Soil Potassium for Potatoes

depletion of soil potassium by cropping necessitates potash fertilization in certain areas of Kern and Tulare counties

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Fertilizer experiments—and a nutrient survey during the 1958 spring season—showed that some fields in Kern and Tulare counties are being depleted of exchangeable soil potassium to the point of deficiency, through frequent cropping to potatoes.

Potatoes as a crop are one of the heaviest known feeders on potassium. Nutrient removal studies in the Kern area showed that a 400-sack per acre crop of potatoes removed from the soil more than 250 pounds of potash—K_2O—per acre, while over 200 pounds were removed by the tubers alone.

With such large quantities of potassium being removed annually by the potato crop, available potassium in the soil is reduced considerably, unless weathering of the potassium minerals occurs at rates sufficient to replenish the supply.

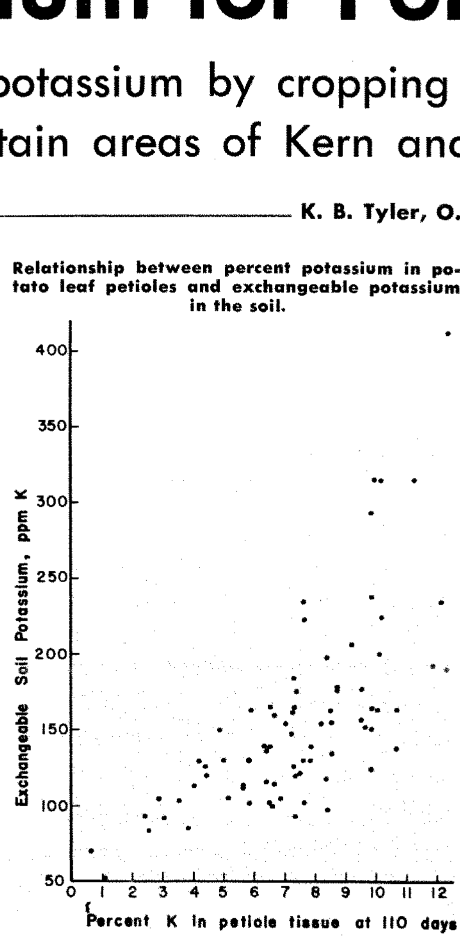
To determine the extent of soil potassium depletion by frequent potato cropping, eight experiments were conducted in certain areas of Kern and Tulare counties. The plots selected were where previously observed foliar symptoms and plant tissue analyses indicated that a response to potash fertilization might be realized. An additional 20 fields in Kern County were chosen at random for making a nutrient survey of White Rose potatoes.

Soil and Plant Potassium and Yield from Eight Field Experiments in Kern Area—1958

Field	Soil pH	Exchangeable Potassium (K_2O) ppm	Percent Potassium (K) in Petiole At the last sampling: No potash	Percent Potassium (K) in Petiole At the last sampling: 200 lbs. K_2O	Yield cwt/acre: No K_2O	Yield cwt/acre: 200 lbs. K_2O
Cropped	6.0	101	7.8	10.6	211	230
Uncrop.	7.8	193				
Cropped	4.6	106	4.8	8.7	156	175
Uncrop.	6.7	275				
Cropped	4.6	104	7.4	9.2	195	217
Uncrop.	6.6	180				
Cropped	4.7	105	4.5	6.4	194	206
Uncrop.	6.9	287				
Cropped	6.9	70	0.6*	5.8	174	224
Uncrop.	6.7	201				
Cropped	7.0	46	1.1*	5.4	194	266
Uncrop.	8.0	132				
Cropped	7.1	101	4.2	7.6	296	304
Uncrop.	7.8	435				
Cropped	7.4	93	2.4*	5.2	370	391
Uncrop.	6.0	149				

*Considered to be in range of K deficiency (less than 4% K at late season).

Relationship between percent potassium in potato leaf petioles and exchangeable potassium in the soil.



Samples of soils from the experimental plots and survey fields were taken from the plow layer prior to planting and fertilizing. Soil samples were collected also from adjacent areas which had not been cropped.

Comparisons of the exchangeable potassium content of the cropped and uncropped soils as shown in the accompanying tables indicate that as a result of cropping the potassium available to plants has decreased in some soils to levels as low as one fourth that in the adjacent uncropped soils. Although these potassium differences between cropped and uncropped soils were appreciable in most of the 20 survey fields, they were generally of lesser magnitude than the differences in the eight experimental fields which were known to be deficient in potassium.

The 1958 studies—and previous experiments—demonstrated that when exchangeable soil potassium is below 100 ppm—parts per million—it is in the deficiency range for potatoes. In these studies exchangeable soil potassium was determined by leaching 50 grams of soil with 500 milliliters of neutral, normal ammonium acetate and analyzing the leachate for potassium. In three of the eight field experiments, potassium was deficient and in the other five fields it was bordering on deficiency. Plant tissue analyses of petiole samples from the same fields verified the fact that potassium was deficient in the three fields and low in the remaining five. Yield responses to potassium fertilization were observed in all eight fields with the greatest responses in fields where exchangeable soil potassium was lowest.

Some of the older fields of the 20 in the survey were on the borderline of potassium deficiency for potatoes as indicated by plant and soil analyses. In two fields which were more recently brought under cultivation and where steer manure had been applied before planting, the exchangeable soil potassium was in excess of 300 ppm in the cropped soil and over 400 ppm in the uncropped. These were the only soils of the entire study where potash application failed to bring about a marked increase in the foliar potassium content of the potato plants. Even in soils which were considered to have adequate levels of exchangeable potassium—above 150 ppm—potash fertilization resulted in higher levels of potassium in the petioles.

In all fields considered there was good

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Soil and Plant Potassium from 20 Potato Nutrient Survey Fields in Kern County—1958

PPM exchangeable Potassium (K): Cropped soil	PPM exchangeable Potassium (K): Uncropped soil	Percent Potassium in Petiole[1]: No K applied	Percent Potassium in Petiole[1]: 200 lbs. K_2O applied[2]
100	160	5.8	8.4
103	178	2.8	6.4
108	150	7.8	8.3
112	150	3.7	5.2
119	198	7.1	11.7
128	130	6.4	7.2
131	121	7.6	8.8
133	315	7.9	9.5
145	240	6.6	9.7
147	189	5.9	9.0
160	232	7.0	8.0
164	179	10.0	11.4
165	310	6.5	9.8
171	319	8.0	9.5
174	258	7.3	10.2
192	365	5.9	8.9
204	325	9.6	10.4
207	242	7.8	8.8
334	422	10.9	10.8
363	410	8.6	8.5

[1] At last sampling of season, average of 4 samples.

[2] Applied after planting in addition to growers' fertilizer treatments.

BRUSSELS SPROUTS

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grams of carbon dioxide per kilogram per hour, and at 68°F was 190 milligrams of carbon dioxide per kilogram per hour, a fivefold increase over the temperature range studied. At higher temperatures, rates dropped off rapidly during the first six days in storage, and increased again toward the end of the storage period, a phenomenon associated with the appearance of decay organisms. At lower temperatures the rate of respiration declined gradually for the first 10 days, and leveled off for the remainder of the holding period. The number of days before half of the sprouts in a sample reached a quality rating of 3—unsalable—is indicated by the termination of each curve in the graph.

Time and Temperature

Over the temperature range studied, decreases in temperature resulted in decreases in deterioration rate. Most rapid loss of green in the outer leaves occurs at 50°F or above and is associated with decreasing quality of Brussels sprouts. In the present study, a yellowing of sprouts was the major symptom of deterioration at high temperatures. At lower temperatures the sprouts retained green color, and deterioration was expressed through gradual changes. At 32°F, and to a lesser extent at 41°F, the slight deviation of the quality ratings from a linear function can be explained as three phases of symptom expression rather than as the single phase shown at higher temperatures. Thus, during the first 30 days in storage at 32°F, deterioration was expressed by a loss of bright green color, with the sprouts deteriorating to a rating of between good and fair. During this period from 50 days to about 70 days appearance changed very little, and finally, deterioration was associated with black specking and subsequent decay.

Regression Coefficients (b values) for Quality Loss of Brussels Sprouts as a Function of Time. Tests 1 and 2 were started in December 1957 and in January 1958.

Temperature °F	Regression coefficient (b) Test 1	Test 2
32	−0.0560	−0.0535
41	−0.1113	−0.1169
50	−0.2362	−0.2281
59	−0.3982	−0.4071
68	−0.5147	−0.5215

Estimated Deterioration of Brussels Sprouts Under Desirable and Undesirable Handling, Transporting and Marketing Conditions for a Hypothetical Transcontinental Shipment. Deterioration Expressed in Terms of the Time Required for an Equivalent Amount of Deterioration to Occur at 32°F.

Handling period and assumed conditions	Deterioration equivalent expressed as days at 32°F: Desirable*	Undesirable
Before cooling:		
Desirable		
4 hrs. at 50°F	0.7	
Undesirable		
10 hrs. at 59°F plus 18 hrs. at 41°F**		4.6
Rail transit:		
Desirable		
6 days at 32°F	6.0	
Undesirable		
13 days at 50°F		57.2
Marketing:		
Desirable		
1 day at 41°F	2.0	
Undesirable		
4 days at 50°F		17.6
Total equivalent days	8.7	79.4
Estimated quality (salability)	Good+	Fair−

* Desirable—assumed minimum time at desirable temperatures. Undesirable—assumed conditions of undesirable time and temperatures.

** Equivalent to an overnight holding period.

The data showing the relationship between time and temperature on quality deterioration are in general agreement with previous findings. The high correlation shown in the graph on page 11 demonstrates the usefulness of the visual rating scale used in this study to describe quality deterioration of Brussels sprouts. Since total storage life depends on average rate of deterioration, the rate at each temperature studied was related to the total storage life at 32°F. Thus, at 41°F the sprouts deteriorated 2.0 times as fast as those held at 32°F, while at 50°, 59°, and 68°F, the relative rates of deterioration were 4.4, 7.3, and 10.0 times as fast as at 32°F. This information was used to illustrate the slower rate of deterioration under desirable handling, transporting and marketing conditions.

Temperature markedly influenced the rate of respiration of Brussels sprouts; respiratory activity decreased as temperature decreased. Carbon dioxide production was greatest at temperatures which most favored rapid quality loss. This response is characteristic of many cool season crops. Initial respiratory activity declined rapidly at higher temperatures, and gradually at lower temperatures, followed by a leveling off.

The respiration rates and quality deterioration data emphasize the value of low temperature in extending the storage life of Brussels sprouts.

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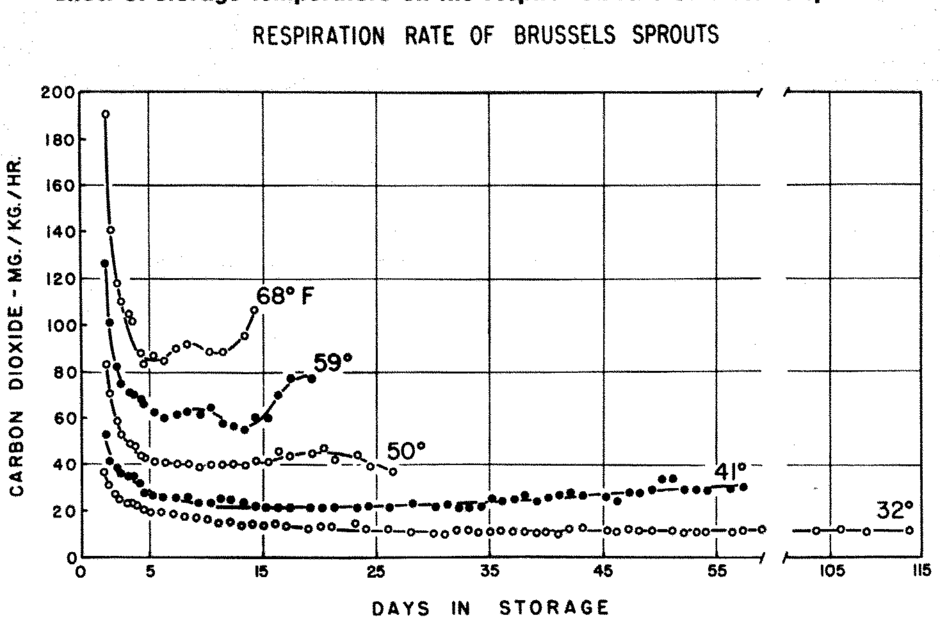
Effect of storage temperature on the respiration rate of Brussels sprouts.



POTATOES

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agreement between the amount of exchangeable potassium in the soil and the amount of potassium absorbed by the plants grown on these soils. According to the graph on page 8, where potassium in the plant samples fell below 4%, exchangeable soil potassium generally was less than 100 ppm. Conversely, where potassium in the plant was above 8% at 110 days, exchangeable soil potassium was observed to be in the sufficiency range or above 150 ppm.

In these investigations it was noted that soil reaction has been considerably reduced over the years through continuous use of acidifying fertilizers such as ammonium sulfate and through the addition of sulfur for potato scab control. In three of the eight soils, for example, the pH—relative alkalinity-acidity—had been reduced by as much as two full units. Liming of two soils where the pH values were acid—below pH 5—resulted in increased potato yields and in more vigorous and healthy appearing potato plants.

These studies have shown that frequent cropping to potatoes has been an important factor in depleting the exchangeable potassium of the soils, and potassium fertilization is becoming increasingly necessary to maintain high potato yields. With the current practice of applying copious quantities of ammonium fertilizers, soil pH has been dropping to dangerously low levels—in some soils—and corrective measures are necessary to restore the soil pH to safe levels.

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LYGUS BUGS

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counts and were higher than for other treatments in the experiments. Three factors were probably responsible for the high populations. *1.* The individual plots were bounded by less effective treatments from which heavy migrations of adults occurred. *2.* There appeared to be a large hatch of nymphs from eggs laid prior to treatment. Both Dylox and Phosdrin have a short residual life and thus had little effect upon the later hatching nymphs. *3.* It was observed that Phosdrin and Dylox practically eliminated beneficial insects and they did not return to the plots as quickly as the lygus bugs, which could increase at an unchecked rate. Control of nymphs was better when Phosdrin was combined with toxaphene than with Phosdrin alone. Initial reduction with the combination was about the same as with Phosdrin but nymph populations did not increase as rapidly.

Sevin, ethion, Thiodan and endrin did not appear to be especially effective in controlling lygus bugs in these experiments.

Although it appears that lygus bugs have developed a tolerance to toxaphene in certain areas, this does not mean that toxaphene will necessarily be ineffective early in the season or in other localities. Also, instances of poor control with toxaphene should not always be attributed to resistance. Other factors may be involved in cases of poor control, such as improper timing, poor penetration of dense vegetation, skips, poor lapping of swaths and migrations of adults. Toxaphene is still the preferred material for lygus bug control. Dylox at one pound actual per acre or Phosdrin at eight ounces per acre are promising alternates when circumstances indicate failures with toxaphene which can be attributed to insecticidal tolerance. Because of the longer residual effect of toxaphene against young nymphs and the rapid kill obtained with Phosdrin and Dylox, combinations of these materials also appear to be promising. It should be possible to achieve satisfactory control if treatments are started before heavy populations develop and entire fields are treated. Phosdrin and Dylox will not give the extended control formerly obtained with DDT or toxaphene. It is likely that if Phosdrin or Dylox are used alone, repeat applications will be necessary about one week thereafter in order to control hatching nymphs. To reduce the hazard to bees Phosdrin should be applied early in the morning before the bees are active or in the evening after the bees have left the field.

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PARASITES

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does not mean that the parasites are established permanently. A period of several years is usually the basis for judgment. However, the majority of introduced natural enemies fail to make a start at all in their new environments, so any recovery is encouraging.

The proportion of plots showing that the new parasites are taking hold is rather encouraging, especially in the San Joaquin Valley and the southern California interior areas. Actually, there has been considerable population increase and dispersal of parasites from some of the plots in those areas, and certainly at least *Aphytis melinus* and *A. fisheri* are now adequately started. If they find environmental conditions favorable, they could add appreciably to the field mortality of the red scale; if not, the parasites may disappear after a severe winter or summer. Laboratory studies offer some hope that the parasites will not disappear, for in several respects both *melinus* and *fisheri* show better temperature tolerances in controlled tests than do the already-established *Aphytis lingnanensis* and *A. chrysomphali.*

The fact that a much higher proportion of recoveries was obtained from the San Joaquin Valley and interior area plots than from coastal area plots does not necessarily mean that the physical environment is responsible for this. The proportion and abundance of recoveries correlate very closely with the abundance of already-established natural enemies in the colonization plots. In the coastal counties, natural enemies were rated as already being common to abundant in every colonization plot obtained; hence, competition for the new parasites was extreme. In the San Joaquin Valley counties already-established natural enemies were rated as being from absent to rare in nearly every plot obtained; hence, competition was virtually nil and the new parasites obtained a good foothold in nearly every case. In the interior areas already-established natural enemies were rated as being from scarce to common in most plots; hence, competition was frequently a factor and the proportion of recoveries reflects this. Regardless of the colonization area, if already-established natural enemies were rated as either none, rare, or scarce when the plot was started, over 85% recoveries were obtained; if, however, already-established natural enemies were rated as being common or abundant, then less than 40% recoveries were obtained.

Regardless of the proportion of recoveries from plots in the various areas, if a newly introduced species of *Aphytis* has significant biological advantages over an established species, such as a higher reproductive capacity and a better tolerance to temperature extremes, the new species should supplant the old one sooner or later and the result should be an increase in the amount of natural mortality of the red scale. If a new *Aphytis* proved to be especially well adapted, good biological control could result because *Aphytis*, of one species or another, seem to be principally responsible for the biological control of the California red scale in much of the Orient, as well as in favorable parts of southern California and other parts of the world with similar climates.

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Ernest B. White and Robert E. Orth, Laboratory Technicians in Biological Control, University of California, Riverside, were largely responsible for the production of the parasites used in this work.

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