LIMING OF VEGETABLE CROPS

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Probably the major effect of liming is its relationship to soil acidity or the pH of the soil. When an acid soil is limed, its acidity is reduced. This reduction in soil acidity is reflected in an increase of soil pH. Increasing the pH of soil has many effects. The availability of many nutrients such as phosphorus and molybdenum is increased and that of other nutrients such as iron and manganese is reduced. In some acid soils, the presence of soluble aluminum and manganese may be great enough to create toxicity problems. Liming of such acid soils reduces the solubility of these elements and thereby reduces their toxic effect. Aluminum and manganese toxicity are considered to be major problems restricting yields on acid soils in western Oregon.

Increasing the pH of acid soils results in the increased activity of microbes and this affects the rate at which plant residues are decomposed in the soil and the supply of nutrients which are released by the decomposition of plant remains and organic materials. The conversion of atmospheric nitrogen into forms which are available to plants by legumes is also reduced in acid soils.

Sources of Acidity in Soils

One of the major sources of acidity in western Oregon soils is fertilizer material. The application of fertilizers to our crops is, of course, essential but it should be borne in mind that most fertilizer materials tend to increase soil acidity and thus increase the need for liming. Other factors creating acidity in soils include growing plants and decomposition of plant remains. Plant roots exude acidic materials into the soil and acids are also created as organic materials decompose in the soil. The acidifying process is hastened by the leaching effect of rainfall and irrigation water. The leaching effect of winter rainfall in western Oregon and resulting removal of bases is an important factor in the acidification of soil.

pH and Base Saturation Trends in Willamette Valley Soils

A summary of pH values of Willamette Valley soils, based on the Oregon State University soil testing lab results is given in Table 1. These results do not indicate a significant trend towards greater acidification of Willamette Valley soils over the period 1962-1968. However, neither do they indicate a significant improvement in soil acid conditions in spite of liming treatments which were applied during this period. The percentage of soils with pH values below 6.0 in 1968 was 37.

Table 1 - pH of Willamette Valley Soils

Year	Percent of Soil Samples Below: pH 5.0	pH 5.4	pH 6.0
1962	2	19	28
1964	2	13	33
1966	2	16	30
1968	2	12	37

The summary of soil test values for total bases recorded in Table 2 does not indicate any improvement in the total base content of Willamette Valley soils during the 1962-68 period. These pH and total base results tend to indicate that soil acidification is being maintained at a more or less constant level by liming. It should be borne in mind, however, that these results reflect the situation only insofar as those growers who submit soil samples are concerned.

Table 2 - Total Bases in Willamette Valley Soils

Year	Percent of Soil Samples Below: 5 meq/100g	10 meq/100g
1962	4	21
1964	6	25
1966	5	25
1968	8	22

An estimate of the acidity resulting from the application of fertilizer materials in Oregon in 1969 is given in Table 3. These estimates indicate that 263.5 thousand tons of pure calcium carbonate limestone would have been required to neutralize the acidity resulting from fertilizer materials applied in the state of Oregon in 1969. A sizable proportion of the acidifying fertilizer materials are applied to non-acid soils in eastern Oregon. Even in areas east of the Cascade Mountains, however, acidifying processes due to fertilization and increased leaching resulting from irrigation are reducing the pH values of soils to the point where it has been considered necessary to initiate lime trials in order to determine whether a need for liming has been created.

Table 3 - Estimated Acidity from Fertilizers Applied in Oregon in 1969

	Fertilizer Applied (1000's of Tons)		Equivalent Acidity (1000's Tons Lime)
N Fertilizers	211.8		184.9
Other Fertilizers	144.6		78.6
		Total	263.5

An important factor relating to the use of lime is the method in which the lime is applied. Lime should be applied well enough in advance of the crop that it will have time to react with the soil before the crop is planted. Ground limestone has a fairly low solubility in soil and requires a period of time before it goes into solution and thereby becomes effective. In the case of spring seeded vegetable crops, for instance, lime should probably be applied and mixed with the soil the preceding fall.

Lime tends to be somewhat immobile in soil due to its low solubility and also due to the absorption of calcium by soil particles. It is therefore necessary to mix lime as thoroughly as possible with the soil following application. This is frequently done by applying lime following plowing and then discing or tilling the lime into the soil to as great a depth as is practical. Applying lime before plowing results in the lime being incorporated in a layer at plow depth and thus a poor job of mixing with the soil.

The rate at which lime is applied depends on the crop and the soil. Some crops, such as potatoes, are more tolerant to acid soils than other crops, such as peas. Some soils, such as those which contain a lot of clay or a lot of organic matter, require more lime to increase their pH than do other soils such as those having a sandy texture. It requires more lime to reduce acidity in clay loam and muck soils than in loamy sand or sandy loam soils.

There are two major kinds of lime, namely, calcitic lime such as ground limestone, which consists almost entirely of calcium carbonate, and dolomitic lime, which in addition to calcium carbonate also contains magnesium carbonate. Dolomitic lime, therefore, in addition to neutralizing acidity, supplies magnesium and is thus effective on magnesium deficient soils.

A series of liming trials in which different rates of ground limestone were applied to vegetable crops in the field were commenced in 1968-69. In most instances, the lime treatments were applied in 1968 and mixed with the soil,with the vegetable crops being seeded in the spring of 1969. Soil samples were removed approximately one year following the application of the lime in order to determine the effect of the lime applications on the acidic properties of the soil. The average results from five different locations are given in Table 4. These results indicate that the lime applications have increased pH and exchangeable calcium, but the increase in exchangeable calcium indicates that a considerable portion of the applied lime had not yet gone into solution in the soil.

Table 4 - Effect of Lime Applications on Soil pH and Exchangeable Ca

Lime Applied (Tons/A)	pH	Exch. Ca (meq/100g)
0	5.8	9.6
2.5	6.0	11.3
5.0	6.2	13.2

In one of the lime trials in which lime was applied to plots which were later seeded to peas, a yellowing of the peas was observed particularly on the plots receiving the heaviest lime application of five tons per acre. These plots were located on an Amity soil having an initial pH value of 5.6 with 8.4 meq/100g of exchangeable calcium. Plant samples were removed from the plots at about the pea harvest stage. The results of the plant analysis are given in Table 5. These results indicate that the lime treatment had a marked effect on the nutrient content of the plants. The major effect appears to have been a marked decrease in the uptake of zinc resulting from the lime application. The zinc levels in the plants on the heavily limed plots were probably in the deficiency range and resulted in a necrotic condition which would be reflected in somewhat higher calcium and magnesium levels and lower nitrogen and potassium levels in the plants.

Table 5 - Effect of Lime Application on the Nutrient Content of Pea Plants

Lime Applied (Tons/A)	Plant Analysis						
	Ca	Mg (Percent)	K	N	Mn	Fe (ppm)	Zn
0	1.6	.20	1.9	2.3	75	116	32
5.0	2.2	.30	.8	0.8	72	100	8

Lime applications also affected the nutrient level in carrot tops. The values in Table 6 show that liming reduced the manganese level in carrot plants, which is one of the important effects of lime applications to acid soils in Western Oregon where manganese is sometimes taken up in toxic amounts by plants. Liming reduces the availability of manganese thereby reducing its toxic effects. It should be borne in mind that manganese is an essential nutrient for plant growth and that over-liming can sometimes induce a manganese deficiency in plants. The soil on which the carrot plots were located initially had a pH of 6.3 with an exchangeable calcium level of 14.9 meq/100g. The soil was, therefore, reasonably well supplied with bases and only slightly acid. The results also indicated that liming resulted in a slight increase in the phosphorus content of the plants. This effect is consistent with other results from liming experiments.

Table 6 - Effect of Lime Applications on the Nutrient Content of Carrots

Lime Applied (Tons/A)	Plant Analysis Ca	Mg	P	K	Mn
	(Percent)				(ppm)
0	2.3	.36	.18	4.7	70
2.5	2.0	.36	.19	4.7	52
5.0	2.0	.36	.22	4.2	37

A nutrient survey of onion fields in the Lake Labish and Gaston areas was carried out by T. L. Jackson, Department of Soils, OSU, and Jim Hay, Extension Agent, Marion County, in 1969. The nutrient levels in soils and plants were determined for several fields. It was observed that the pH of the soil bore a strong relationship to the nutrient content of the onion plants. The results reported in Table 7 show that the manganese content of the onions was much lower at higher pH values than was the case at lower pH values. At low pH values it is possible that the manganese content of the onion plants was in the toxic range in some fields whereas at higher pH values it is possible that the manganese level in the onions was in the deficient range. A similar comparison could be made in the case of zinc. A decrease in the iron levels in onion plants at higher pH values was also observed.

Table 7 - Relationship Between Soil pH and the Nutrient Content of Onions

pH	Plant Analysis Mn	Fe	Zn	Cu
	(ppm)			
Below 5.0	300+	158	53	6.3
5.0 - 5.2	128	113	29	6.6
5.3 - 5.6	49	61	25	4.3
5.7 - 6.1	20	54	18	5.8

Other observations which were made in 1969 included soil and plant analysis in celery and cauliflower fields. The results reported in Table 8 show that in a celery field containing good and poor plants that the poor plants were growing in a comparatively acid soil and that the manganese content of the poor plants was high and the phosphorus content low. Likewise poor cauliflower plants had a higher manganese content and lower phosphorus content than did good cauliflower plants.

Table 8 - Nutrient Content of Good and Poor Celery and Cauliflower Plants

Kind and Condition of Plant	Soil Test Values		Plant Analysis		
	pH	Ca (meq/100g)	Ca (Percent)	P (Percent)	Mn (ppm)
Celery					
Good	5.4	7.8	1.3	.51	78
Poor	4.7	5.9	2.2	.17	437
Cauliflower					
Good			1.2	.75	35
Poor			2.7	.54	280

The preliminary results reported in this paper indicate some of the important effects of liming under western Oregon soil and cropping conditions. It is apparent that the major responses to liming are likely to be a result of the interaction of lime with other nutrients rather than a direct response to calcium. At this date some of the important interactions appear to be effect of lime on the uptake of manganese, phosphorus, and zinc. Also, it is known that under acid soil conditions, aluminum, which is not a plant nutrient, can be absorbed by plants in toxic amounts. Researchers at OSU are interested in the uptake of aluminum by plants under acid soil conditions and the effect which liming has on this uptake. Equipment is being installed in the plant analysis laboratory so that plant analysis for aluminum content can be conducted in the near future.