CONNECTICUT

AGRICULTURAL EXPERIMENT STATION

NEW HAVEN, CONN.

BULLETIN 163, FEBRUARY, 1909.

AGRICULTURAL LIME

Its Sources, Composition and Prices. With Notes on its Action in the Soil.

By E. H. Jenkins and E. M. East.

CONNECTICUT AGRICULTURAL EXPERIMENT STATION.

OFFICERS AND STAFF.

BOARD OF CONTROL.

His Excellency, GEORGE L. LILLEY, *Ex officio, President.*

PROF. H. W. CONN, *Vice President*.....Middletown.
PROF. W. H. BREWER, *Secretary*.....New Haven.
B. W. COLLINS.....Meriden.
CHARLES M. JARVIS.....Berlin.
FRANK H. STADTMUELLER.....Elmwood.
J. H. WEBB.....Hamden.
E. H. JENKINS, *Director and Treasurer*.....New Haven.

STATION STAFF.

Chemists.

Analytical Laboratory.

JOHN P. STREET, M.S., *Chemist in Charge.*

E. MONROE BAILEY, M.S.
C. B. MORRISON, B.S.
C. A. BRAUTLECHT, PH.B.
CLARENCE W. RODMAN, B.S.

Laboratory for the Study of Proteids.

T. B. OSBORNE, PH.D., *Chemist in Charge.*

Botanist.

G. P. CLINTON, S.D.

Entomologist.

W. E. BRITTON, PH.D.

Assistant in Entomology.

B. H. WALDEN, B.AGR.

Forester.

AUSTIN F. HAWES, M.F.

Agronomist.

EDWARD M. EAST, PH.D.

Seed Testing.

MARY H. JAGGER.

Stenographers and Clerks.

MISS V. E. COLE.
MISS L. M. BRAUTLECHT.
MISS E. B. WHITTLESEY.
MISS C. A. BOTSFORD.

In charge of Buildings and Grounds.

WILLIAM VEITCH.

Laboratory Helper.

HUGO LANGE.

Sampling Agent.

V. L. CHURCHILL, New Haven.

THE SOURCES OF AGRICULTURAL LIME FOR CONNECTICUT.

Lime for our farms must come, for the most part, from Connecticut, or from its bordering states, and chiefly from quarries of what is called the Stockbridge limestone.

"Stockbridge Limestone" is the name given in Connecticut geology to a formation which "is found in more or less parallel belts which extend from Vermont to Georgia."

"In Connecticut all the exposures of any importance are in the western and northwestern part of the state. A wide belt extends from Canaan Valley southwestward to Sharon and underlies a large portion of the towns of North Canaan, Canaan and Salisbury. A narrow belt extends from Cornwall Bridge to Gaylordsville, forming the valley of the Housatonic. A small belt, rarely attaining a mile in width, extends from New Preston through Marbledale, Northdale, New Milford, Brookfield and Danbury to West Redding. In the vicinity of Danbury this belt widens and sends an arm westward to the New York line. An area, somewhat detached from the main belt, occurs at Ridgefield, and a number of small limestone areas are found in other parts of the state, as at Winsted, Robertsville, East Hartland, Long Hill and at a few places east of the Connecticut River. These small detached areas are identical in composition with the main masses of the Stockbridge limestone." (Manual of Geol. of Conn., pp. 87-88.)

Small amounts of an impure limestone are also found at Bolton, in Union, Ashford, Willington, Woodstock, Stafford and other parts of the eastern counties, but neither the quality nor quantity of the formation makes it worth considering for commercial use.

The western border of the state is practically the only part of it from which agricultural lime can be got in quantity.

The Composition of Limestone.

The Stockbridge limestone is carbonate of lime (calcite), containing more or less carbonate of magnesia (magnesite). When

the two carbonates crystallize together in the proportion of 1 to 1 they form the mineral dolomite, and this Stockbridge formation ranges from a dolomite to a dolomitic limestone and even to a pure calcite.

TABLE I.—COMPOSITION OF

	Danbury.			
	A	B	C	D
Lime	55.14	54.22	54.46	31.70
Magnesia	0.14	0.35	0.60	20.25
Silica and Insoluble	1.10	2.46	1.80	1.60
Oxides of Iron and Aluminum	0.11	0.28	0.15	0.28
Carbonic Acid	43.51*	42.69*	42.99*	46.17*
	100.00	100.00	100.00	100.00

* By difference.

A is selected white limestone. B, bluish limestone, constituting the larger part of that at present quarried. C, granular limestone, impossible to burn in the ordinary kilns because it falls to pieces half as large as a pea when heated. D, pearl-colored stone from a small vein recognized by the

It has no fixed composition even in any one place of deposit, some of it being nearly pure carbonate of lime and much more containing magnesia never quite equalling the lime in amount.

The analyses, Table I, show the differences of composition which are common in this formation in the western part of Connecticut.

These analyses show that the lime may range from 56 per cent.—a pure calcite—to about 29 per cent. and the magnesia from nothing to about 21½ per cent.

Pure dolomite contains 30.4 per cent. of lime and 21.7 per cent. of magnesia.

The samples A to D were taken by the writer at the works of the Stearns Lime Co. of Danbury, and indicate that most of the lime in sight at this newly opened quarry is quite pure calcite, though one vein represented by Sample D, has the usual composition of Housatonic or Stockbridge limestone. Some veins

of nearly pure calcite are found in many other places and it is extensively worked at the Adams and Cheshire quarries in Massachusetts by the New England Lime Co.

CONNECTICUT LIMESTONES.

Canaan.	East Canaan.	Lime Rock.		Sharon.		Housatonic Valley.
E	F	G	H	I	J	K
30.40	31.31	52.09	27.78	36.03	28.96	56.02
21.48	21.01	0.47	16.63	17.76	18.54	....
0.08	0.48	4.11	4.21	4.00	9.98	0.15
0.25	0.20					
47.73	47.00	†	†	†	†	43.83
100.00	100.00					100.00

† Undetermined.

eye as magnesian. E, analysis from U. S. Geol. Survey, 1898–9, pt. 6, p. 570. Analyses G to I, from Bulletin 6, Geol. and Hist. Survey Conn., p. 89. K is a white crystallized limestone. Analyses A, B, C, D, F, J and K, made at this station.

Small deposits of limestone rock occur in other parts of the state and have been analyzed at this station with the following results:

TABLE II.

	Near Bolton Notch.		Lebanon.	North-west of Norwich.	North Stoning-ton.	Durham.	
Lime	53.51	6.67	26.65	22.82	31.17	53.91	52.91
Magnesia	0.54	0.98	0.92	0.60	17.80	0.63	0.62
Oxides of iron and aluminum	1.50	5.71	4.78	7.56	2.57	....	....
Phosphoric acid ...	0.07	0.09	0.09	0.15	....	0.08	0.12
Insoluble in acid ..	1.73	80.26	46.51	32.24	4.39	1.84	3.71

Three of the samples are too impure for commercial use. The limestone from Durham was quarried forty years ago and is of excellent quality for commercial purposes, as is one from Bolton Notch. The one from North Stonington might also be used. It is not likely that paying quantities of such rock can be found in these places.

To fit them for agricultural use limestones should be fine enough to pass an 80-mesh sieve and the finer the better. No machinery is at present installed in Massachusetts or Connecticut to grind limestone. At the West it is stated that limestone is ground fine for agricultural use at a cost of $1.00 per ton. These mills, we understand, work where limestone is crushed for road-making and the dust is a by-product.

The New England Lime Co., at its works at Adams, Mass., can furnish two grades of limestone dust. Both are practically pure calcium carbonate. The finer grade all passes silk bolting cloth having 130 meshes to the inch. The coarser grade has the following mechanical analysis:—

Finer than 130 mesh	15.5 per cent
Between 63 and 130 mesh	45.8 "
Between $\frac{1}{60}$ inch and 63 mesh	30.3 "
Coarser than $\frac{1}{60}$ inch	8.4 "

The company states that the two grades would be sold together in the proportion of two by weight of the finer to one of the coarser. Mixed in that proportion, the mechanical analysis would be:—

Finer than 130 mesh	71.8 per cent
Between 63 and 130 mesh	15.3 "
Between $\frac{1}{60}$ inch and 63 mesh	10.1 "
Coarser than $\frac{1}{60}$ inch	2.8 "

Mills for grinding feldspar, a harder material than limestone, to a very fine powder, are operated in Glastonbury and at works near Middletown.

Lime, Quicklime or Stone Lime.

Calcium is a metal rarely seen, because it can only be prepared

TABLE III.—ANALYSES OF

	Adams, Mass., New Process.	Glen Falls, N. Y.	Glen Falls, N. Y.	Cheshire, Mass.
Lime	98.13	90.99	89.56	90.52
Magnesia	0.42	1.14	1.22	4.27
Other matters by difference	1.45	7.87	9.22	5.21
	100.00	100.00	100.00	100.00

at great expense, and when exposed to air at once absorbs oxygen, forming calcium oxide or lime, which is familiar to us in a nearly pure state in certain "stone limes" or "quick limes."

Pure carbonate of lime, like sample K in Table I, contains 56 parts by weight in 100 (or 56 per cent.) of lime (calcium oxide), and 44 parts of carbonic acid. When roasted in the limekiln, the 44 parts of carbonic acid are expelled, leaving the 56 parts of lime free or uncombined, as "burned lime," "stone lime" or "quick lime." Carbonate of magnesia, if present in the limestone, is decomposed in the same way, leaving magnesium oxide or magnesia behind.

The composition of stone lime is shown in Table III by analyses made at this station. When pure limestone is used, the product seems to be either 90 per cent. of lime, or 56 to 60 per cent. of lime with 30 to 40 per cent. of magnesia, always 90 per cent. or more of the two.

With one exception these limes are in lumps and can not be evenly spread on land without grinding or slaking. The Adams lime, which is burned by a special process from a granular rock, is in fine granular condition and could be spread by machine or with the shovel without previous slaking.

Slaked Lime and Air-Slaked Lime.

When water is added to quick lime a certain definite quantity combines chemically with the lime, setting free much heat and forming calcium hydrate, or *"slaked" lime.* Fifty-six pounds of lime will yield 74 pounds of perfectly dry slaked lime. Such slaked lime contains about 75.6 per cent. of lime, but usually slaked lime also contains moisture besides the chemically combined water.

Stone Lime or Quick Lime.

Vermont.	Housatonic, av. four analyses.	East Canaan, Conn. Lime Co.	Lee, Mass.	Western Conn. av. seven analyses.
59.90	56.60	55.86	54.63	52.12
35.13	38.62	40.24	37.83	36.08
4.97	4.78	3.90	7.54	11.80
100.00	100.00	100.00	100.00	100.00

Slaked lime, as it is offered by the lime companies, is much less uniform in composition than limestone or quick lime because of the varying amount of moisture in it and because it is often made from lime which, for one or another reason, is not fit for mason's use. It may contain other rock than limestone, it may be off color, or it may have been imperfectly burned.

The following analyses show the composition of samples analyzed by us:

TABLE IV.—ANALYSES OF SLAKED LIME, "HYDRATED LIME."

	From Stearns Co., Danbury.	Adamant Plaster Co., New Haven.	N. J. Lime Co., Hamburg, N. J.	Average three analyses, Housatonic Lime.
Lime	56.00	38.27	71.16	46.15
Magnesia	3.94	25.84		32.70
Silica and insoluble	10.80			
Oxides of iron and aluminum	1.20			
Moisture	8.07	35.89		21.15
Combined water and other matters by difference	19.99		28.84	
	100.00	100.00	100.00	100.00

The average of three analyses shows a lime not completely slaked but containing still some quick lime.

Air-Slaked Lime

is formed when quick lime is exposed for a considerable time to air and moisture. This lime combines with both carbonic acid and water and gradually slakes, while more or less of it changes to carbonate, the state in which it was previous to burning. Its composition depends wholly on the conditions under which it has been stored, ranging from that of slaked lime to carbonate of lime.

The following analysis represents the interior of a pile of 125 tons or more of waste lime from the kilns, thrown in a pile out of doors. The sample was taken by C. S. Phelps from stock of the Connecticut Lime Co., at East Canaan. The interior of the pile is quite dry.

AIR-SLAKED LIME.

Silica and insoluble	4.42
Oxides of iron and aluminum	1.11
Lime	45.82
Magnesia	33.30
Other matters	15.35
	100.00

There is a by-product from the Adams process lime, produced in rather small amount, which is in excellent mechanical condition, being fine enough to use in a fertilizer sower and consisting of a mixture of quick lime and carbonate. It is sold by the New England Lime Co. and has the following composition:

Silica and insoluble	1.18
Oxides of iron and aluminum	0.21
Lime	59.98
Magnesia	1.12

LIME-KILN ASHES.

This is the material taken from the furnaces which heat the lime-kilns, and is a mixture of ashes from the fuel with fine lime which falls into them from the kiln.

The average of ten analyses, made at the Massachusetts Station and printed in the 18th Report of that station, p. 159, is given in the following table, with average analyses of the New England Lime Co.'s ashes from Canaan and also from New Milford. The Canaan ashes come mostly from pine or soft wood and have been exposed to the weather. Those from New Milford have not been thus exposed and are more largely from hard wood.

ANALYSES OF LIME-KILN ASHES.

	10 Mass. Analyses.	Canaan Ashes.	New Milford Ashes.
Moisture	11.35	....	....
Potash, water soluble	....	0.73	2.29
" total	2.04	1.11	2.77
Phosphoric acid	0.78	0.89	1.07
Lime	41.49	35.32	38.33
Magnesia	1.30	8.00	10.80
Insoluble	6.78	....	....

Obviously a part or all of the Massachusetts samples were from kilns in which limestone was burned which was nearly free from magnesia.

The New Milford ashes are sold for about $2.50 per ton more than Canaan ashes.

THE FIRMS MAKING LIME IN CONNECTICUT.

The following list includes all the firms which we have been able to find. The New England Lime Co. also owns works at a number of points in Massachusetts.

The makers of lime in Connecticut are the following:

Name.	Office.	Works.
Atlas Lime Co.	132 Nassau St., N. Y. City	Bethel.
Bethel and Redding Lime Co.	16 East 1st St., N. Y. City	Bethel.
Canfield Lime Co.	Canaan	East Canaan.
Connecticut Lime Co.	Canaan	East Canaan.
Connecticut Western Lime Co.	Canaan	Canaan.
New England Lime Co.	Canaan	East Canaan.
Stearns Lime Co.	Danbury	Brookfield.
Arthur J. Todd	West Redding	Redding.

FREIGHT RATES ON LIME IN CAR LOTS OF 25 TONS OR MORE, GIVEN IN CENTS PER 100 POUNDS.

These rates do not apply to lime in bulk. In general, bulk rates are the same but to certain points are lower. Forty-eight hours allowed for unloading; $1.00 per day or fraction thereof, per car, demurrage, for any further delay.

The general statements here given are substantially correct at the time of writing but subject to change. The exact rate should be learned from the shipper or local agent.

New York Division (all points between the New York line and New Haven, also points on Danbury and Norwalk branch and New Canaan branch).

From Canaan and Mass. kilns, 7.

From New Milford and kilns south of it to points between New York line and South Norwalk, 6½*; to South Nor-

*Less from Redding to a few points.

walk and most points on Danbury and Norwalk branch and to points as far as New Haven, 5½.*

Shore Line Division.

From Mass. and Conn. kilns to stations between East Haven and Waterford, 7.

From Mass., Canaan and New Milford kilns to New London and points on New London Northern, 7½.

From Brookfield, Bethel and Redding kilns to New London, 7; and to points on New London Northern, 7½.

From Mass. and Conn. kilns to points between New London and R. I. line, 8½.

Hartford Division.

From Mass. and Conn. kilns to all points on this division north of New Haven, 7.

Air Line Division.

From Mass. and Conn. kilns to all points between New Haven and Portland, 7; to points between Cobalt and Chestnut Hill, 7½.

Northampton Division.

From kilns at New Milford and North of it to points between New Haven and Plainville, 7.

From Brookfield and Bethel kilns to same points, 6½.

From all kilns to points between Plainville and Mass. line, 7½.

Naugatuck Division.

To Ansonia from kilns north of New Milford, 7; from New Milford and kilns south of it, 5½.

From Mass. and Conn. kilns to points between Seymour and Union City and points between Waterville and Torrington, 7.

From Mass. and Conn. kilns to Burrville and Winsted, 7½.

From New Milford, Canaan and Mass. kilns to Waterbury, 7.

From kilns south of New Milford to Waterbury, 6½.

---

* Considerably less to some points on D. & So. Norwalk branch.

Berkshire Division.

Rates are very various because of the nearness of certain kilns. In general, rates *from Canaan and Mass. kilns* to points between Tyler City and Brookfield Junction and on the Shepaug branch, 7. *From New Milford and other Conn. kilns to same points,* from 2½ to 7. For other stations see local tariff schedules.

Highland Division.

From Mass., Canaan and New Milford kilns to points between Sandy Hook and East Hartford and to points on the Springfield branch, 7 (but to Mill Plain from New Milford, 5½).

From kilns south of New Milford to Hartford, 6½ (but to Mill Plain, 5½), to points on Springfield branch, 7.

From Mass. and Canaan kilns to points from Burnside to Hop River, 7½; *from kilns south of Canaan,* 7.

THE AVERAGE COST OF LIME.

The following statements give only a general indication of the relative cost of lime in its different forms. Of course before ordering, an exact quotation should be obtained, with the freight charge in force at the time. The time of payment will also affect the price and in general cash payment must be made.

The Average Cost of Lime and Magnesia in Form of Stone Lime and in Car Lots.

In this calculation magnesia is reckoned as having the same agricultural and trade value as lime.

Stone lime free from magnesia may be bought of the New England Lime Co. for about $7.25 in barrels, with an average freight rate of $1.40, making the cost delivered $8.65, or 48 cents per 100 pounds of actual lime.

The Stearns Lime Co. offer quite a pure calcite lime for $6.00 in bags and about $8.10 in barrels, making $9.30 delivered, and the cost of actual lime 49 cents per 100 pounds. Twenty-five cents per ton extra is charged for fine lime.

The New England Lime Co. also have Adams New Process Lime, very pure lime (98 per cent., see analysis, page 6) which, unlike those mentioned above, is fine granular (see page 7).

This costs $6.50 in bulk, or $8.50 in barrels and $9.90 delivered, or 51 cents per 100 pounds for pure lime, *ready to spread on the* field.

The Adams process fine lime described on page 9 is a mixture of quick lime and carbonate and could be bought for about $3.00 per ton, bagging $1.50, freight about $1.50, making total cost delivered $6.00, and the cost of lime 49 cents per 100 pounds. This is in a form which can be immediately spread on the land.

Stone lime shipped in bags instead of barrels would cost about 60 cents less per ton, equivalent to about 3 cents less per 100 pounds of pure lime.

Stone lime containing magnesia costs about $5.00 per ton in bulk on cars at the kilns. In barrels it costs $7.10. The freight to most Connecticut points from Conn. kilns ranges from 5½ to 7½ cents for 100 pounds and for all our calculations we assume the average of 6¼, of $1.25 per ton, making the average cost, delivered, $8.35 per ton in barrels. Reckoning on 90 per cent. of pure lime and magnesia in the goods, they cost the buyer 44 cents per 100 pounds.

Occasionally lime companies have a quick lime which proves to be unsuited for building purposes. Thus the Connecticut Lime Co. offers lime, the analysis of which is given on page 9, at $3.50 in bulk, $5.00 in sacks or $4.00 in buyer's sacks. This would be about $6.25 in sacks *delivered,* and actual lime and magnesia would cost about 33 cents per 100 pounds.

The Average Cost of Lime and Magnesia in Form of Water-Slaked or Air-Slaked Lime.

This is more uncertain and various because it is usually made from burned lime that is off grade by reason of color, faults in burning, etc.

Thus the Stearns Lime Co. offer water-slaked lime at $5.50 in bulk, $7.50 in bags. Adding average freight $1.25, the cost delivered is $8.75 and the cost of 100 pounds of pure lime and magnesia (as by analysis, page 8) 73 cents per 100 pounds.

The New Jersey Lime Co. offer N. J. slaked lime at $5.00, bags about $1.50, freight about $2.80, making $9.30 delivered, and cost of actual lime (see analyses, page 8) 65 cents per 100 pounds.

Housatonic lime, slaked (see analysis), has been offered at $4.50 per ton, bagged $6.00, delivered $7.25, making the cost of actual lime 46 cents per 100 pounds.

The air-slaked lime of the Connecticut Lime Co., described on page 9, can be bought for about $7.50 per ton delivered, making the actual cost of lime 41 cents per 100 pounds.

The Average Cost of Lime in Lime-Kiln Ashes.

The calculation is uncertain, depending on the allowance made for potash. For correcting acidity in the soil it is as valuable as lime or magnesia and has added value as a fertilizer. In most cases it will not have a higher agricultural value than muriate of potash and we therefore allow 4¼ cents per pound for it.

Canaan ashes average 43 per cent. of lime and magnesia and 0.73 per cent. of water-soluble potash. At $4.50 per ton at the works, or about $5.75 delivered *in bulk,* and allowing 62 cents for the potash, actual lime and magnesia costs about 59 cents per 100 pounds.

New Milford ashes cost about $8.55 delivered, and calculated as above, actual lime and magnesia costs 67 cents per 100 pounds.

The above list includes the sources of lime within the state or just beyond our borders. There is only one lime-kiln, as far as our information goes, in Rhode Island, owned by Herbert Harris, Lime Rock, R. I., who produces a lime similar to the Canaan output.

The Rockland-Rockport Lime Co., of Rockland, Me., with an office at 24 Milk street, Boston, have sold considerable lime in this state and offer R. R. Agricultural Lime, Pine Cone Hydrated Lime, stone lime and ground limestone, all from rock averaging 98 per cent. carbonate of lime. We have analyzed only the R. R. Agricultural lime, which contained 62.62 per cent of lime and 0.86 of magnesia. It is a partly slaked lime, containing some carbonate from "cores" which were not sufficiently burned, the whole ground to a fine powder. Quotations on car lots can be got from the Boston office.

The Hamburg Lime Co., Hamburg, N. J., offer a fresh burned lime, unslaked, stated to run 96 per cent. of lime, for $3.50 per ton in bulk, in car lots, made from a granular limestone, probably like C described on page 4. It is easy to handle, being

in small pieces for the most part. Probably $2.00 would need to be added for barrels and $2.60 to $2.80 for freight, making the cost about 43 cents per 100 pounds of actual lime.

MARL.

This material is a soft, fine carbonate of lime, coming from disintegrated shells. It is a very desirable form for agricultural use.

The Caledonia Marl and Lime Co., Caledonia, N. Y., have offered it at $3.00 per ton in paper sacks, in car lots, f.o.b. Probably the freight charge to Central Connecticut points would be from $2.25 to $3.00 per ton. It has been retailed here for $7.00.

Two analyses made last year at this station showed 48.35 and 46.60 per cent. of lime respectively, making the cost of actual lime about 63 cents per 100 pounds.

WOOD ASHES.

For discussion of wood ashes and the cost of lime in them the reader is referred to the Report of this station for 1907-08, p. 562.

SUMMARY.

It thus appears that at present, lime, or lime magnesia, can be delivered on the farm for from 33 to 44 cents per 100 pounds in form of magnesia lime, from 47 to 51 cents in forms moderately free from magnesia, for 41 to 73 cents in forms of slaked lime and magnesia, for 59 to 67 cents in lime-kiln ashes, and for 63 cents in form of marl.

COST OF HANDLING LIME ON THE FARM.

The foregoing figures show the cost of several sorts of lime at the local freight station. Some of them may be spread on the field directly, either from the cart with a shovel or from the fertilizer spreader.

Quick lime, or stone lime, however, unless it is fine ground, requires more handling, which adds to its cost. It must be slaked to pulverize it for spreading. Two ways are practiced. It may be dropped in heaps of one to three bushels, at regular intervals

over the field, and each heap covered two or three inches deep with moist earth. The lime takes from the earth the water it needs to slake it and will soon fall to a fine powder and should then be spread.

It is recommended, however, where several tons are to be slaked, to lay down say one quarter of it, sprinkle on water at the rate of 2 to 2½ pails for each barrel of lime, then immediately empty the rest of the lime on top, adding water in the proportion just given, and cover the top and sides with fresh earth as soon as may be. When slaked it must be loaded and spread.

In considering the relative cost of lime in different forms the operation of slaking must be reckoned with.

It should also be remembered, that both quick and slaked lime are very caustic and the dust of them attacks the skin of the hands and face, especially when moist, and is very irritating to the membranes of the nose, throat and lungs, so that it is not possible to handle them comfortably. The dust of carbonate of lime has no such corrosive action, only causing the same irritation as any other mineral dust.

In what has been written we have called attention to the sources of agricultural lime which were nearest to the farms of this State and to their composition and relative prices. Prospective buyers should of course get quotations and freight rates direct from the manufacturers and then calculate the cost of actual lime and magnesia *ready to apply to the land.*

CHEMICAL EFFECTS OF LIME.

The element calcium is a necessary constituent of plants; but as almost all soils contain it in sufficient amounts for their needs, the action of lime is not like that of a direct fertilizer. Indirectly, however, it is an agent by which insoluble potash is changed to a form available as plant food. For this very reason it must not be made to take the place of potash fertilizer, unless it is absolutely certain that large quantities of insoluble potash are present in the soil under consideration. Otherwise, the time when the soil will be depleted of potash is simply hastened. Whether the addition of lime affects the solubility of soil phosphates is undecided. Any chemical action on these compounds must, at least, be slight.

The other important chemical action of lime is to correct soil acidity. This lies largely in its effect on low forms of plant life.

Neither of these reactions is affected by the form of lime used. Soil, air and water contain much carbonic acid, which quickly acts on burned lime, on water-slaked lime, and converts it back into a calcium carbonate, the form in which it existed before burning. The kind of lime to be used thus depends almost entirely on the cheapness of the brand when figured to burned lime or calcium oxide, and on the ease with which it can be handled from the car to the field. The only time when the use of burned lime is inadvisable is when large quantities (2,000-3,000 pounds) are necessary to correct the acidity and the application is to be made in the spring. It takes some time for such quantities as these to be changed to calcium carbonate, and in the meantime the caustic lime is burning out the humus in the soil. If large amounts of quick lime are to be applied to the soil, it should be spread in the early winter and worked into the soil in the spring.

PHYSICAL EFFECTS OF LIME.

Lime has a further effect upon soils which may be partly a chemical action but which is in the main an effect upon their mechanical character. Clay soils are probably the most benefited, for it greatly increases their porosity. The movement of water, both upward and in drainage, is thereby facilitated. A possible injury may result, however, if clay soils are limed too much or too frequently, through its cementing action, analogous to that when used in mortar.

Paradoxical as it may seem, light soils are also benefited, for lime increases both their water holding capacities and their capillarity.

EFFECTS OF LIME ON LOWER ORGANISMS.

The most important effect of liming Connecticut soils is the correction of soil acidity. The decomposition of organic materials, as well as the use of acid phosphates and other agricultural chemicals, tends to make soils acid. If we may reason from determinations made in Rhode Island, some of the soils

of this state need nearly two tons of lime to the acre to correct this acidity. Even those soils which overlie beds of limestone are often acid in the first foot of surface soil. The main reason for wishing to neutralize this acid is to give a better environment to the bacteria which work in the soil. We are dependent upon different forms of bacteria to decompose organic matter, and in this decomposition acids are produced which, as they increase gradually, kill off the little workers and put an end to their work. Furthermore, we must depend entirely upon bacteria if we intend to make use of the great quantities of nitrogen present in the air. Certain of them are able to live in connection with the roots of legumes, such as clover, alfalfa, beans, peas and lupines, to take nitrogen from the air and to change it to a form that is available to plants. These bacteria can live and do their work best in soil that is very slightly alkaline. Lime furnishes this alkalinity.

After the original acidity is corrected, an application of 200 to 400 pounds, once in three or four years, will keep the soil sweet, but a fairly heavy initial application is needed on most Connecticut soils.

It should be noted that the growth of fungous diseases, such as potato scab, is also promoted by liming, for they develop best in an environment similar to that needed by bacteria. This fact cannot be changed, but it is well to avoid liming just before planting a crop like potatoes, whose value depends largely upon its appearance.