THE BRIDGEHAMPTON SOILS

R. S. Bell and Arthur Shearin

UNIVERSITY OF RHODE ISLAND
Agricultural Experiment Station

BULLETIN 390

Contents

Contribution No. 1203, Agricultural Experiment Station, University of Rhode Island.

THE BRIDGEHAMPTON SOILS

R. S. Bell and Arthur Shearin*

Introduction

The Bridgehampton soils, while limited in extent, are important because of their excellent physical characteristics. The series was first described near Bridgehampton, Long Island, New York (16) in 1924. The soil on which the agronomy plots were established at the Rhode Island Agricultural Experiment Station is classified as Bridgehampton silt loam. Experimental results over a period of more than 70 years are available from these plots.

The soil on the agronomy plots was originally classified as Miami silt loam in the soil survey report of Rhode Island in 1905 (4). This bulletin reported that "The yields of hay from the experimental fields averaged in recent years 4 to 6 tons per acre. Bushels of shelled Indian corn were in the range of 60 to 75 with an occasional yield as high as 90 bushels. Potatoes yielded from 250 to 380 bushels per acre, while the onion crop (1904) amounted to 423 bushels." This soil was considered as one of the best in Rhode Island.

That such productivity was reached so soon after the Rhode Island Agricultural Experiment Station was established is a tribute both to the good physical condition of Bridgehampton soil and the use of lime and fertilizers applied to certain experimental areas. According to Director C. O. Flagg in Bulletin No. 2 (1889), "After 100 years of cropping by the white settlers and by many generations of Narragansett Indians previous to this, the soil was so exhausted that there was not sufficient grass to pay for cutting." Director Flagg stated the problem this way—"How to till and crop such fields and secure to the farmer of ordinary means a fair return for his labor and expense, and at the same time stem the tide of continual reduction of plant food in the soil, is a problem, the solving of which is of vital importance to American agriculture."

The purpose of this new bulletin is to present the most recent profile descriptions and physical and chemical properties of the Bridgehampton soils, along with results of 75 years of soil fertility and crop yield experiments.

---

*Associate Professor, Department of Agronomy and Mechanized Agriculture, University of Rhode Island; and State Soil Scientist, Soil Conservation Service, U.S. Department of Agriculture, respectively.

Distribution, Land Use and Acreage

The acreage of the Bridgehampton soils is not large but they are important agricultural soils. They occur principally in two areas. One is in eastern Long Island, New York, in the vicinity of West Hampton, Bridgehampton and East Hampton. The other is in the eastern part of Washington County, Rhode Island, with the most extensive areas in the vicinity of West Kingston in the town of South Kingstown and in the vicinity of Slocum in North Kingstown (see map). Small areas occur in other sections of southern Rhode Island, southeastern Connecticut and probably southeastern Massachusetts.

On Long Island the Bridgehampton soils occur in fairly large continuous sections. In Rhode Island and southeastern Connecticut these soils appear in scattered areas ranging in size from 600 or 800 to a few acres. The principal associated soils in Rhode Island are in the Narragansett, Enfield, Merrimac, Hinckley and Charlton series. On Long Island associated soils include the Haven and Riverhead series. The latter series has a tentative status in the classification system.

The principal crop grown on Bridgehampton soils in Rhode Island and on Long Island is potatoes. Other market garden crops and some nursery stock are grown in both places.

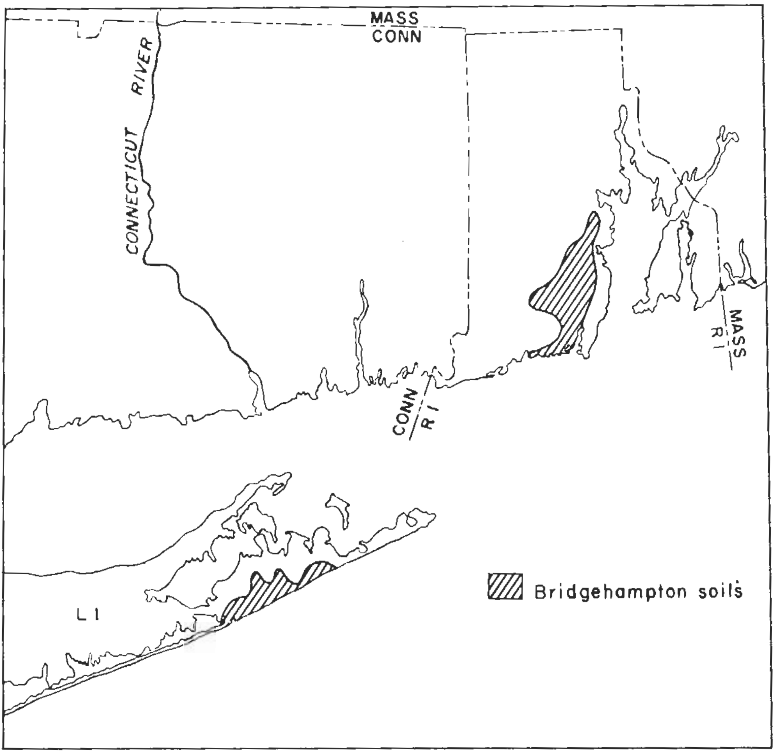
The soil survey report (16) for Suffolk and Nassau Counties, New York, lists the following acreages of Bridgehampton soils as mapped:

Bridgehampton silt loam	14,080 acres
Bridgehampton loam	3,200 acres
Bridgehampton loam, slope phase	1,088 acres
TOTAL	18,368 acres

In the soil survey report (32) for Washington and Kent Counties, Rhode Island, issued in 1939, the following acreages of Bridgehampton soils as mapped were listed:

Bridgehampton silt loam	960 acres
Bridgehampton very fine sandy loam	4,672 acres
TOTAL	5,632 acres

Because of the changes in concepts of the Bridgehampton and Narragansett series since this report was published, much of the acreage mapped as Narragansett loam and stony loam is in the range of the Bridgehampton series as now defined. From recent mappings it is estimated that the acreage of Bridgehampton soils in Rhode Island and Connecticut is 25,000-30,000 acres.



Geology and Physiography

The Bridgehampton soils have developed from waterlain or windblown sediments high in coarse silt and very fine sand and low in clay. The sediments are derived principally from crystalline rocks of gneiss, schist and granite and sedimentary rocks of sandstone, conglomerate and shale. The soils are largely on low-lying nearly level to gently sloping coastal terraces underlain by stratified drift consisting mainly of sands, gravel and cobbles.

The Bridgehampton soils are largely on nearly level to gently sloping or undulating terraces. Small areas, however, are on steeper slopes of the terraces. Elevation above sea level ranges from 20 to 150 feet. In Rhode Island and Connecticut low lying upland areas vary from nearly level to sloping with slope gradients generally less than 15 percent. Elevation above sea level here ranges from 150 to 300 feet above sea level.

The stratified drift is derived from a variety of rocks including schist, gneiss, granite, sandstone, conglomerate and shale. Some areas of Bridgehampton soils in Rhode Island and Connecticut are on uplands and are underlain by glacial till derived mainly from gneiss, granite, schist with some sandstone and conglomerate. The till is coarse to moderately coarse textured and is very friable to firm.

Soil Genesis

The soils in the Bridgehampton series are at the order level classified as Spodosols. They were formerly classified as Brown Podzolic soils. Spodosols are soils which somewhere in their profiles have distinctive horizons, called spodic horizons. The spodic horizon is an illuvial horizon in which amorphous materials that have high exchange capacities, including organic colloids and iron and aluminum, have accumulated from the layers above. Some downward movement of water is essential for the formation of a spodic horizon. Soil texture is important in the formation of spodic horizons and most of these horizons have sandy, coarse loamy or coarse silty textures.

At the subgroup level the Bridgehampton soils are classified as Entic Haplorthods. Within the subgroup the series is a member of the coarse silty, mixed, mesic family. The formation of Entic Haplorthods (weak Spodosols) is dominated by acid weathering. The intensity of weathering, however, is not great enough to cause gross translocation of iron, aluminum, organic matter or silicate clays. This is demonstrated by the lack of well developed spodic horizons and textural B horizons. Structure is generally weak.

The Bridgehampton soils have bisequum profiles in deep silty material with a spodic upper sequum and a lower sequum with an aluvial (A'2) and illuvial (B'2) sequence of iron depletion and iron enrichment, respectively. The iron enriched or B'2 horizons do not always meet the requirements of a spodic horizon. This lower sequum of horizons may be due to a seasonal perched or virtual water table above the abrupt textural change at the base of the silty mantle.

Description of the Bridgehampton Series

The Bridgehampton series was established in the Soil Survey of Suffolk and Nassau Counties (Long Island), New York, completed in 1924. Silt loam, loam, sandy loam and loamy sand types were mapped. A typical profile of Bridgehampton silt loam was described as having a "surface soil of dark brown friable finely granular silt loam. This grades very abruptly into yellowish brown slightly compact friable finely granular clay loam or silty clay loam, which becomes duller in color toward a depth of 18 to 20 inches, approximately light grayish yellow. From a depth of about 20 to 27 inches the material consists of olive yellow rather compact finely granular silt loam or very fine sandy loam." The report states that the soil is underlain by coarse sand or sand and gravel at depths ranging from 30 to 40 inches.

In the Soil Survey of Washington and Kent Counties, Rhode Island (32), published in 1939, the Bridgehampton soils were described as having stonefree, nearly level surfaces. Deep silty or very fine sandy loam soils, 36 to 40 inches deep, overlay stratified sand and gravel. The lower horizons were olive gray and rich yellowish brown or rich brown velvety very fine sandy loam.

In recent years the concept of the Bridgehampton series has been broadened to include deep silty soils with bisequum profiles over both stratified and unstratified glacial drift. In other words, the Bridgehampton series as now defined includes nearly level areas on terraces over stratified sand and gravel and low-lying glacial uplands with slope gradients ranging from nearly level up to about 15 percent. Areas on the terraces are generally free of stone, whereas areas on glacial uplands are stony and very stony in places.

Official Description (Rev. AES, 5-5-65)

The Bridgehampton series is a member of the coarse-silty, mixed, mesic family of Entic Haplorthods. This classification is tentative, see "Remarks." These are bisequal soils formed in deep silty material. The upper sequum is dominated by dark brownish colors whereas colors of more reddish hue are conspicuous in at least part of the B'2 horizon of the lower sequum. Stratified gravelly outwash or coarse textured gravelly till is at depths of about 3½ feet.

Typifying Pedon: Bridgehampton silt loam (Colors are for moist soil).

Ap — 0-8" —Very dark grayish-brown (10YR 3/2) silt loam; weak fine and medium granular structure; very friable; few pebbles; strongly acid; abrupt smooth boundary. (8 to 10 inches thick.)

B21 — 8-16"—Dark yellowish-brown (10YR 4/4) silt loam; weak coarse platy structure in upper 6 inches due to compaction by farm machinery; friable; few pebbles; strongly acid; clear wavy boundary. (6 to 10 inches thick.)

B22 — 16-24"—Brown (10YR 5/3) silt loam; structureless, massive, breaking to soft subangular clods when removed; very friable; strongly acid; clear wavy boundary. (8 to 12 inches thick.)

A'2 — 24-32"—Grayish-brown (2.5Y 5/2) silt loam, a few fine mottles of yellowish-brown (10YR 5/6); structureless, massive, breaking to soft subangular clods when removed; very friable; strongly acid; clear wavy boundary. (4 to 8 inches thick.)

B'2 — 32-38"—Strong brown (7.5YR 5/8) in the center of the horizon grading to yellowish-brown (10 YR 5/6) at the upper and lower boundaries, silt loam; structureless, massive, breaking to soft subangular clods when removed; very friable; strongly acid; clear wavy boundary. (2 to 8 inches thick.)

B'3 — 38-41"—Light olive-brown (2.5Y 5/4), finely mottled grayish-brown (2.5Y 5/2) very fine sandy loam; very friable.

IIC — 41-60"—Sand, gravel and cobbles mainly from gneiss, quartz and granite, a small amount of fine sand; silt caps common on pebbles and cobbles; in the upper part many pebbles and cobbles have complete or partial coatings of iron stains.

Type Location: Washington County, Rhode Island; town of Charlestown, on the eastern edge of the U.S. Naval Air Station auxiliary landing field.

Range in Characteristics: Solum thickness ranges from about 36 to 48 inches and corresponds closely to the boundary between the silty mantle and the underlying coarser textured glacial drift. The upper sequum is continuous and more or less uniform in thickness but the lower sequum is irregular in thickness, depending somewhat on the thickness of the silty mantle. The depth to the top of the A'2 horizon ranges from about 22 to 33 inches. The silty mantle commonly contains less than 10 percent clay, and up to 70 or 80 percent silt. Texture of the solum is centered on silt loam, but includes very fine sandy loam. The IIC horizon is glaciofluvial deposits of stratified sand, gravel and cobbles or glacial till that is alternately firm and very friable and ranges in texture from gravelly sandy loam to gravelly loamy sand or sand. Where the solum is underlain by stratified drift it is generally free of stones; but in some places it contains some cobbles and small waterworn stones probably moved upward by frost action; pebbles in the solum range from practically none up to 5 percent. Areas underlain by till range from stone-free to stony or very stony on the surface; small angular rock fragments in the solum range from practically none to 5 percent or more. In places, a few inches of watersorted sand and gravel are between the silt mantle and the underlying glacial till. Both the solum and the IIC horizon are very strongly acid to strongly acid. The Ap and A1 horizons have colors of 10YR hue; values are 2 or 3, and chromas are 2 or 3. The B21 horizon commonly has colors of 7.5YR and 10YR hue; values are 4 or 5, and chromas are 4 through 6. Color in the B22 horizon is generally slightly yellower in hue, one unit higher in value, and one or two units lower in chroma than the B21 horizon. The A'2 horizon commonly has hues of 2.5Y or 5Y, values of 5 or 6, and chromas of 2 or 3, and in most places, some fine, faint to distinct mottles. The B'2 horizon has hues of 7.5YR, 5YR, or 10YR, values of 4 or 5 and chromas of 4 through 8.

Competing Series and their Differentiae: These are in the Amboy, Belgrade, Broadbrook, Enfield, Hartland, Narragansett, Tisbury, and Unadilla series.

The Hartland, Enfield and Narragansett soils are in the same family as the Bridgehampton soils but they lack A' and B' horizons. In addition, Enfield soils are formed in silty mantles that are 20 to 30 inches in depth over loose sand and gravel, and the Narragansett soils are formed in silty mantles that are 18 to 30 inches in depth over firm to friable gravelly sandy loam glacial till. Broadbrook soils have a distinct fragipan in the lower part of the solum. Tisbury soils have distinct mottles in the lower part of the B horizon and are underlain by sand and gravel at 18 to 30 inches. Belgrade soils have distinct mottles in the lower part of the B horizon. The Amboy soils have a cambic horizon and a fragipan formed in coarse silts and very fine sands low in clay. The Unadilla soils have a cambic horizon, lack A' and B' horizons, and are formed in poorly graded silty materials.

Setting: These soils are on nearly level terraces and on low lying glaciated uplands at elevations generally of less than 250 feet. Slopes on the terraces are commonly less than 3 percent but they are steeper on terrace margins and in pitted areas. On the glaciated uplands slopes range from nearly level up to about 15 percent. The regolith is a silty mantle underlain by stratified drift of sand, gravel and cobbles or gravelly glacial till of Wisconsin Age. Source of materials is gneiss, granite, schist and varying amounts of sandstone, conglomerate and shale.

Principal Associated Soils: These are the moderately well drained Tisbury and Belgrade soils and the poorly drained Raynham soils which are associated in a drainage sequence, and the Enfield, Narragansett and Wapping soils.

Drainage and Permeability: Well drained and the better drained part of moderately well drained. Surface runoff is slow to rapid depending on the slope and soil cover. Internal drainage and permeability are moderate in the upper sequum. The lower sequum is often waterlogged in winter, early spring and after heavy rains; the strong contrast in texture between lower B horizon and IIC horizon inhibits vertical movement of water.

Use and Vegetation: A large part of the soil is cleared. Principal crops are potatoes and other market garden crops, nursery stock, silage corn and hay. Common trees in forested areas are white, red and black oaks, white ash, red maple and white pine.

Distribution and Extent: Eastern Long Island, southern Rhode Island, southeastern Connecticut and probably southeastern Massachusetts. The series is of small extent—between 7,000 and 10,000 acres.

Series Established: Suffolk-Nassau Counties, New York, 1928.

Remarks: The series is classified as Entic Haplorthods but this placement is tentative. The B horizon in these soils may be a cambic horizon rather than a spodic horizon. For this reason, the soil might properly be classified as a Typic Dystrochrept. The mineralogy class may be siliceous rather than mixed. Bridgehampton series was classified in the Brown Podzolic great soil group in the modified 1938 yearbook classification.

Descriptions of Profiles Used for Laboratory Characterizations

The descriptions of the three profiles used in obtaining the laboratory characterization data are as follows:

Profile No. 1 Bridgehampton Silt Loam
S58RI-5-2-(1-7)

Location: Washington County, Rhode Island. .4 mile east of Slocum in the Town of North Kingstown.

Vegetation: Cultivated area used for potatoes.

Topography: Nearly level to very gently undulating terrace. Sample collected on about one percent slope.

Elevation: About 150 feet.

Drainage: Probably intermediate between well and moderately well drained.

Description:

Horizon	Depth	
Ap	0-10"	Very dark brown (10YR 2/2) silt loam; moderate coarse granular; very friable; boundary abrupt.
B21	10-21"	Yellowish brown (10YR 5/6) silt loam; slightly compact due to traffic and breaks into coarse prismatic-like peds that are very friable when disturbed; boundary clear and wavy.
B22	21-31"	Light olive brown (2.5Y 5/4) with pockets of olive (5Y 5/3) and streaks of yellowish brown (10YR 5/6) silt loam; breaks into soft, coarse blocky peds that are very friable when disturbed; boundary clear.
B23	31-38"	Olive gray (5Y 5/2) mottled or streaked with yellowish brown (10YR 5/8) and strong brown (7.5YR 5/8) silt loam; breaks into soft, coarse subangular peds when disturbed; very friable; boundary abrupt.
A'2	38-40"	Gray (5Y 5/1) with a few mottles of yellowish brown (10YR 5/6) silt loam or very fine sandy loam; very weak coarse platy; very friable; boundary abrupt.
IIC	40-43"	Dark yellowish brown (10YR 4/4) gravelly coarse loamy sand; loose; boundary abrupt.
IIC2	43-52"	Olive gray (5Y 4/2) and olive (5Y 5/3) coarse

sand with 10-15 percent fine and medium gravel; loose.

Remarks: Worm holes with material from the Ap horizon common in the B21 and B22g horizons.
Sample collected by E. J. Pederson, M. A. Puchalski, J. W. Gonick, and A. E. Shearin, SCS; and by John B. Smith, University of Rhode Island.
Profile described by A. E. Shearin—11/11/58.

Profile No. 2 Bridgehampton Silt Loam
S58RI-5-3-(1-9)

Location: Washington County, Rhode Island about 1/2 mile east of Asa Pond in the Town of South Kingstown in an idle area.

Vegetation: Quackgrass, redtop, goldenrod, wild cherry and virburnum.

Topography: Sample collected on nearly level area on nearly level to very gently undulating terrace.

Elevation: About 60 feet.

Drainage: Probably intermediate between well and moderately well drained.

Description:

Horizon	Depth	
Ap	0-10"	Very dark grayish brown (10YR 3/2) grading to dark brown (10YR 3/3) silt loam; upper 4 inches moderate coarse granular and the lower 6 inches breaks into soft subangular peds; very friable; boundary abrupt.
B21	10-14"	Dark yellowish brown (10YR 4/4) silt loam; breaks into soft, coarse blocky peds; very friable; boundary clear and wavy.
B22	14-19"	Olive brown (2.5Y 4/4) silt loam; breaks into soft, coarse blocky peds; very friable; boundary clear and wavy.
A'2	19-26"	Olive (5Y 5/3) finely mottled with grayish brown (2.5Y 5/2) and light olive brown (2.5Y 5/4) silt loam; mottles are few, fine and faint; breaks into soft, coarse blocky peds; very friable; boundary clear and wavy.
B'21	26-32"	Strong brown (7.5 YR 5/8) in the center, grading to yellowish brown (10YR 5/6-5/8) in the upper and lower parts of the horizon; texture silt loam;

		breaks in soft, coarse blocky peds; very friable; boundary clear and wavy.
B'22	32-38"	Mottled olive gray (5Y 5/2) olive brown (2.5Y 4/4) and yellowish brown (10YR 5/6) very fine sandy loam or loamy very fine sand; mottles are many medium and distinct; very friable; boundary abrupt.
A''2(IIC1)	38-41"	Gray (5Y 5/1) and dark gray (5Y 4/1) gravelly coarse sand with a few dark brown (10YR 3/3) iron or organic stains; very friable; boundary abrupt.
IIC2	41-50"	Coarse sand and gravel with pockets of coarse sandy loam; numerous iron stains on gravels and in pockets; slightly firm in place but loose when disturbed; boundary diffuse.
IIC3	50-56"	Same as overlying horizon with only a very few iron stains.

Remarks: Worm holes with material from the Ap horizons are common in B21 and B22 horizons. Roots are many in the Ap horizon but some roots extend to the IIC2 horizon. The underlying gravel is derived principally from gneiss, quartz and schist.

The Bridgehampton soils have developed from silty mantles, ranging from about 24 to 42 inches in depth, over sand and gravel or coarse textured glacial till. Typically they occur on nearly level to gently undulating surfaces.

Sample collected by E. J. Pederson, M. A. Puchalski, J. W. Gonick and A. E. Shearin, SCS; R. S Bell, University of Rhode Island; D. E. Hill, CAES.

Profile described by A. E. Shearin—11/12/58.

Profile No. 3 Description for Thesis by C. T. Lim (17)

Soil Type: Bridgehampton silt loam.

Location: Town of South Kingstown, Washington County, R. I., about one and one-half miles west of Kingston, just south of Rt. 138 on Ministerial Road.

Elevation: About 103 feet.

Topography: Nearly level.

Vegetation: Twenty to 30 year old pole stage white oak forest with a dense undergrowth of low bush blueberries and sheep laurel.

Description:

Horizon	Depth	
01	3- 2''	Mostly deciduous foliage which is essentially unaltered.
02	2- 0''	Partially decomposed and matted organic debris. Soil fauna excrement and remains make up a large part of this material.
A1	0- 3''	Very dark brown (10YR 2/2) silt loam; very weak medium granular structure; friable; abrupt smooth boundary.
B21	3- 6''	Dark brown (7.5YR 4/4) silt loam; very weak coarse granular; friable; abrupt wavy boundary.
B22	6-13''	Yellowish brown (10YR 5/6) silt loam; structureless, massive breaking into soft subangular clods when disturbed; very friable; clear wavy boundary.
B23	13-20''	Brown (10YR 5/3) silt loam; structureless; massive breaking into soft subangular clods when disturbed; very friable; clear wavy boundary.
A'2	20-28''	Grayish brown (2.5Y 5/2) with streaks of yellowish brown (10YR 5/6) silt loam; structureless massive; clear wavy boundary.
B'21	28-34''	Strong brown (7.5YR 5/8) silt loam; structureless, massive breaking into soft subangular clods when disturbed; very friable; abrupt wavy boundary.
IIC	34-42''	Olive brown (2.5Y 4/4) coarse sand; loose. Roots numerous and well distributed in the A1, B21 and common in the B22, B23 horizons.

Sample collected by Chang Taik Lim, U.R.I.; M. A. Puchalski, A. E. Shearin, SCS; and M. Salomon, U.R.I. Description by M. A. Puchalski.

Laboratory Characterization

In April 1961 the Soil Survey Laboratory characterization report was prepared for the three Bridgehampton silt loam profiles presented in the previous section. The following excerpt is taken from that report. Classification is discussed in terms of the 1938 system of classification. Tables of physical and chemical data and descriptions for these profiles are contained in subsequent sections.

"The major profile features of the Bridgehampton soils are the development of a Brown Podzolic profile to a depth of about 20 inches. From the particle size analysis there appears to be a silt overlay probably of aeolian origin on a more sandy glacial deposit. Although not apparent at the sampling sites, profile irregularities caused by ice wedge displacement have been observed in the Bridgehampton soil. The solum below the Brown Podzolic profile seems to have been influenced by a fluctuating water table or seasonal lateral movement of water as indicated by the position of blanched and iron enriched horizons. The blanched horizons were designated as A'2 or A''2 when they occurred in sequence. Zones of iron enrichment usually occurred below the blanched horizons. Some of the blanched material occurred in flat tubular forms indicating localized movement of ground water through the soil. The A'2 and A''2 (IIC1) horizons have lower free iron oxide contents, but do not have a consistent or significant decrease in clay. Organic matter increased at the break between the silty overlay and the underlying sandy material. An organic matter increase also occurred in the lowest sequence of bleached and iron enriched A''2 (IIC1) and IIC1 horizons. This increase is apparent even when the organic carbon is calculated on basis of the total soil including the 2 mm fraction. The organic matter content and C/N ratios of the upper sequence of horizons is typical of cultivated Brown Podzolic soils."

Physical and Chemical Properties

Particle size distribution for three profiles of Bridgehampton silt loam is shown in Tables 1 and 2. As will be noted all three profiles were high in silt and very low in clay. Most of the silt was coarse. In the data from C. T. Lim (17), coarse silt made up approximately 95 percent of the total silt. The data showed a strong contrast in texture between the solum and the unconforming IIC horizons. Clay mineral analyses using an X-ray Geiger Counter by Lim (17) showed that kaolinite and muscovite were the dominant clay minerals in the B21 horizon of the profile which he studied.

Chemical characteristics of two Bridgehampton profiles are shown in Table 3.

The cation exchange capacity, except for the more highly organic horizons (Ap horizons), is low. See Table 3. The percent clay is also slightly higher in the Ap. The higher contents of organic matter and clay in the Ap account in part for the greater CEC of this horizon. Percent base saturation is low except for the IIC horizons indicating a low base status of the original parent material and/or soil development under a regime of active leaching.

The Ap horizons have cation exchange capacities of 28 milliequivalents per 100 grams of oven dry soil. The exchange capacity decreases markedly with depth due to the low content of organic matter. As expected in an acid soil, hydrogen ions are abundant so that base saturation was in

Table 1. Particle size distribution for 2 profiles of Bridgehampton silt loam, Washington County, R. I.

Horizon	Depth in.	Very coarse sand 2.1	Coarse sand 1-.05	Medium sand .5-.25	Fine sand .25-.10	Very fine sand .10-.05	Silt .05-.002	Clay < .002	Coarse skeleton > 2.0	Textural class**
			Percent particle size distribution (in mm)							
			S 58 RI-5-3 (1-9) 1960*							
Ap	0-10	0.7	1.5	2.1	4.1	14.9	70.5	6.2	1	sil
B21	10-14	0.1	0.4	0.6	1.2	14.6	78.0	5.1	< 1	sil/si
B22	14-19	0.2	0.4	0.4	1.1	15.2	78.5	4.2	< 1	sil/si
A'2	19-26	0.0	0.2	0.2	0.7	18.5	78.0	2.4	< 1	sil
B'21	26-32	0.1	0.2	0.5	1.8	22.1	72.9	2.4	< 1	sil
B'22	32-38	1.0	2.7	4.3	11.2	34.6	44.6	1.6	8	vfsl
A''2 (IIC1)	38-41	7.4	12.6	10.7	18.5	27.1	22.9	0.8	49	ls
IIC2	41-50	19.0	31.8	15.1	11.0	8.7	13.5	0.9	72	lcos
IIC3	50-56	24.0	33.1	13.4	16.0	6.9	5.9	0.7	72	lcos
			S 58 RI-5-2 (1-7) 1960*							
Ap	0-10	0.4	0.7	0.8	1.8	20.2	72.1	4.0	< 1	sil
B21	10-21	0.1	0.2	0.3	0.9	20.4	76.0	2.1	0	sil
B22	21-31	0.0	0.2	0.3	1.0	19.1	75.2	4.2	0	sil
B23g	31-38	0.1	0.2	0.3	0.9	20.4	76.6	1.5	< 1	sil
A'2	38-40	2.3	1.8	1.3	1.9	22.2	69.3	1.2	6	sil
IIC1	40-43	17.4	29.6	17.8	12.7	6.2	15.6	0.7	35	lcos
IIC2	43-52	26.7	38.5	19.3	10.7	1.5	2.7	0.6	57	lcos

*Data by Soil Survey Lab, SCS, Beltsville, Maryland.

**Sil = silt loam, si = silt, lcos = loamy coarse sand, vfsl = very fine sandy loam, ls = loamy sand.

Table 2. Bridgehampton profile analysis by C. T. Lim (17), URI (1965), Washington County, R. I.

Horizon	Depth inches	Very coarse sand 2-1	Coarse sand 1-0.5	Medium sand 0.5-0.25	Fine sand 0.25-0.100	Very fine sand .10-0.05	Coarse silt 0.05-0.005	Fine silt 0.005-0.002	Clay 0.002	Textural class
A1	0- 3	1.0	3.8	5.6	4.3	11.5	62.9	0.8	10.1	sil
B21	3- 6	0.3	1.6	3.3	3.0	12.6	71.5	2.3	5.4	sil
B22	6-13	0.5	1.5	3.0	2.6	15.1	71.3	4.7	0.1	sil
B23	13-20	0.2	1.1	2.0	5.9	11.2	72.4	5.3	2.0	sil
A'2	20-28	0.5	1.0	1.6	1.5	13.4	74.8	3.1	2.7	sil
B'21	28-34	1.5	3.8	6.6	6.0	14.4	60.9	2.0	2.2	sil
IIC	34-42	11.5	23.3	35.1	18.5	6.0	2.1	2.6	0.004	sil

the range of 7-11 percent. The percent base saturation increased with depth. Exchangeable calcium ranges from 1.5—2.3 me, magnesium from 0.3—0.4 me, and potassium from 0.2 to 0.4 me per 100 grams of oven dry soil. The exchangeable calcium, magnesium and potassium decreased with depth.

The reaction of the A1 and Ap horizons ranges from pH 4.4 to 4.7. The layers below these have pH variations from 5.0 to 5.7. The percent base saturation is lower in the A horizon indicating more reserve acidity ($H+$) and a lower content of basic cations in this zone.

Organic carbon decreased with depth but did not decrease regularly in the two profiles. Free iron oxides were highest in the Ap and B_2 horizons, decreased noticeably in the A_{12} horizons and increased in the horizons just beneath.

The first chemical analyses of these soils were published in 1894 by Wheeler and Hartwell (41). The samples were selected from spots which appeared to be uncontaminated and which represented the natural condition. The analyses were probably made by extraction with dilute hydrochloric acid. The soils were judged to be acid, since the moistened soil imparted a red color to blue litmus. No free calcium carbonate was detected. Iron (Fe_2O_3) ranged from 3.463 to 3.728% and aluminum from 3.086 to 4.641%. Interest in the aluminum content and its effect on crop growth and fertility has persisted to the present time. The calcium content (CaO) approximated one-half percent and magnesium (MgO) was slightly over two-tenths percent. Potash (K_2O) ranged from 0.155 to 0.175% and phosphate (P_2O_5) from 0.106 to 0.127%. It is also interesting to note this early analysis for organic phosphate in humus ranging from 0.042 to 0.079%.

Bulk densities and moisture tension values at 1/3 and 15 atmospheres for the profiles 558RI-5-2 and 558RI-5-3 are presented in the section on soil moisture and irrigation.

Moisture retention values for two profiles by the USDA Soil Survey Lab are shown in Table 4. The percent water by weight at suction tensions of 0.33 atmosphere (field capacity) ranged from 25.3 to 26.8 for the Ap horizon (0-10"). At 15 atmospheres tension (wilting point) the percent water ranged from 8.2 to 10.5 for the Ap.

While the percentages of moisture vary with the organic matter and soil texture the inches of available water held per inch of soil are quite similar. Computations from the Soil Survey Lab indicate 0.180-0.184 inches of water per inch of soil in the Ap horizons. In the B_{21} horizons the range was from 0.178 - 0.20 inches of water per inch of soil.

Tisdell (38) after several determinations of the moisture content of sieved samples of Bridgehampton soil from the experimental plots decided on a percent moisture of 30% for field capacity (1/3 atmosphere) and 9 per-

Table 3. Chemical characteristics* of Bridgehampton silt loam, Washington County, R. I.

Horizon	Depth inches	Extractable cations me per 100 g soil Ca	Mg	H	K	Na	Cation exchange capacity me	% base sat.	pH 1:1 paste	Organic matter: Organic carbon %	Nitrogen %	C/N	Free iron oxide %
					S 58 RI-5-2 (1-7) 1960								
Ap	0-10	2.3	0.4	25.0	0.4	0.1	28.2	11	4.7	3.20	0.224	14	1.4
B21	10-21	0.8	0.3	5.8	0.3	0.1	7.2	19	5.0	0.33	0.035	9	1.2
B22	21-31	0.8	0.3	4.9	0.3	0.1	6.3	22	5.3	0.30			1.3
B23g	31-38	0.2	0.2	3.4	0.3	0.1	4.1	17	5.5	0.09			1.0
A'2	38-40	0.2	0.1	2.4	0.2	0.1	2.9	17	5.5	0.14			0.4
IIC1	40-43	0.3	0.1	1.3	0.2	0.1	1.9	32	5.4	0.42			1.0
IIC2	43-52	0.3	0.1	0.0	0.1	0.1	0.5	100	5.3	0.19			0.4
					S 58 RI-5-3 (1-9) 1960								
Ap	0-10	1.5	0.3	26.4	0.2	0.1	28,5	7	4.6	5.16	0.282	13	1.6
B21	10-14	0.5	0.2	20.6	0.1	0.1	21.4	4	4.5	0.90	0.085	10	1.8
B22	14-19	0.4	0.2	7.7	0.1	0.1	8.4	8	4.5	0.48	0.039	12	1.7
A'2	19-26	0.2	0.1	6.0	0.1	0.1	6.4	6	4.7	0.37	0.035	11	0.6
B'21	26-32	0.2	0.2	5.4	0.1	0.1	5.9	8	4.8	0.23			1.7
B'22	32-38	0.2	0.2	3.2	0.1	0.1	3.6	11	5.0	0.12			1.0
A''2 (IIC1)	38-41	0.2	0.2	1.2	0.1	0.1	1.7	29	5.4	0.24			0.6
IIC2	41-50	0.2	0.1	1.0	0.1	0.1	1.3	23	5.2	0.22			0.8
IIC3	50-56	0.2	0.1	0.4	0.1	0.1	0.7	43	5.3	0.12			0.6

*Data by Soil Survey Lab., SCS, Beltsville, Maryland.

cent for wilting point (15 atmospheres tension). Bulk densities, per cent water held at 60 cm tension and percent capillary and non-capillary moisture were also determined by Tisdell in one plot planted to redtop hay and another nearby where Irish potatoes were growing. These are shown in Table 5. The moisture at 60 centimeter tension averaged very close to 33 percent in each area. Both the capillary and non-capillary porosities were slightly greater under redtop sod than under potatoes.

Tisdell (38) estimated percent available moisture (field capacity minus wilting point) as follows: 0.33 atm = 100%, 1 atm = 46% 2 atm = 27%, 5 atm = 5% and 15 atm = 0%. These data indicated that when water tension increased to one atmosphere the available moisture was approximately half consumed or dissipated. With further depletion of available water, approximately 25% was left in the soil at 2 atmospheres tension.

Irrigation of Potatoes

Bridgehampton soils have a well-known reputation among farmers for their ability to supply moisture for crops during dry periods. This is one reason potato farmers have sought out the Bridgehampton soils. A more detailed discussion of climatic conditions follows this section on irrigation.

During an experiment continued for a five-year period 1956-1960, potatoes responded to irrigation only in 1957 when rainfall was extremely deficient in June and July. Five inches of irrigation water produced a significant increase in yield. Data concerning potato yields and available moisture for 1957 and 1960 in Table 6 were abstracted from a northeastern regional publication by Vittum et al (42). With a rainfall of 9.1 inches during the growing season Katahdin potatoes without irrigation yielded 357 cwt/A of US No. 1 tubers. One and one-half to 3 inches of additional water did not increase the yields or quality. In 1957, however, with a total of 6.8 inches with a severe drought in June and July, five inches of irrigation increased yields significantly from 238 to 320 cwt/A.

Climate

Since climate is so pertinent to irrigation and crop adaptation, a review of the current moisture deficiency as well as temperature variations and evaporation losses at Kingston, Rhode Island, is included here to partially describe the environment surrounding Bridgehampton soils.

Because of the proximity to the ocean, the climate is comparatively moderate. Less precipitation as snow and more as rain is common to areas occupied by Bridgehampton soil compared to interior New England. Likewise, the summers are a little cooler and more humid than farther inland. Some of the areas are close enough to the sea to receive small amounts of salt during hurricanes.

Table 4. Moisture retention, bulk density, organic carbon and nitrogen content in two profiles of Bridgehampton silt loam.*

Horizon	Depth inches	Percent water by weight at suction of 0.1 atm	0.33 atm	15 atm	Inches water per inch soil	Bulk density
			S 58 RI-5-3- (1-9) 1960			
Ap	0-10		26.8	10.5	0.180	1.11
B21	10-14		21.8	6.9	0.178	1.20
B22	14-19		20.9	6.0		1.19
A'2	19-26		18.4	3.7		1.33
B'21	26-32		16.8	3.2		1.36
B'22	32-38	25.4	9.1	1.7		1.63
	38-41	13.2	4.2	1.0		1.74
	41-50	8.9	4.2	0.9		
	50-56	3.3	1.7	0.6		
			S 58 RI-5-2 (1-7) 1960			
Ap	0-10		25.3	8.2	0.184	1.08
B21	10-21		20.4	4.4	0.200	1.27
B22	21-31		21.2	4.4		1.34
B23g	31-38		15.2	2.6		1.44
A'2	38-40		12.3	1.5		1.47
	40-43	8.3	5.1	1.2		
	43-52	2.3	1.6	0.7		

*Data by Soil Survey Lab., SCS, Beltsville, Maryland. See profile descriptions in previous section.

Table 5. The average bulk densities, percent water held at 60 centimeters tension, capillary and non-capillary porosities of Bridgehampton silt loam.*

Depth inches	Bulk density	% Water 60 cm	% Capillary porosity	% Non-cap porosity
		Redtop hay		
4-5	1.39	33.3	46.2	5.0
9-10	1.41	32.7	45.9	6.8
14-15	1.37	33.9	46.6	5.2
		Potatoes		
4-5	1.25	32.9	41.0	4.1
9-10	1.30	31.1	40.5	3.4
14-15	1.24	33.7	41.9	2.4

*Tisdell (38), Agronomy plots, Kingston, R. I.

Table 6. Response of Katahdin potatoes to irrigation of Bridgehampton silt loam, Agronomy plots, Kingston, R. I.

Year	Treatment	Maximum tension (atm)	No. appl.	Total inches applied	Rainfall inches	US No. 1 cwt/A	Specific gravity
1957	None	—	0	0	6.8	238	1.064
	75 % depletion	5.8	3	5.0		320	1.065
	55 % depletion	2.7	3	6.4		331	1.059
	35 % depletion	1.2	5	9.7		350	1.064
	LSD(19:1)	—	—	—		57	
1960	None	—	0	0	9.1	357	1.074
	75 % depletion	5.8	1	1.5		349	1.073
	55 % depletion	2.7	1	1.4		328	1.072
	35 % depletion	1.2	2	2.9		337	1.072
	LSD(19:1)	—	—	—		NS	

The mean monthly temperatures and inches of precipitation prepared by the U.S. Weather Bureau are shown for three weather stations in the areas where Bridgehampton soil is located. See Table 7. The discussion, however, is confined to the data from the agronomy plots at Kingston, R. I., since these data are related to the experimental results. January had the lowest mean temperature, 29.2°F., while the temperature for July averaged 69.9°F. January, March, August and November each averaged more than four inches of precipitation annually. July was the driest month with an average rainfall of 2.84 inches. The total annual rainfall at Kingston (agronomy plots) was 44.82 inches with slightly more than half occurring between April and October 31.

The total annual rainfall and the deviations from normal for the past 21 years are presented in Table 8. This shows a variation from 30.69 inches in 1965 to 61.11 in 1953. In 14 out of 21 years rainfall has been below normal. The 21-year deficiency totaled 118.42 inches. When the above-normal total rainfall of 40.74 is subtracted, a net deficiency of 77.68 inches of precipitation results.

Length of growing season was determined by the number of days between the last day in spring and the first day in the fall when a temperature of 32°F. or lower is recorded. During the 14-year period 1933-1946 (10) the average was 136 days. The variations in length of growing seasons between 1960 and 1965 are shown in Table 9. The range is from 137 to 160 days with an average of 148. In 1961 a damaging frost occurred May 31 but the first fall frost did not occur until October 16 which allowed a normal growing period. Damaging frost rarely occurs before mid-September.

Measurements of evaporation from a free-water surface are useful in planning irrigation practices. The total evaporation in inches per month at Kingston, R. I., is shown in Table 10. The six-year averages for June, July and August, respectively, were 5.60", 5.49", and 4.70" of evaporation.

Soil temperatures at four depths (4", 8", 12", and 24") under bluegrass lawn at Kingston, R. I., were recorded daily. Five years' data for April, July and December are presented in Table 11 to indicate the variations which occur in Bridgehampton soil planted to Kentucky bluegrass lawn. The average monthly temperatures at four inches deep for April, June and December, respectively, were 44.3°F., 70.5°F., and 34.3°F. In contrast at 24" depth the averages were 42.5°F., 66.0°F., and 41.1°F. These figures indicate that in April and July the soil is slightly cooler at two feet than at the four-inch depth. During December, however, the soil near the surface is considerably cooler than at the two-foot depth.

Table 7. Monthly, annual, and growing season (April 1-October 31) normal mean temperature (°F) and precipitation (inches) based on 1931-60 data.*

	Temperature (°F)			Precipitation (inches)		
	Kingston R. I.	Storrs Conn.	Bridgehampton N. Y.	Kingston R. I.	Storrs Conn.	Bridgehampton N. Y.
January	29.2	26.2	32.0	4.07	3.61	3.84
February	29.8	26.8	31.9	3.38	2.85	3.59
March	36.4	34.2	37.6	4.27	4.20	4.61
April	45.8	45.4	46.6	3.92	3.89	3.62
May	55.6	56.3	56.1	3.44	3.85	3.44
June	64.3	65.0	65.3	3.02	3.48	2.88
July	69.9	70.0	71.3	2.84	3.91	2.92
August	68.9	68.3	70.7	4.50	4.94	4.42
September	62.2	61.1	64.4	3.74	4.09	3.67
October	52.4	51.6	55.1	3.29	3.48	3.55
November	42.5	40.9	45.3	4.57	4.26	4.66
December	31.8	29.1	34.8	3.78	3.66	4.10
Annual	49.1	47.9	50.9	44.82	46.22	45.30
Apr.-Oct.	59.9	59.7	61.4	24.75	27.64	24.50

*Table prepared by J. J. Brumbach, State Climatologist, Storrs, Connecticut.

Table 8. Total Annual precipitation and deviation from normal. Agronomy plots, Kingston, Rhode Island (1945-1965)

Year	Inches precipitation	Inches below normal	Inches above normal
1945	42.85	7.36	
1946	39.24	10.97	
1947	41.68	8.53	
1948	42.73	7.48	
1949	35.85	14.36	
1950	35.41	14.80	
1951	42.65	7.56	
1952	44.95	5.26	
1953	61.11		10.90
1954	53.82		3.61
1955	50.40		0.19
1956	45.63	4.58	
1957	34.00	16.21	
1958	55.82		11.12
1959	44.47	0.23	
1960	46.38		1.68
1961	53.15		8.45
1962	49.61		4.79
1963	42.04	2.78	
1964	40.65	4.17	
1965	30.69	14.13	
Total deviation	933.13	118.42	40.74

Engineering Test Data

Engineering test data for several Bridgehampton profiles have been published by Moultrop (20) in Bulletin No. 4 of the Rhode Island Engineering Experiment Station. Readers should refer to this publication for the detailed mechanical analyses.

The Bridgehampton soil, classified as A-4 in the ASSHO system, provides a firm riding surface when dry, with little rebound after loading. When wet it becomes elastic and shows considerable rebound where load is removed. At high moisture contents it has very low stability and bearing capacity and is subject to frost heave. It is generally difficult to compact because of poor gradation and because the moisture range for satisfactory compaction is very narrow.

Site Conditions for Tree Growth

McGahan (19) and associates made a study of the composition and growth of Rhode Island forests using 70 one-quarter acre plots. A few of these plots were located in Bridgehampton soils. Correlations were based on groups of soils grouped on drainage and texture, and not on individual soils. The soils were classified as Bridgehampton on two mixed oak plots and one white pine plot. The site index on one mixed oak plot was 59 and the other 63 which is considered low for Bridgehampton. Although significant regressions were developed for mixed oak stands, red maple and white pine, they were considered inadequate for accurate height growth predictions. Height growth of mixed oak stands was greatest on the more poorly drained, finer-textured soils having the deeper A horizons. Observations indicate that these situations are also rather favorable for white pine because the better moisture supply allows it to compete with deciduous trees.

Drainage Fields for Septic Tanks

The Bridgehampton soils over stratified sands and gravels transmit septic tank effluents in a satisfactory manner. The stratified sands and gravels are more loosely packed than the unstratified glacial till. Effluent disposal is satisfactory, however, in the glacial till when the sewer systems are properly installed with adequate disposal area.

The looser packing of the stratified sands and gravels is evidenced in the experimental plots and nearby potato fields after the frost leaves the ground in March. A few small sink holes (6-12 inches across) are found scattered throughout this area each spring. Apparently the gravel underneath settled allowing the silt to be drawn down 8-10 inches into the profile.

Soil Fertility Studies

The agronomy plots of the Rhode Island Agricultural Experiment Station were started on a level area of the Watson Farm purchased in Sep-

Table 9. Date of last spring frost and first fall frost, minimum temperature at this date, and length of frost free period. Agronomy plots, Kingston, R. I. (1960-65).

Year	Last frost Min. temp. °F	Last frost Date	First frost Min. temp. °F	First frost Date	Frost free days
1960	29	5/ 3	30	9/17	137
1961	29	5/31	23	10/16	137
1962	29	5/13	30	9/21	150
1963	32	5/13	28	9/25	154
1964	26	5/ 4	21	10/12	160
1965	30	4/30	32	9/28	150
Av	29	——	27	——	148

Table 10. Inches of evaporation from a free-water surface. Agronomy plots, Kingston, R. I. (1960-65)

	May	June	July	August	Sept.	Oct.
1965	5.52	6.12	5.87	5.22	3.88	3.38
1964		6.14	4.97	4.37	4.08	2.52
1963	5.23	5.37	5.94	4.88	3.57	3.76
1962	4.85	5.45	4.97	5.00	3.69	3.02
1961	4.32	4.99	5.13	4.47	4.12	2.63
1960	4.33	5.55	6.08	4.25	3.35	3.02
Av	4.85	5.60	5.49	4.70	3.78	3.06

Table 11. Average monthly soil temperatures (F°) under bluegrass lawn on Bridgehampton silt loam at Agronomy plots, Kingston, R. I.

Years	Depth 4"	8"	12"	24"
		April		
1960	48.1	45.8	44.9	43.8
61	44.0	42.2	41.3	40.8
62	44.4	43.5	42.7	44.4
63	41.4	40.5	39.7	39.6
63	43.8	43.4	42.9	43.9
Av	44.3	43.0	42.3	42.5
		July		
1960	74.8	71.0	69.3	67.5
61	71.1	69.8	68.7	66.7
62	67.0	66.8	66.5	65.0
63	70.7	70.1	68.2	66.2
64	68.8	69.0	67.0	64.8
Av	70.5	69.3	67.9	66.0
		December		
1960	32.9	34.7	37.3	41.3
61	34.4	36.1	39.7	42.4
62	33.9	35.8	38.1	41.5
63	34.4	35.8	40.0	42.5
64	36.0	36.3	36.8	37.7
Av	34.3	35.7	38.4	41.1

tember 1888. In September 1890, bulletin No. 8 was published. It was written by Dr. H. J. Wheeler, Chemist, and discussed soils and fertilizers under the following topics: (a) soils, their origin, analysis and renovation, (b) commercial valuation of fertilizers and (c) composition of fertilizing materials.

By 1894 Wheeler and Hartwell (41) had conducted sufficient tests on this soil, which was eventually classified as Bridgehampton silt loam, to publish the following observations:

1. Tests with fertilizers have shown that the soil of the Kingston Plain cannot be profitably cultivated without immediate resort to phosphatic fertilizers.
2. In the case of acid soils an application of caustic or carbonate of lime proved to be an efficient remedy.
3. There was probably no question but that barnyard manure in sufficient quantities reduced the need for lime, but the application of lime was more practical.
4. Where muriate and sulfate of potash or sulfate of ammonia were used, the crops remove chiefly bases, leaving the greater portion of the acid behind. This increased the need for lime.
5. Sodium nitrate was thought to be beneficial not only because the nitrate which the crop removed left a slightly alkaline residue, but because the sodium probably liberated potash which may have been of some direct fertilizing value to certain plants.

These early experiments led to numerous detailed fertility studies with Bridgehampton soil. Some of the major results of fertility experiments during the past 75 years will be reviewed briefly. Certain papers and bulletins will be mentioned, each of which contains an extensive bibliography with references to several other research papers.

Lime and Liming

Soon after the establishment of the Rhode Island Agricultural Experiment Station it became evident that lime must be applied to grow most crops. Spinach and lettuce were more seriously affected by high soil acidity than any other crops. The most important crops requiring lime were beet, onion, muskmelon, cabbage, cauliflower, cucumber, barley, red clover, pea and rutabaga. Potato yields were increased as was the scab disease. Watermelon yields decreased but the fruits ripened earlier.

In a study (15) of the effect on soils and crops of long-continued use of sulfate of ammonia and nitrate of soda with and without lime, it was found that 4.2 to 4.5 pounds of CaO per acre were needed for each pound of nitrogen as ammonium sulfate, if pH levels were to be maintained in a favorable range. The use of 4 pounds of CaO per pound of nitrogen from ammonium sulfate was a standard recommendation for many years.

Salomon and Smith (34) reported that the cation exchange capacity of the soil in these plots was about 11.5 me per 100 grams of oven dry topsoil. The exchange capacity of the subsoil ranged from 4 to 6 me. Since the soil contained less than two percent clay, the exchange capacity was assumed to be principally due to the organic matter content which ranged from 4.0 to 4.3 percent.

Hartwell (11) found no differences in response of crops to high magnesium hydrate, high calcium hydrate, high calcium limestone and high magnesium limestone when applied in chemically equivalent amounts with the limestones ground to pass through an 80-mesh sieve. He indicated that the high-magnesium limestone did not react as rapidly as the others.

A recent test (29) wtih ground dolomitic limestone applied to Bridgehampton silt loam indicated that pH changes were modest even when the limestone applications were high. These data are shown in Table 12. Even though pH changes were small, the benefits of liming acid soils were considerable.

Phosphate

The fairly large quantity of aluminum and iron in Bridgehampton soil led to the supposition that the phosphate fertilizers which were so essential to adequate crop production were precipitating as slightly available aluminum and iron phosphate. Manning and Salomon (18) have recently shown that 65 years of consistent fertilization with superphosphate resulted in large accumulations of aluminum phosphates and lesser amounts of iron phosphate. The calcium phosphate fraction was increased by rock phosphate. Phosphate from manures also bonded more readily with aluminum than with iron. The summary of data for the unfertilized soil in Table 13 shows 45% aluminum phosphate, 25% iron phosphate, and 2% calcium phosphate. The very high superphosphate and the complete fertilizer plots had a range of 60-66% Al-P, 19-21% Fe-P, 5-6% Ca-P. Where large quantities of readily available phosphate were applied, considerable increase in the percentage of Al-P occurred, a slight increase in Ca-P, and a slight decrease in Fe-P.

The need for phosphates was established soon after the Rhode Island Agricultural Experiment Station was established, and crop responses to the various carriers have been periodically studied as new materials were introduced. Odland and Cox (26) in 1942 reported the response of eleven vegetable and field crops to several sources of phosphate. They concluded that ordinary and concentrated superphosphate were the most economical and satisfactory sources of phosphorus. In general, rock phosphate did not prove satisfactory, especially for potatoes or for crops on adequately limed areas. Dicalcium phosphate was about as effective as superphosphate.

Eight phosphate fertilizers were compared by Odland, Bell and Salo-

Table 12. Soil pH after application of various amounts of dolomitic limestone, (A) land recently reclaimed from brush and (B) land fertilized and cropped for 50 years. Agronomy plots, Kingston, R. I.

	A				B			
	Tons/A limestone							
Year	0	5	7-2/3	10	0	3-3/4	6	9
1954	5.7	6.5	6.5	6.9	5.5	6.2	6.4	6.6
1956	5.3	6.2	6.2	6.6	5.7	6.3	6.6	6.7
1959	5.5	5.8	6.2	6.2	5.5	5.9	6.5	6.9

Table 13. Inorganic phosphorus content of Bridgehampton soil after 65 years of fertilization and cropping (adapted from Manning and Salomon, (18) R. I. Agr. Exp. Station).

	Total lb P	Total P extract	Percent		
Treatment*	applied	ppm	Al-P	Fe-P	Ca-P
VL superphosphate	373	503	48	24	2
L superphosphate	1436	780	47	23	6
VH superphosphate	3620	1400	66	19	6
L rock phosphate	1478	777	39	16	28
M rock phosphate	2248	963	26	12	42
Manure	3206	1063	56	23	5
Complete Fertilizer	3680	1459	60	21	5
Check	none	528	45	25	2

*All treatments with exception of check and manure were balanced with N and K.

Table 14. Phosphorus sources used, extractable phosphorus and pH after 15 years of fertilization. (R. I. Agr. Exp. Station, 1955)

	%	Extractable P lb/A			
Phorphorus sources	P_2O_5	Truog	Thornton	Bray P_2	pH
A Ordinary superphosphate	21	83	109	280	5.1
B Concentrated superphosphate	48	87	109	320	5.1
C Dicalcium phosphate	42	95	127	294	5.3
D Rock phosphate, TVA	32	185	195	330	5.3
E Calcium metaphosphate, TVA	63	128	146	335	5.4
F Fused phosphate, TVA	29	131	171	341	5.7
G Potassium metaphosphate, TVA (35% K_2O)	58	97	114	325	5.4
H Potassium metaphosphate, USDA (40% K_2O)	60	94	109	308	5.3
LSD at 0.05		32.5	57.4	NS	
LSD at 0.01		43.5	NS	NS	

Table 15. Average yields per acre of corn, potatoes and mixed hay with different phosphorus sources at Rhode Island Agricultural Experiment Station (1941-1955).

Phosphorus sources	West Branch 1941 grain	Ohio K-24 1946 silage	Penn 602 1953 silage	US No. 1 potatoes 6-yr average		Mixed clover hay 3-yr average
	Bu/A	T/A	T/A	Bu	%	T/A
A Ordinary superphosphate	53	13.6	19.2	255	90	2.50
B Concentrated superphosphate	51	14.6	18.9	248	88	2.29
C Diacalcium phosphate	48	14.7	17.9	241	88	2.49
D Rock Phosphate, TVA	45	14.1	19.1	147	84	2.41
E Calcium metaphosphate, TVA	46	14.5	18.6	200	86	2.47
F Fused phosphate, TVA	49	14.8	19.4	212	87	2.85
G Potassium metaphosphate, TVA (35 % K_2O)	50	14.1	19.5	234	89	2.52
H Potassium metaphosphate, USDA (40 % K_2O)	50	14.2	18.8	227	85	2.57
LSD at 0.05	7	1.2	2.0	18		0.31

mon (23) over a 15-year period with a five-year rotation consisting of potatoes two years, corn one year, and red clover-timothy hay two years. The phosphate applications were lower than those usually recommended for Bridgehampton soil. Rock phosphate was applied at double the phosphoric acid content of superphosphate. Fused phosphate was also used at the double P_2O_5 rate for 10 years and reduced to the single rate for the last 5-year period. The data in Table 14 show the extractable phosphorus and pH level after 15 years of fertilization. The fused phosphate plots were the least acid, with a pH of 5.7 at the end of the test, while the soil where ordinary or concentrated superphosphate was used had a pH of 5.1. The area received 3000 pounds per acre of dolomitic limestone in 1940 and again in 1948. The average yields are reported in Table 15. The higher yields of mixed clover hay from the fused phosphate probably reflect the less acid condition.

Potatoes produced higher yields where the readily available superphosphates were applied. Corn and mixed hay were less critical of the phosphorus source and other sources could be substituted if the cost were comparable for the various phosphates. More residual phosphate accumulated in the soil following treatments with rock phosphate, fused phosphate, and calcium metaphosphate. The Bray P_2 method of phosphate analysis showed a closer relationship between residual soil phosphorus and crop yields than did either the Truog or Thornton methods.

Gilbert and Pember (9) using barley seedlings, rated several phosphate materials and found that ammoniated superphosphates, calcined phosphate, dimagnesium phosphate, and calcium pyrophosphate also compared favorably to superphosphate.

Potash

Odland and Cox (25) reviewed the experiments with potash fertilizers on Bridgehampton soils. The original soil was deficient in potassium so manure or fertilizers were necessary. Among the crops which showed a good response to potash were clovers, alfalfa, mangel beets, potatoes, onions, parsnips, and tomatoes. Cereals, grasses and carrots showed the least response. Equal amounts of potash whether supplied in kainit, sulfate of potash-magnesium, muriate of potash of sulfate of potash had about equal value. It was concluded that the cheapest source should be used.

In Table 16 yields for eight crops with low potash and the percentage increases for standard and high potash are shown. Yield percentage increases ranging from 106 to 348 were obtained when the annual average applications of potash were increased from 22 to 63 pounds per acre per year. The percentage increases between the standard and the high potassium ranged from 9% for corn to 61% for mangel beets.

Nitrogen

Nitrogen from the readily soluble fertilizers has been considered equally available to economic crops providing adequate lime was used to correct excess acidity (15). Smith and Salomon (36) determined the optimum nitrate concentration needed for certain vegetables. Celery made the best growth with 25 ppm of nitrate nitrogen during the first third of the growth period and 50 ppm for the rest of the season.

Beets benefited from 50 ppm during the first two-thirds of the period and lower concentration after that. Single large applications of nitrogen at planting were satisfactory for beets. Nitrate applied in the fertilizer band was more effective than a broadcast application.

Late spinach grew best when the nitrate nitrogen concentration was 50 ppm throughout the growth period. Sweet Spanish onions did well at concentrations of 10-25 ppm. Larger amounts of nitrate were not favorable. Carrots responded best when 10-25 ppm of nitrate was maintained during the first third and increased to 25-50 ppm for the remainder of the season.

Nitrogen fertilizer for rye cover crops was investigated by Smith, Salomon and Beverage (37). The length of the growing period was more important than nitrogen fertilization for the rye cover crop grown in the interval between successive potato crops. Rye planted as late as October 1 and plowed in early May did not respond to nitrogen. Rye grown for a longer period benefitted from nitrogen. The amount of rye plowed under before planting potatoes was usually too small to have any effect on the amount of nitrogen required by the potato crop.

Aluminum

The presence of large quantities of soluble aluminum in Bridgehampton soil led the early investigators at the Rhode Island Agricultural Experiment Station to the conclusion that the unfavorable effect of acid soils on some crops was due to this toxic element. Hartwell and Pember (13) (1918), Burgess and Pember (5) (1923), and Gilbert and Pember (7) (1931) published numerous research reports concerning the toxic action of aluminum. Burgess and Pember (5) determined the comparative resistance of certain crops to

Table 16. Relative response of ten crops to increased potash applications.*

Crop	No of years grown	Unit	Potash Low	Potash Standard	Potash High	Percent increase in yield for extra potash
Corn	3	Bu	29.00	337	368	9
Oats (hay)	3	T	5.39	106	122	15
Carrots	5	Bu	573.00	127	157	24
Onions	6	Bu	167.00	224	293	31
Hay	7	T	1.58	166	220	33
Potatoes	11	Bu	140.00	181	248	37
Parsnips	2	Bu	186.00	348	496	42
Tomatoes	4	Bu	244.00	170	245	44
Cabbage	4	Bl	194.00	243	354	46
Mangels	7	T	7.14	194	311	61

*Odland and Cox (26) 1941. R. I. Agr. Exp. Station.

acidity and active aluminum. This is shown in Table 17.

Gilbert and Pember (7) reported the effect of lime and large amounts of acid phosphate on the yields of Cos lettuce, barley and onion bulbs, the soil pH after each crop and the active aluminum at the end of the test. The three crops were grown in sequence in the same pots of soil. Calcium hydrate was used as the source of CaO. Three tons per acre of this material raised the pH from 4.46 to 6.72. Large amounts of acid phosphate did not materially alter the soil reaction or active alumina. Excessive amounts of phosphate were more effective than lime in promoting the growth of Cos lettuce but were not beneficial to subsequent crops of barley and onions. Increasing amounts of lime progressively decreased the quantities of soluble aluminum.

In another test 20 tons per acre of acid phosphate were mixed with Bridgehampton soil which originally contained 840 ppm of Al_2O_3 and had a pH of 4.5. At the end of 5 days the concentration had lowered to 500 ppm but by the end of 9 months it had risen to 660 ppm and had a reaction of pH 4.7. It seemed evident from the many experiments that liming was a much less expensive and more efficient method of raising the soil reaction and lowering the content of active aluminum.

Magnesium Deficiency

Certain plots of highly acid soil which received large amounts of potash fertilizers for several years produced crops with chlorotic foliage and reduced yields. Knoblauch and Odland (14) determined that the difficulty could be overcome by the application of magnesium sulfate. A minimum of 20 pounds of MgO per acre from Epsom salts ($MgSO_4 \cdot 7H_2O$) was required. It is now a common practice to furnish magnesium by liming wtih dolomitic limestone. On crops such as potatoes, where liming is restricted, fertilizers are fortified with a non-alkaline magnesium compound.

Manganese Deficiency

During the course of the many liming experiments the Bridgehampton soil in several of the plots became neutral or alkaline in reaction. Several crops growing in these areas became chlorotic. The chlorosis was particularly noticeable on spinach, beets and oats. The lack of chlorophyll in beets brought out deep red or purple colors, while spinach and oats were yellowed. At first it was suspected that iron might be deficient but chemical analyses often showed more iron in the chlorotic plants. Since the chlorosis was as evident on soil made neutral or alkaline by magnesium lime as by calcium lime, it was concluded that a magnesium deficiency was not the cause. Gilbert (8) found that an application of manganous sulfate either as a foliar spray or mixed with fertilizer readily corrected the malady. Where manganese deficiency was found, the following amounts of manganous sulfate per acre were sufficient: 8 pounds dissolved in water and sprayed

Table 17. The comparative resistance of crops to aluminum toxicity (based on research with Bridgehampton topsoil).*

	Resistance		
	Low	Medium	High
pH range	Above 6	6 to 5.3	below 5.3
CaO requirement (Jones)	1500 lb/A	1500-3000 lb/A	above 3000 lb/A
active alumina†	below 300 ppm	300-500 ppm	above 500 ppm
	alfalfa	barley	alsike clover
	asparagus	cabbage	buckwheat
	beets (sugar)	dandelion	corn
	leeks‡	rape	carrots
	lettuce‡	red clover	millet
	mangels	sweet clover	potatoes
	onions‡		redtop
	parsnips		rye
	spinach‡		wheat

*Burgess and Pember. 1923. R. I. Agr. Exp. Sta. Bul. 194.
†soluble in 0.5 N acetic acid.
‡extremely sensitive to active aluminum.

evenly over the crop or 30 pounds mixed with the complete fertilizer used in seedbed preparation. No more lime should be used until the soil reaction indicates a need for it.

Boron

Few tests have been conducted to determine whether crops growing in Bridgehampton soil respond to applications of boron. Three years of testing with potatoes showed no improvement in yields or quality from the use of boron in the fertilizer. According to Wakefield and co-workers (39) a fertility test with Ladino clover on a recently reclaimed piece of Bridgehampton soil showed that boron at 2.5 pounds per acre at seeding and thereafter in a fall application markedly increased the yields. It is now standard practice to apply fertilizer containing boron when preparing the seedbed for alfalfa.

Sodium

In the early years of the station many studies were conducted to find the effect of sodium on several crops grown in Bridgehampton soil. Wheeler and Hartwell (42) in the 1906 annual report published results of experiments conducted since 1898 that indicated that sodium could partially substitute for potassium in some crops. Hartwell and Damon (12) summarized additional experiments in 1919. Beets benefitted directly from applications of sodium in addition to potassium. Several crops displayed an indirect effect since they removed larger amounts of K from potassium deficient soils when supplied with sodium.

Fertilizing Potatoes

Odland and Sheehan (27) investigated the yields of potatoes from Bridgehampton silt loam which had been well fertilized in previous years. Little response was obtained to increased amounts of P_2O_5 or K_2O above the 90-pound-per-acre minimum. Increasing the nitrogen from 60 to 100 pounds per acre gave a positive increase in yields. They concluded that in well-fertilized Bridgehampton soil, potato growers should shift to a 1-1-1 ratio fertilizer and apply from 1500 to 2000 pounds per acre of an 8-12-12, 10-10-10 or similar fertilizer.

In another test, Odland and Sheehan (28) examined the response of potatoes to different amounts of nitrogen, P_2O_5 and K_2O when grown in continuous culture and in rotation with redtop grass. Potatoes grown in rotation averaged 60 to 80 more bushels per acre annually. The tubers from the redtop rotation had a consistently higher specific gravity which was correlated with better quality. No significant increases in yields of potatoes were obtained in continuous culture when the application was increased beyond 1500 pounds per acre of an 8-12-12 fertilizer. When grown in rotation with redtop, increases were obtained up to 1750 pounds per acre of this fertilizer.

Fertilizing Ladino Clover and Alfalfa

Wakefield, Schallock, Salomon and Olney (40) studied the effect of fertilizer treatments on the yield and chemical composition of Ladino clover. Satisfactory stands of clover were maintained with a minimum application of 60 pounds of P_2O_5 and 120 pounds of K_2O per acre per year for a four-year period. Large initial applications of phosphate were not as effective as similar amounts divided over two to four years. The land used had been recently reclaimed from brush and had very low fertility. No accumulation of extractable P_2O_5 was found. Banding of superphosphate was more effective than broadcasting and disking it. Removal of potassium by the crop about equalled the 120-pound K_2O application. Where 240 pounds per acre of K_2O were used, potash accumulated both in the crop and the soil.

The importance of lime in the establishment of alfalfa was emphasized by Odland, Wakefield and Bell (29) (see Tables 18 and 19). Where the soil was pH6, two tons of ground dolomitic limestone per acre were usually adequate. If the soil is more acid than this, a liming program should be started a year in advance of seeding, since dolomitic limestone reacts rather slowly.

Band seeding was the best method of seeding alfalfa. Phosphorus was the most important element in promoting vigorous seedling growth. This was especially important in band seeding where the young alfalfa roots were in contact with the drilled fertilizer. For maintenance, high potash fertilizer, such as 0-15-30 at 600 pounds per acre, was recommended. A split application, 1/2 in spring and 1/2 in summer, was preferable.

Corn Fertilization

Where field corn for grain or silage was planted thick enough to produce 18,000 stems per acre, Sheehan (35) recommended 1,000 pounds of 10-10-10 or 750 pounds of 15-10-10 per acre. When the corn was planted at the rate of 25,000 stalks per acre, 1,500 or 1,000 pounds per acre, respectively, of 10-10-10 or 15-10-10 fertilizer were suggested. All but 300-400

Table 18. Average yields of alfalfa-brome hay on lime-phosphate experiment. Plains area, 1955-1959.

Phosphate rate	Lb/A P	Tons/A limestone 0	3-3/4	6	9	Average
None	0	2.32	4.42	3.95	3.83	3.63
Low	90	2.63	4.46	4.04	4.04	3.79
Medium	180	3.16	4.61	4.46	4.26	4.12
High	270	4.08	4.70	4.54	4.22	4.39
	Average	3.05	4.55	4.25	4.09	3.98
	LSD (P = 0.05) L or P = 0.22 L x P = 0.41					

Table 19. Average yields of alfalfa-brome hay on lime-phosphate experiment. Peckham farm, 1955-1959.

Phosphate rate	Lb/A P	Tons/A limestone 0	5	7-2/3	10	Average
None	0	0.54	1.17	1.80	1.57	1.27
Low	160	1.35	2.58	2.25	2.63	2.20
Medium	320	1.64	2.93	2.99	3.26	2.71
High	480	1.76	3.17	3.01	3.11	2.76
	Average	1.32	2.46	2.51	2.64	2.24
	LSD (P = 0.05) L or P = 0.17 L x P = 0.33					

pounds of this fertilizer should be broadcast and disked in or plowed under. The remainder should be banded, using a side placement fertilizer applicator. Silage corn growing in Bridgehampton soils is capable of using greater amounts of fertilizer than commonly applied, providing it is placed properly. It must be broadcast or banded at a safe distance from the seed. Where corn was seeded at the rate of 50,000 plants per acre, yield increases occurred from rates up to 230 pounds per acre each of N, P_2O_5 and K_2O. Rich and Odland (31) found no advantage to plow-sole placement of fertilizer for corn in Rhode Island.

Bell and Odland (3) reported yields of several varieties of corn grown in Bridgehampton soil. Corn for grain averaged 87 bushels per acre with 4.6 tons of dry stover. Silage corn averaged 17.9 tons per acre green with a dry weight of 3.6 tons. The average analysis of the corn silage was 1.48%, 12.05%, 0.28% and 5.76%, respectively, for protein, nitrogen-free extract (carbohydrate), fat and crude fiber. This corn was fertilized with 1,000 pounds per acre of a 4-12-8 fertilizer and grown in rotation with legume-grass hay.

Crop Rotation

Bell, Odland and Owens (2) summarized 53 years of crop rotation studies on Bridgehampton soil. Irish Cobbler potatoes yielded 222 bushels per acre in the clover rotation, 246 in the alfalfa and 294 bushels in the hay-redtop rotation. The low value of grass hay compared to legume hay made this a less profitable rotation in spite of the higher yields of potatoes. Because of the higher value of alfalfa hay compared to mixed clover, the alfalfa rotation was the most profitable.

Odland, Bell and Smith (24) reviewed a half century of crop sequence studies. On highly acid soils, onions were affected adversely by mangels, cabbage, rutabagas, and buckwheat. Crops following squash, redtop, onions and potatoes were generally produced well. Rye, oats, timothy, corn and buckwheat were intermediate in their effects on subsequent crops, while carrots, alsike clover, and red clover were usually followed by lowered crop yields. Mangels, rutabagas, cabbage and millet were unclassified because their effects ranged from favorable to unfavorable. Favorable crops created less soil acidity and removed smaller amounts of basic elements from the soil.

Rynasiewicz (33) determined the water stable soil aggregates after certain crops and related them to the yields of onions. Redtop grass left the soil well aggregated. The soil where mangels were grown was not as well aggregated, and the yield of a subsequent crop of onions was less. Yields of onions were directly correlated with the amounts of water stable aggregates in the soil.

Crop rotations which favored the production of a poor physical condition in the soil and some increase in acidity and soluble aluminum also favored a root rot condition. Liming or partial soil sterilization with chloropicrin both tended to ameliorate the deleterious effect of crops on a subsequent crop of onions. Proper treatment of the soils with chloropicrin materially increased the yields of mangels following mangels, but did not completely eliminate evidence of an unfavorable effect of the previous crop. Rotations favoring maintenance of a suitable soil structure and a slightly acid condition were conducive to high yields of crops grown in Bridgehampton soil.

Accumulation of Fertility

Peech (30) in 1945 reported that 35 samples of Bridgehampton soil from potato fields in Suffolk County, New York, had a maximum accumulation of 925 pounds of available P_2O_5 per acre, a mean of 572 pounds and a minimum of 320 pounds. In Rhode Island, Albritten, Odland and Salomon (1) analyzed soil samples obtained from local potato fields and ad-

Table 20. Chemical data on soil samples from potato fields and adjacent uncultivated areas, 1946. (R. I. Agr. Exp. Station, Kingston, R. I.).

Condition and number of years in potatoes	pH	Pounds per acre: Available P_2O_5	Exchangeable K_2O	Exchangeable MGO	Exchangeable CaO	Exchangeable MnO_2
New land	4.78	36	49	47	679	6
Cultivated 2 years	5.02	222	386	61	3957	4
Brush land	4.73	14	28	37	360	18
Cultivated 6 years	5.07	617	671	45	3421	11
Brush land	4.77	73	139	58	530	3
Cultivated 15 years	5.07	642	829	65	4125	8

jacent uncultivated areas. Some of the data are shown in Table 20. It is evident from these results that the continued use of large amounts of complete fertilizer led to an accumulation of considerable quantities of available phosphate, potash and calcium. For example, land just reclaimed from brush contained 36, 49, and 679 pounds per acre, respectively, of P_2O_5, K_2O and CaO. After two years of fertilization and cropping there were 222, 386, and 3957 pounds per acre, respectively.

Summary

This bulletin contains the most recent detailed descriptions of the important Bridgehampton soils located on the outwash plains and associated rolling hills in southern New England and on Long Island, New York. Because the experimental fields of the Rhode Island Agricultural Experiment Station were located on this soil, data on soil fertility and crop responses are available for a 75 year period. Some of these tests are summarized to complement the soil survey descriptions.

Literature Cited

1. Allbritten, H. G., T. E. Odland and M. Salomon. 1950. Nutrient status of soils on commercial potato producing areas of Rhode Island. Soil Sci. Soc. Amer. Proc. 15: 248-250.
2. Bell, R S., T. E. Odland and A L. Owens. 1949. A half century of crop rotation experiments. R. I. Agr. Exp. Sta. Bul. No. 303.
3. Bell, R. S., and T. E. Odland. 1949. Corn varieties in Rhode Island, R. I. Agr. Exp. Sta. Bul. No. 306.
4. Bonsteel, F. E. and E. P. Carr. 1905. Soil survey of Rhode Island. Bureau of Soils, U.S.D.A.
5. Burgess, P. S. and F. R. Pember. 1923. Active aluminum as a factor detrimental to crop production in many acid soils. R. I. Agr. Exp. Sta. Bul. 194.
6. Gilbert, B. E., F. T. McLean, L. J. Hardin. 1926. The relation of manganese and iron to a lime-induced chlorosis. Soil Sci. 22: 437-446.
7. Gilbert, B. E. and F. R. Pember. 1931. Further evidence concerning the toxic action of aluminum in connection with plant growth. Soil Science 31: 267-273.
8. Gilbert, B. E. 1934. Normal crops and the supply of available soil manganese. R. I. Agr. Exp. Sta. Bul. 246.
9. Gilbert, B. E. and F. R. Pember. 1936. A study of the availability of ammoniated superphosphate and various unusual phosphatic carriers by means of vegetative pot tests. R. I. Agr. Exp. Sta. Bul. 256.
10. Harris, B. K. and T. E. Odland. 1948. Rhode Island Weather. R. I. Agr. Exp. Sta. Bul. 299.
11. Hartwell, B. L. 1921. Liming with high-magnesium versus high-calcium limes. R. I. Agr. Exp. Sta. Bul. 186.
12. Hartwell, B. L. and S. C. Damon. 1919. The value of sodium when potassium is insufficient. R. I. Agr. Exp. Sta. Bul. 199.
13. Hartwell, B. L. and F. R. Pember. 1918. Aluminum as a factor influencing the effect of acid soils on different crops. Jour. Amer. Soc. Agron. 10: 45.
14. Knoblauch, H. C. and T. E. Odland. 1934. A magnesium deficiency induced by previous fertilizer treatments. Jour. Amer. Soc. Agron. 26: 609-615.

15. Leo, Wei-ming, T. E. Odland, R. S. Bell. 1959. Effect on soils ond crops of long continued use of sulfate of ammonia and nitrate of sodo with ond without lime. R. I. Agr. Exp. Sto. Bul. 344.
16. Lounsbury, C., F. B. Howe, R. E. Zoutner, W. T. Moran and P. D. Beers. 1924. Soil survey of Suffolk and Nassou Counties, New York. U.S.D.A. and Cornell (N. Y.) Agr. Exp. Sta. Series 1928 No. 28.
17. Lim, Chang Taik. 1965. Mineralogical choracterization of the Bridgehampton and Newport silt loams. Masters thesis. University of R. I.
18. Manning, P. B. and M. Salomon, 1965. Forms of phosphorus in soil after long-continued fertilization. Proc. Soil Sci. Soc. Amer. 29: 421-423.
19. McGahan, W. W., J. H. Brown, Jr., W. P. Gould, H. C. Lampe and A. E. Shearin. 1961. Site conditions and tree growth. R. I. Agr. Exp. Sta. Bul. 357.
20. Moultrop, K. 1956. Engineering soil survey of Rhode Island. R. I. Engineering Exp. Sta. Bul. No. 4.
21. Odland, T. E. and H. G. Allbritten. 1950. The effect of various amounts of nitrogen, phosphoric acid and potash on the yields of silage corn. Proc. Soil Sci. Soc. of Amer. 14: 221-223.
22. Odland, T. E., R. S. Bell and D. A. Schallock. 1951. Potato growing in Rhode Island. R. I. Agr. Exp. Sta. Bul. 310.
23. Odland, T. E., R. S. Bell and M. Salomon. 1956. A field comparison of eight phosphate fertilizers. Agron. Jour. 48: 409-412.
24. Odland, T. E., R. S. Bell and J. B. Smith. 1950. The influence of crop plants on those which follow. U. R. I. Agr. Exp. Sta. Bul. 309.
25. Odland, T. E. and T. R. Cox. 1941. Field experiments with potash fertilizers. R. I. Agr. Exp. Sta. Bul. 280.
26. Odland, T. E. and T. R. Cox. 1942. Field experiments with phosphate fertilizers. R. I. Agr. Exp. Sta. Bul. 281.
27. Odland, T. E. and J. E. Sheehan. 1956. The response of Irish patatoes to different amounts and ratios of nitrogen, phosphoric acid and potash when grown in continuous culture. Amer. Potato Jour. 33: 22-27.
28. Odland, T. E. and J. E. Sheehan. 1961. Response of potatoes to different amounts of nitrogen, phosphoric acid and potash when grown in continuous culture and in rotation with redtop. Amer. Potato Jour. 38: 33-42.
29. Odland, T. E., R. C. Wakefield and R. S. Bell. 1962. Alfalfa in Rhode Island. R. I. Agr. Exp. Sta. Bul. 363.
30. Peech, M. 1945. Nutrient status of soils in commercial potato-producing areas of the Atlantic and Gulf Coast. Part II. Chemical data on the soils. Soil Sci. Amer. Proc. 10: 245-251.
31. Rich, A. E. and T. E. Odland. 1947. Fertilizer placement for silage corn. Proc. Soil Sci. Soc. of Amer. 12: 253-254.
32. Roberts, R. C., H. C. Knoblauch, S. V. Madison and V. A. Hendrick. 1939. Soil Survey, Kent and Washington Counties, R. I. U.S.D.A. and R. I. Agr. Exp. Sta. (Series 1934 No. 9).
33. Rynasiewicz, J. 1945. Soil aggregation and onion yields. Soil Sci. 60: 387-395.
34. Salomon, M. and J. B. Smith. 1947. The effect on soil of long continued use of nitrate of soda and sulfate of ammonia as single nitrogen sources. Soil Sci. Soc. Amer. Proc. 12: 296-299.
35. Sheehan, J. E. 1965. Rhode Island Agronomy Guide. R. I. Agr. Exp. Sta. Bul. 142.
36. Smith, J. B. and M. Salomon. 1947. Optimum soil-nitrate levels for celery, carrots, spinach, onions and beets. R. I. Agr. Exp. Sta. Bul. 300.
37. Smith, J. B., M. Salomon and R. M. Beverage. 1952. Nitrogen fertilizers for rye cover crops. R. I. Agr. Exp. Sta. Bul. 314.
38. Tisdell, T. F. 1958. Response of potatoes to irrigation and methods of soil moisture analysis. Master of Science Thesis. U.R.I.
39. U.S.D.A. 1960. Soil classification. A comprehensive system. (7th approximation.) Soil Survey; Soil Conservation Service.
40. Wakefield, R. C., D. A. Schallock, M. Salomon and C. E. Olney. 1957. Yield and chemical composition of ladino clover as affected by fertilizer treatments. Agronomy Journ. 49: 374-377.
41. Wheeler, H. J. and B. L. Hartwell, 1894. Rhode Island soil. R. I. Agr. Exp. Sta. Bul. 28.
42. Wheeler, H. J. and B. L. Hartwell, 1906. Concerning the functions of sodium salts. Annual Report, R. I. Agr. Exp. Sta.
43. Vittum, M. T. et al. 1963. Crop response to irrigation in the Northeast. New York (Geneva) Agr. Exp. Sta. Bul. 800.

This bulletin, describing 75 years of research with the Bridgehampton soil on which the Rhode Island Agricultural Experiment Station is located, is issued during the 75th Anniversary Year of the University of Rhode Island.

1892 - 1967