OVER FERTILITY CAN BE A PROBLEM

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NUTRIENT REQUIREMENT FOR POTATOES

Potatoes have a high nutrient requirement. The high yields of potatoes commonly obtained in central Washington require relatively large amounts of the essential nutrient elements. Dr. Robert Kunkel has indicated that a 732 cwt per acre (36.6 T/A) crop of potatoes will remove, in the total plant, the following 1/:

Element	lbs/A Removed
N	291
P	56 (128 lbs P_2O_5)
K	328 (395 lbs K_2O)
Ca	58
Mg	31
S	26
B	0.2
Zn	0.2
Fe	5.0
Mn	1.5

WSU fertilizer recommendations for potatoes under certain conditions are high. Suggested rates in the current FR in terms of lbs N-P_2O_5-K_2O per acre run as high as 320-300-480. There is a suggestion that even higher rates may be used where very high yields are expected.

Dr. Kunkel has shown results where rates of fertilizer much higher than those indicated above were applied. The results indicate that apparently neither yield nor quality is harmed at high rates. This is in contrast to other crops which may be depressed in yield or harmed in quality from excessive fertility. Furthermore he has shown that probably the most efficient method of application is banding 2 inches to one side and 2 inches below the seed piece. This method of applying high rates of fertilizers means that there is an extremely concentrated band of fertilizer salt very close to the roots which apparently has no deleterious effect on the potato plant.

1/ Kunkel, R., "Potato Crop Nutrient Removal", Agrichemical West, Nov. 1969, pp. 8-10

CAN HIGH FERTILITY LEVELS LEAD TO TROUBLE?

Salinity

The high rates of fertilizers mentioned above may involve as much as 1 ton or more of fertilizer material per acre. Fertilizer material is salt- it is no different from other soluble salts which are involved in normal salinity problems. The salt index resulting from a certain rate of fertilizer application can be roughly predicted as follows:

Fertilizer material applied = 2000 lb/A

$$\text{Percent salt in the soil if mixed into the upper 6 inches} = \frac{\text{2000 lb fertilizer salt}}{\text{2,000,000 lbs of soil}} = 0.1\%$$

A salt concentration of 0.1% in a medium-textured soil would result in salt index of between 3 and 4 mmhos/cm.

Now it happens that a salt index of 3 or 4 is where we begin to become concerned about salinity and the effects of salt on plant growth. Fortunately this is not as bad as it appears. Young plants begin removal of nutrients very early in their growth. In addition, the salts are redistributed and moved downward by irrigation water, thus lowering the concentration at a given point.

However, growers should be aware that recommended rates of fertilizer can result in surprisingly high salt index levels. Under normal conditions there is not likely to be a problem during the current season. The problem may arise in succeeding seasons if fertilizer salts are not removed but are allowed to accumulate. It can readily be seen that within a very few years the salt index could easily reach toxic levels. The degree of accumulation of fertilizer salts in the soil will depend on the following:

1. The size of the crop. If fertilization is for a high yield of potatoes, but if the potatoes are lower than expected, part of the fertilizer will not be used. This could happen either because the potatoes were harvested earlier than expected or because there were other factors limiting production. This emphasizes the importance of predicting yield as accurately as possible and then fertilizing for that expected yield.

2. The method and amount of irrigation water applied. The sprinkler method is much more efficient in leaching salts downward than the rill method. In either case the amount of leaching is nearly always related to the amount of water applied.

An example

Although salinity is not a very common problem in potato fields, salinity problems have been observed.

A demonstration trial in a Norgold potato field in Franklin County was set up. Areas of extremely poor plant growth were prevalent in an otherwise excellent field of potatoes. Preliminary soil tests indicating borderline levels of salt index led to the possibility that salinity may have been a factor. A program was worked out with the grower where heavy applications of water were applied by flooding in October 1968 after the potatoes were harvested. Results of soil tests taken in November 1968 are shown in Table 1.

Table 1. Salt Index Levels (mmhos/cm) Before and After Flood Irrigation in a Franklin County Potato Field

Soil Depth Inches	Before Irrigation Sept. 20	After 1 Irrigation Oct. 2	After 2 Irrigations Oct. 26
0-6	5.3	0.5	0.6
6-12	2.9	0.5	0.4
12-18	1.8	0.4	0.4
18-24	1.6	0.4	0.4

The field was again cropped to Norgold potatoes in 1969. In July of that year soil samples were again taken for salt index readings. The results are shown in Table 2. It will be seen that the differences in salt level are rather small in the surface six inches. Nevertheless the difference between 4.0 and 5.1 may be critical. The big differences are in the salt levels below the 6-inch depth. Growth and symptoms were closely associated with salt index levels from the three areas.

Table 2. Salt Index Levels in a Franklin County Potato Field in July 1969.

	Depth Inches	Salt Index mmhos/cm
Area Flooded - normal growth	0-6	4.0
	6-12	2.0
	12-24	0.7
	24-36	0.4
		Avg. = 1.4
Area Not Flooded - growth slightly depressed	0-6	5.1
	6-12	2.6
	12-24	3.2
	24-36	2.2
		Avg. = 3.1
Area Not Flooded - Sick Plants - growth severely depressed	0-6	5.1
	6-12	5.1
	12-24	5.1
	24-36	4.0
		Avg. = 4.7

The effect of leaching of salts on potato growth can be seen in Figure 1.

It should be pointed out that accumulation of salts, either from fertilizer or from other sources, was difficult to avoid. There were impermeable or slowly permeable layers in the soil below 2 to 3 feet making it difficult to move salts downward with normal irrigation practices. If possible, such hardpan layers should be shattered by subsoiling. In any case, careful irrigation and an occasional over-irrigation may be necessary to remove salts.

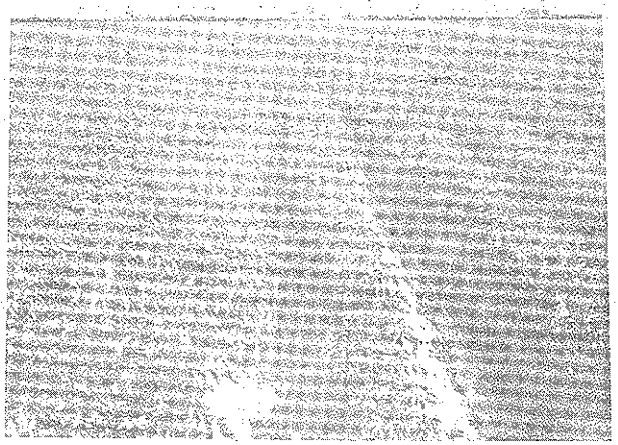

Figure 1. Franklin County potato field showing the effect of salt level on the growth of potatoes. The area on the left was flooded and had a lower salt level than the untreated area on the right.

Consider the Crop Which Follows

Some crops are more salt sensitive than others. Potatoes are medium with respect to salt tolerance. They may be less sensitive than the crop which follows. The senior author has observed a number of instances of reduction in growth or even total crop failure where salt--previously from fertilizer--was at fault. A case in point was the severe growth depression in several hundred acres of peppermint in an area of central Washington. The peppermint had followed several years of heavily fertilized potatoes. Very high yields of potatoes were obtained but the mint crop was a near failure. Salt index readings of 5 to 10 were measured on soil samples taken from the surface few inches where the mint roots were concentrated.

What About Nitrates?

It is not precisely known what the effect is on potato growth or quality of very high concentrations of soil nitrogen. We have already indicated that fairly high levels do not seem to be harmful. This effect is more precisely known for other crops. Consider an example of sugar beets following potatoes. There may remain a medium to high level of nitrogen after the potatoes. If the level is not known--and it can only be measured by soil test--a grower could apply a "normal" amount of nitrogen

for the sugar beet crop but could easily and unwittingly end up with an excessive amount of nitrogen on the sugar beets. Sugar beet growers are well aware of the problem of reduced sugar content and reduced sugar yield where the crop does not run out of nitrogen by September 1. In 1967 Dr. D. W. James, Soils Scientist at Prosser, soil tested 12 prospective sugar beet fields for nitrates and found that 10 of the 12 were sufficiently high that not nitrogen fertilizer was needed. Had nitrogen been applied to those 10 fields, reduction in sugar yield and in profits would surely have been the result.

Additional comments could perhaps be made regarding nitrates and pollution, but these are outside the scope of this paper. If agriculture is not the main contributor to the nitrate problem, perhaps we should avoid giving the public reason to believe that it is.

Nutrient Balance

Nutrient balance is a very involved subject and cannot be justly dealt with in this paper. At the present time we do not know how to attain an ideal "nutrient balance" except to (1) keep all nutrient elements at an adequate level and (2) avoid amounts known to be excessive.

However, we do know of some specific instances of nutrient "imbalance" in central Washington potatoes. We will mention two:

1. At medium levels of zinc, excessive rates of phosphorus can create an imbalance resulting zinc deficiency.

2. At medium levels of potassium, a high rate of magnesium resulted in severe potassium deficiency in one case. There was little or no potassium deficiency where the magnesium had not been applied.

Soil Test to Avoid Trouble

One of the main objectives of this paper is to emphasize the need for using the soil test--not, in this case, as a basis for determining fertilizer needs--but as a tool for determining when not to fertilize. It can also tell you what not to apply. It may also tell you that you need to apply extra irrigation water to lower the salt index level.

All WSU standard soil tests include the salt index. This should be watched very carefully. If it rises to 2 or more, additional samples, including subsoil samples, should be tested for salt index. Growth may be depressed in areas where the salt index level is 4 or more. These salts may or may not have come from fertilizer.

The nitrate-nitrogen test is very useful in avoiding an over supply of nitrogen. This is especially useful for crops such as sugar beets that are sensitive to high levels of nitrogen late in the season.

Nutrient imbalance can be frequently predicted in the soil test. The soil test will readily detect excessive amounts of any element tested. Excessive amounts of toxic element such as boron will be shown in the soil test.

SUMMARY COMMENTS

1. High yields of good quality potatoes require high levels of fertility .

2. Apparently quite high concentrations of fertilizer salts near the roots of potato plants are not harmful.

3. The truth of points Number 1 and 2 could lead to trouble. Fertilizer rates for maximum production, if used repeatedly and if not removed by cropping or irrigation water, can accumulate to dangerously high salt levels. This could be harmful for potatoes or for other crops which follow in the rotation.

4. The soil test is a necessary tool for the prevention or correction of certain soil chemical problems. Some of these problems are (1) high salt levels, (2) high nitrate levels, (3) certain toxic elements, and (4) nutrient imbalance.