POTASSIUM AVAILABILITY VERSUS POTATO PRODUCTION IN CENTRAL WASHINGTON SOILS

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The overall picture on the potassium fertilizer requirements for production of potatoes, under central Washington conditions, is far from complete. Despite this fact, more is known about the potassium situation on potatoes than for any other crop grown in this area. In order to improve on this situation a rather broad research program has been implemented at the Irrigation Experiment Station which is designed to provide more information on the problem of soil-plant relationships, respecting potassium, for crops in general. This report will deal with some of the results obtained for potatoes in 1963.

That potassium may indeed be a production limiting factor for potatoes in central Washington was established clearly in 1960 by Dow and Kunkel.[1/] They observed, and documented in detail, potassium deficiency symptoms in two different field experiments that year. They showed that the deficiency symptoms were associated with low levels of K in the soil and in the plant and that the symptoms could be eliminated through the use of potassium fertilizer. Appreciable yield increases were obtained in both experiments using 83 pounds of K per acre (100 pounds of K_2O per acre).

The potassium situation in potatoes has developed to the point where, at the present time, potassium is regarded as a potential limiting factor for potato production throughout central Washington.

In order to obtain more information on the potassium nutrition of potatoes in our area, two major problems need to be analyzed. These are:

(1) What is the best method of assessing the relative availability to plants of the potassium in the soil?
(2) If the soil contains inadequate quantities of available potassium, how much potassium fertilizer should be added to obtain the best results.

These two problems will be discussed separately.

Estimating Available K in the Soil

Routine laboratory analyses of soil samples are utilized extensively in this state and elsewhere as an aid in making fertilizer recommendations.

1/ A. I. Dow and Robert Kunkel, "Fertilizer Tests with Potatoes," March 1963. Experiment Stations and Extension Service, Washington State University.

A question which is being raised continually is just how good is the soil test for estimating available plant nutrients?

The best method for assessing the relative value of the potassium soil test is to compare the soil test index for K with potassium in the plant during active growth and with the final yield results. This kind of evaluation was performed during 1963 in an experiment which was conducted at the Columbia Basin Research Unit #1 (Othello).

Potatoes which were planted on April 4 were tissue sampled on June 27 and again on July 28. The tissue sample consisted of petioles taken from the 4th node down from the terminal bud. About 20 petioles were composited from each plot. Yield measurements were made on September 26 with the cooperation of Robert Kunkel.

The association between K in the petiole and the soil test K index is shown in figures 1 and 2 for the 1963 experiments. Figure 1 shows the scatter diagram for trial A and the regression and correlation coefficients for trials A and B. Trial A received 375 pounds of nitrogen per acre and trial B received 150 pounds of nitrogen per acre. The correlation coefficients of .95 and .88 for the two cases indicate that the soil test for K is a very good indicator for the availability of soil K. It should be noted that trial B had a narrower spread in the range of soil test values. This undoubtedly accounts in part for the lower correlation coefficient.

Figure 2 shows the effect of sampling time on the amount of K which occurs in the plant for trial A. Both sampling times indicate that the K in the petiole changes by 1.5% for each change of 100 on the soil test scale. The average K percentage dropped by about 1.8% during the one month interval between the two samplings. The correlation between sampling times and within plots was close to 100% indicating that there was very little sampling error.

The yield of potatoes in pounds per plot is shown as a function of soil test K in figure 3. The solid line in figure 3 is not a curvilinear regression line. The true curvilinear regression line had not been calculated at the time of this writing. There is considerable scatter of the points in figure 3 but the indication is clear that the average yield of tubers increased as the soil test K value increased up to about 350. Beyond 350, increasing amounts of available K in the soil had no further effect on yield of potatoes. In comparing the data given in figures 1 and 3, it becomes apparent that considerable luxury consumption of K took place where the soil test indicated high levels of availability.

The association between quality factors and soil test is of interest also. In the 1963 results a change in the per cent of number 1 potatoes seems to have occurred at about 200 on the soil test scale. Below 200 the

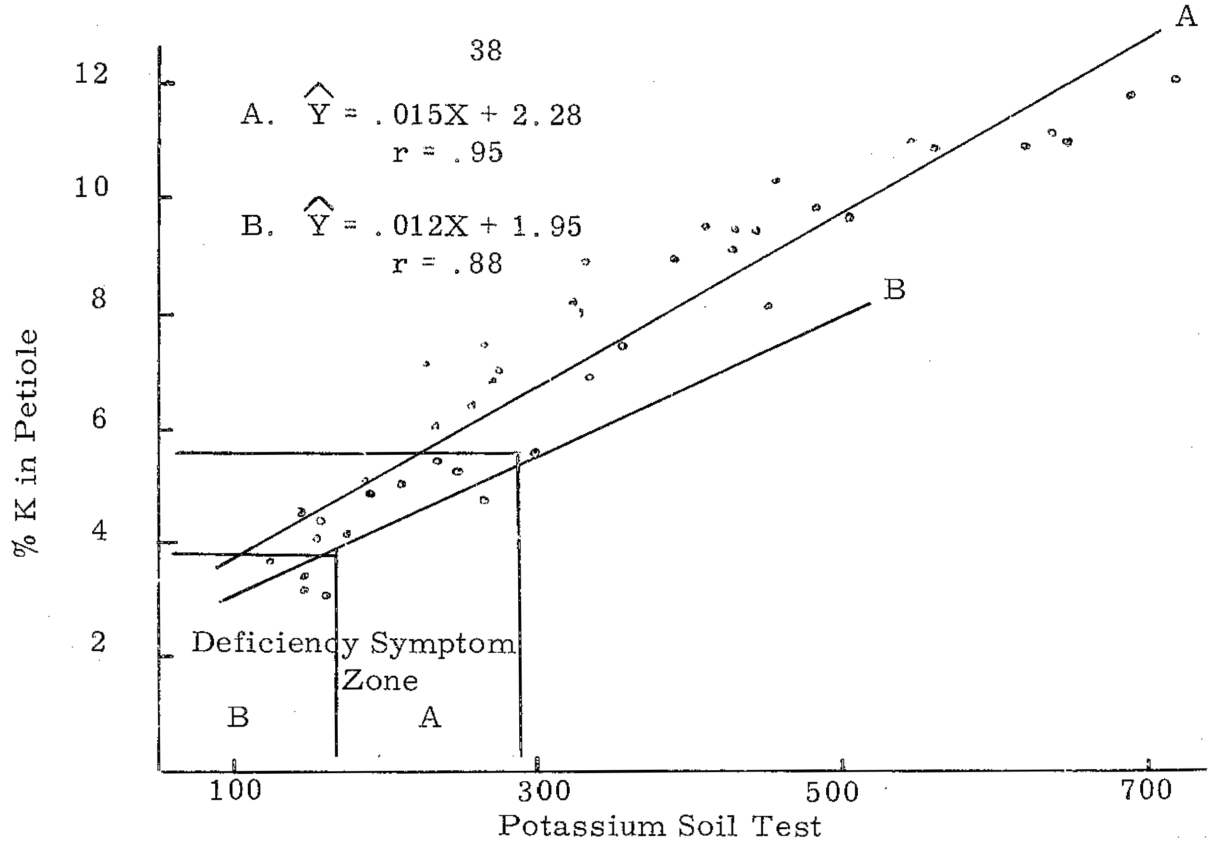

Figure 1. Relationship between K soil test, K in the plant and K deficiency symptoms for trials A and B. Data points for trial B not shown.

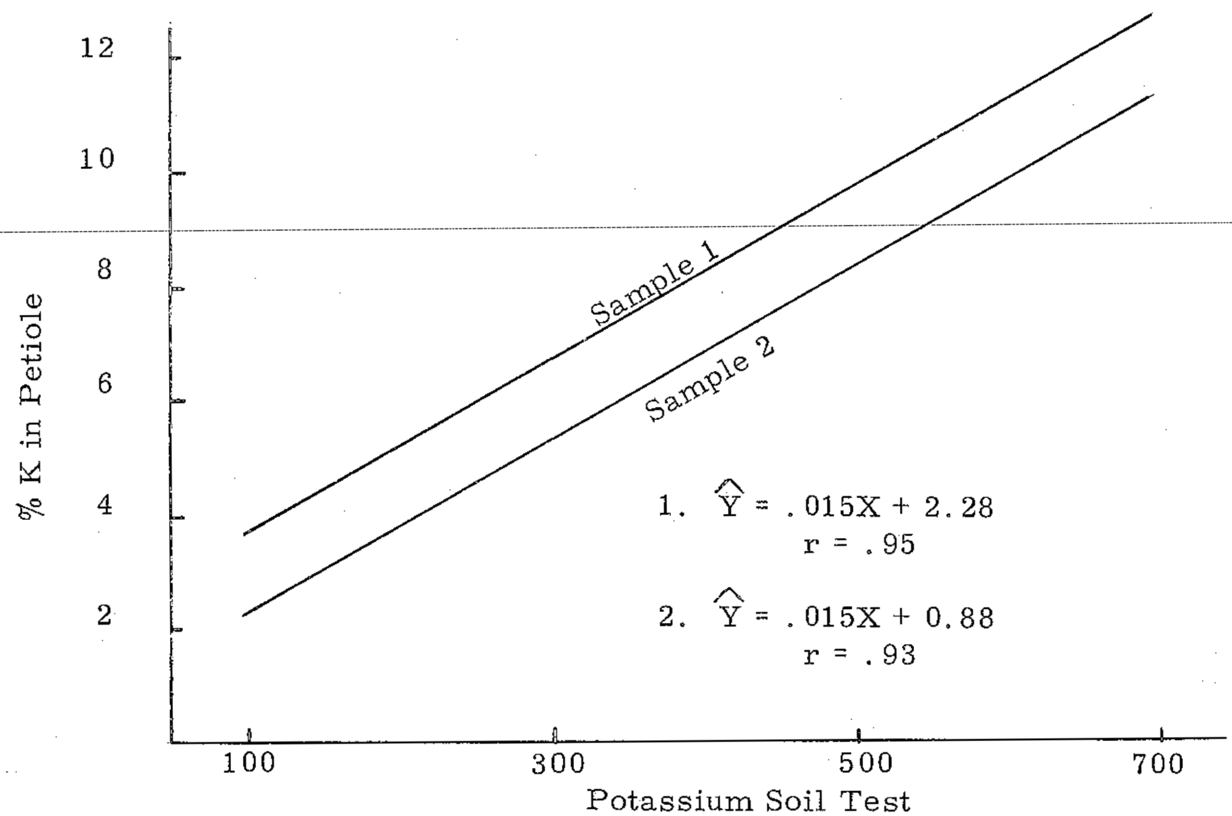

Figure 2. Affect of time on K levels in plant. Sample 1 taken June 27; sample 2 taken July 28. In the equations $\hat{Y}$ is the estimated K content of the petiole and X the soil test.

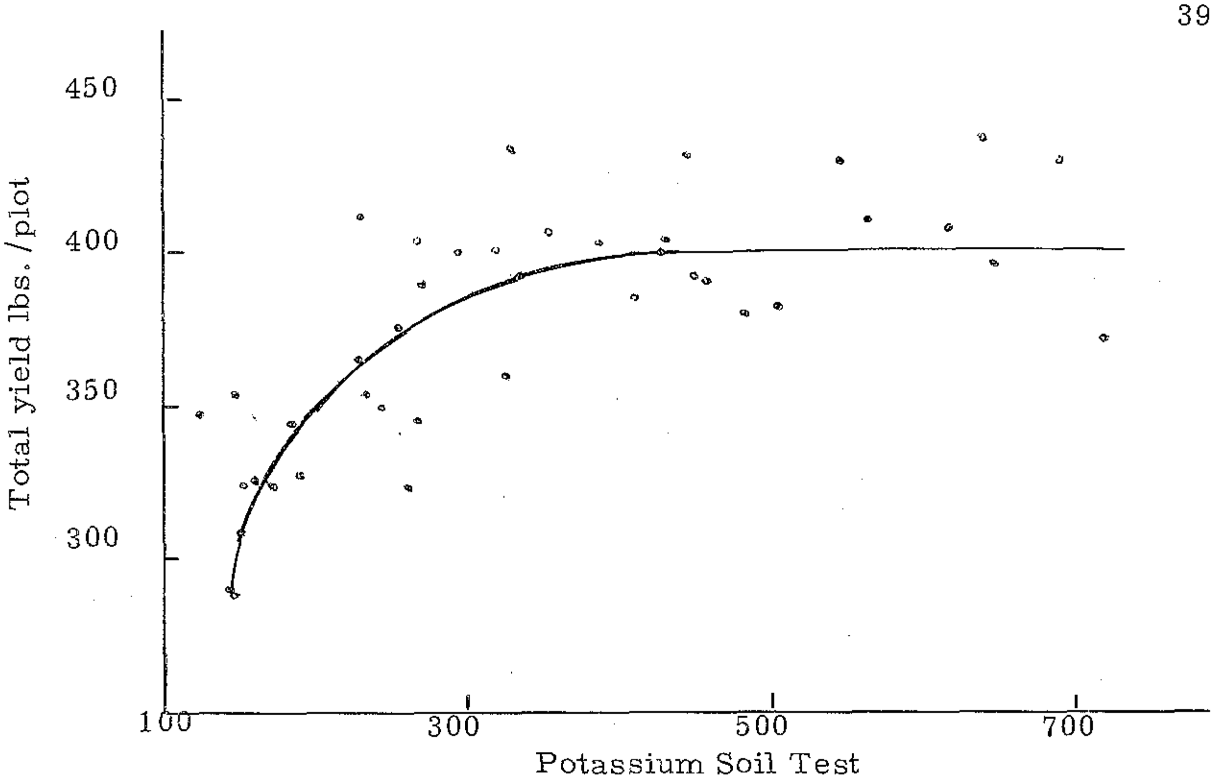

Figure 3. Relationship between K in the soil and total yield of potatoes. On a per acre basis, the yield curve levels off at 668 cwt. /A.

number ones averaged about 72%; above 200, the number ones averaged about 80%.

The net yield of number one tubers followed about the same pattern as the total yield. The average yield of number one potatoes in plots testing about 300 was 22% greater than for plots testing below 300.

From the foregoing results it would appear that the soil test for potassium is unquestionably valid as a tool in estimating the amount of available soil potassium. (It should be emphasized at this time that the results shown here for potatoes can not be applied to crops in general. Time and space do not allow for a discussion of all the considerations involved but suffice it to say that the potassium uptake pattern of potatoes is considerably different from that of most other crops. Nevertheless, with regard to potatoes in particular, the results given here are re-assuring indeed.)

Having discussed the question on the validity of the soil test, it is apropos that we discuss the significance of the soil sample. It is obviously necessary to obtain a representative soil sample if the soil test is to have any meaning.

The general recommendation of the Extension Service and the Experiment

Stations is that a soil sample should be a composite subsample of many randomly taken soil cores. However, the term random needs to be applied with caution. Anyone acquainted with soils of the Columbia Basin knows that many fields in this area are not uniform. Extreme differences can be observed, in fields which have been leveled, simply by visual inspection.

Soils of central Washington are characterized by a non-calcareous, medium to coarse textured surface material. From the point of view of irrigation farming, the soil initially may be medium to high in available potassium, medium to low in available phosphorus and low in nitrogen. The subsoils of this area almost invariably are calcareous; calcium carbonate content is usually 5% or lower but one field is on record as having 10% $CaCO_3$. This calcareous subsoil, for all practical purposes, has no available N, extremely low levels of available P and usually low levels of K.

It is obvious in a field where the subsoil has been exposed by leveling that two entirely different fertilizer schemes are called for. On the one hand, during the first year or two of cultivation, the noncalcareous soil will require little if any K and the calcareous soil will require upwards of 320 pounds of K per acre (400 lbs. K_2O/A). On the other hand, the noncalcareous soil will require only 22 to 44 pounds of P per acre (about 50 to 100 lbs. P_2O_5/A) while the calcareous soil will require rates of P as high as 130 pounds per acre (about 300 lbs. P_2O_5/A). Thus, two different "random" soil samples are required in order to determine the fertility status of leveled fields.

The pattern of cut areas in fields vary from small spots a few feet in diameter to large areas several acres in size. See figure 4 for examples. The relative size and frequency of exposed subsoil areas will have to be assessed to determine the practicality of fertilizing the spots separately from the "normal" surface soil. Or, if the spots are not to be fertilized separately, whether to fertilize the field to meet the requirements of the calcareous or the noncalcareous soil. Certainly it is an important decision to make because large quantities of fertilizer on non-calcareous soils are extremely undesirable and uneconomical. At the same time only "ordinary" rates of fertilizer on calcareous soil will probably result in 1/3 to 1/2 of the yields which these soils are potentially capable of producing.

With careful attention to the details, the difficulty of the problem of how to fertilize leveled fields decreases with time. Over a period of years, the high levels of plant nutrients (e. g. K) in certain areas will be reduced by crop removal and the low levels of nutrients (e. g. K and P) will be increased by the carry-over of applied fertilizers. Thus, the extremes will move toward moderate levels or a more uniform fertility status for the whole area.

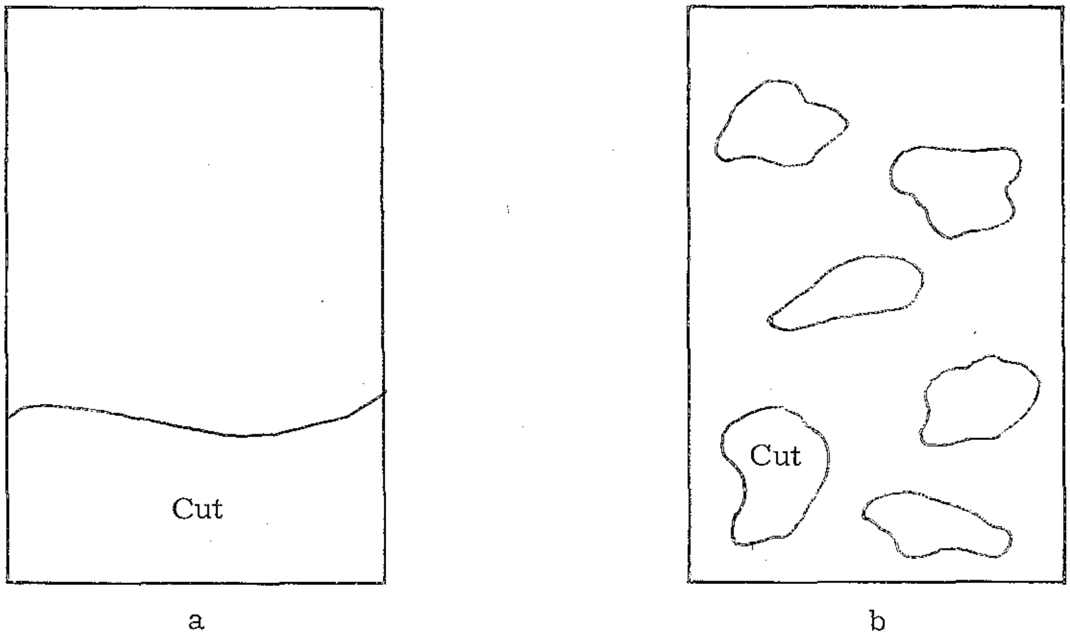

Figure 4. Patterns of subsoil exposure resulting from land leveling.

(a) This pattern is commonly observed, the cut area may be up to 5 acres or more where long ridges have been leveled. It would be a simple matter to obtain soil samples from the two distinctly different areas, and to use two different fertilizer practices.

(b) The difficulty of soil sampling and fertilizing irregular spots will depend on their relative size and frequency. Probably the simplest approach to a situation like this would be to formulate the fertilizer according to the needs of the "normal" uncut areas and then to double over the cut spots for an extra dose.

How Much Potassium to Apply

A thorough discussion of question number 2, i.e. how much potassium fertilizer to apply to obtain the best results, is beyond the scope of this paper. An intelligent statement on this question can be made only if the amount of available nitrogen in the soil is known. The importance of this concept is demonstrated in the results of trials A and B referred to in figure 1. These trials were originally designed to demonstrate the effect of nitrogen on K uptake. But this aspect of the experiment failed because of the large carry-over of nitrogen from two previous years of beans on trial B. The high average yield for trial B, 540 cwt./A using only 150 pounds of nitrogen per acre, dramatizes the effect of residual nitrogen.

The soil test for available nitrogen, which is now being adapted for use on irrigated lands at the Irrigation Experiment Station, in conjunction with the soil test for K, will eventually be utilized to great advantage in making recommendations for both the amount of nitrogen and potassium fertilizer to be used for potato production in this area.