSIUM LEVELS

FIGURE 4

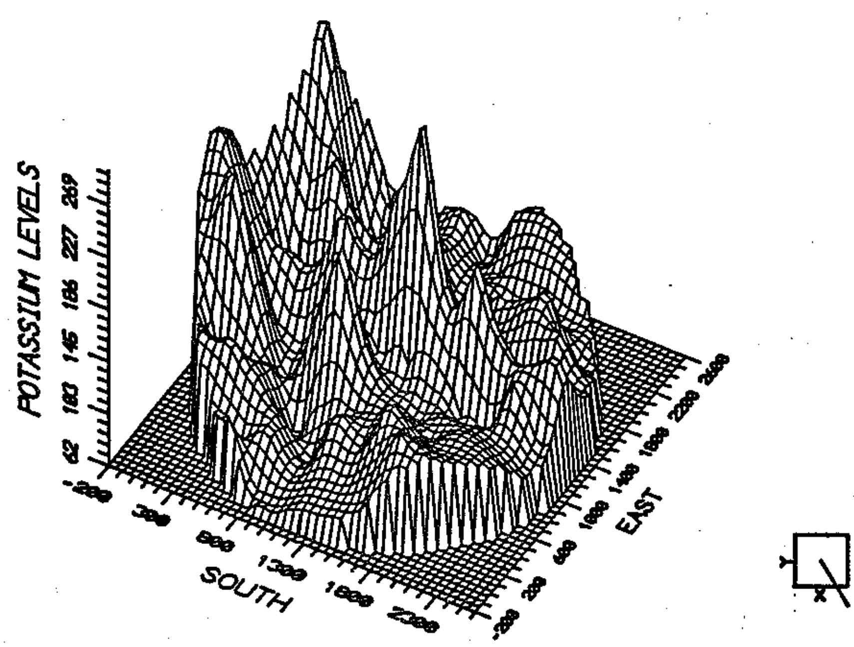


FIGURE 5

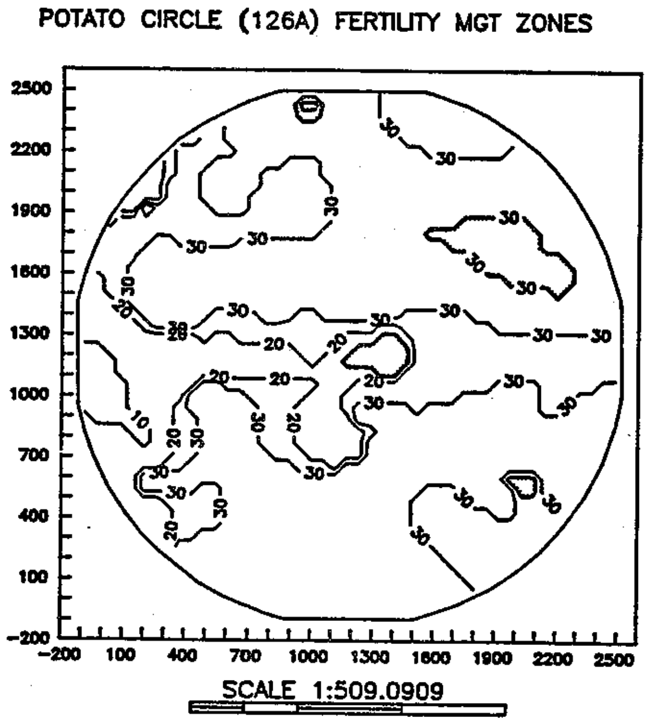


FIGURE 6

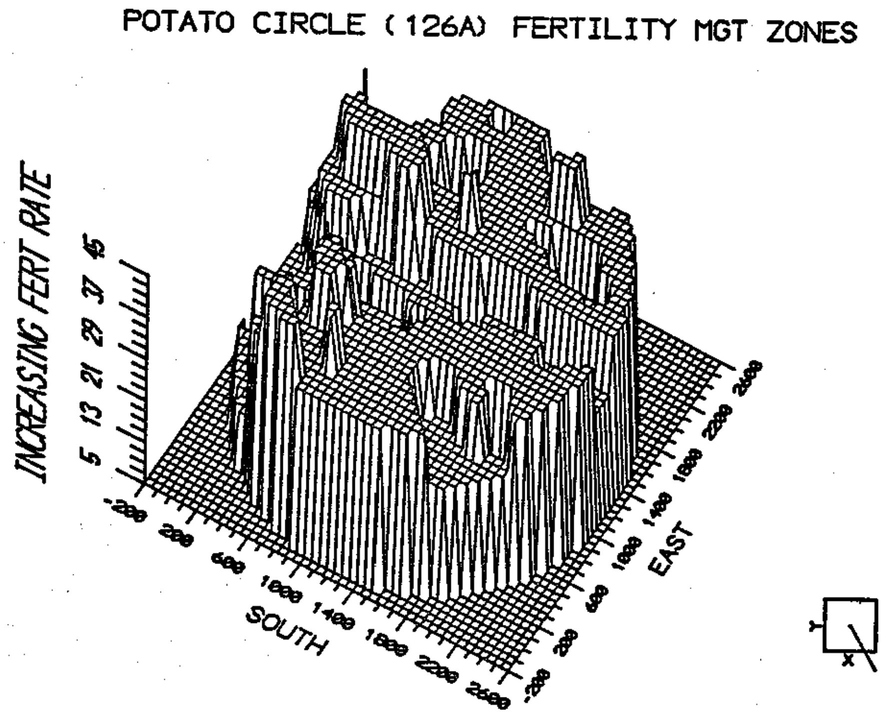


TABLE 1

APPLICATION EFFICIENCY
Conventional vs. variable mgt.

	Rec lbs/A	A over/under	
Phosphorus			
A zone	20	(O) 18%	
Conventional	150		
B zone	180	(U) 26%	(U) 82%
C zone	180	(U) 56%	
Potassium			
A zone	240	(O) 18%	(O) 44%
B zone	320	(O) 26%	
Conventional	340		
C zone	400	(U) 56%	

TABLE 2

126 ACRE POTATO CIRCLE

CONVENTIONAL MGT.	VARIABLE MGT.
REC./FIELD	REC./MGT.-ZONE
240 - 150 - 340 40S - 5ZN	A 120 - 20 - 240 B 120 - 180 - 320 C 120 - 180 - 400 40S - 5ZN
FERT. COST/A	FERT. COST/A-ZONE
$119.83	A - $ 74.08 B - 123.78 C - 140.30
TOTAL FERTILIZER COST	
$15,098.07	$15,676.35

INCREASE OF $578.28

INCREASE OF $4.59/A
OVER ENTIRE CIRCLE

TABLE 3

VARIABLE FERTILITY MANAGEMENT COSTS

Sampling & Analysis	$6.45/A
Mapping	.87/A
Spreading	2.50/A

Total	$9.82/A