HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS

AGRICULTURAL COLLEGE.

BULLETIN NO. 51.

I. ANALYSES OF MANURIAL SUBSTANCES SENT ON FOR EXAMINATION.

II. ANALYSES OF LICENSED FERTILIZERS COLLECTED BY THE AGENT OF THE STATION DURING 1897.

FEBRUARY, 1898.

The Bulletins of this Station will be sent free to all newspapers in the State and to such individuals interested in farming as may request the same.

AMHERST, MASS.:
PRESS OF CARPENTER & MOREHOUSE,
1898.

HATCH EXPERIMENT STATION

OF THE

Massachusetts Agricultural College,

AMHERST, MASS.

By act of the General Court, the Hatch Experiment Station and the State Experiment Station have been consolidated under the name of the Hatch Experiment Station of the Massachusetts Agricultural College. Several new divisions have been created and the scope of others has been enlarged. To the horticultural, has been added the duty of testing varieties of vegetables and seeds. The chemical has been divided, and a new division, "Foods and Feeding," has been established. The botanical, including plant physiology and disease, has been restored after temporary suspension.

The officers are :—

Henry H. Goodell, LL. D.,	*Director.*
William P. Brooks, B. Sc. Ph. D.,	*Agriculturist.*
George E. Stone, Ph. D.,	*Botanist.*
Charles A. Goessmann, Ph. D., LL. D.,	*Chemist* (Fertilizers).
Joseph B. Lindsey, Ph. D.,	*Chemist* (Foods and Feeding).
Charles H. Fernald, Ph. D.,	*Entomologist.*
Samuel T. Maynard, B. Sc.,	*Horticulturist.*
J. E. Ostrander, C. E.,	*Meteorologist.*
Henry M. Thomson, B. Sc.,	*Assistant Agriculturist.*
Ralph E. Smith, B. Sc.,	*Assistant Botanist.*
Henri D. Haskins, B. Sc.,	*Assistant Chemist* (Fertilizers).
Charles I. Goessmann, B. Sc.,	*Assistant Chemist* (Fertilizers).
George D. Leavens, B. Sc.,	*Assistant Chemist* (Fertilizers).
Edward B. Holland, B. Sc.,	*Ass't Chemist*(Foods and Feeding).
Fred W. Mossman, B. Sc.,	*Ass't Chemist*(Foods and Feeding).
Benjamin K. Jones, B. Sc.,	*Assistant in Foods and Feeding.*
Robert A. Cooley, B. Sc.,	*Assistant Entomologist.*
G. A. Drew, B. Sc.,	*Assistant Horticulturist.*
H. D. Hemenway, B. Sc.,	*Assistant Horticulturist.*
H. H. Roper, B. Sc.,	*Assistant in Foods and Feeding.*
A. C. Monahan,	*Observer.*

The co-operation and assistance of farmers, fruit-growers, horticulturists, and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the

Hatch Experiment Station, Amherst, Mass.

DEPARTMENT OF CHEMISTRY.

C. A. Goessmann.

I.

ANALYSES OF COMMERCIAL FERTILIZERS AND MANURIAL SUBSTANCES SENT ON FOR EXAMINATION.

459—462. WOOD ASHES.

I. Received from Sunderland, Mass.
II. Received from Fitchburg, Mass.
III. Received from North Danvers, Mass.
IV. Received from Sunderland, Mass.

	Per Cent.			
	I.	*II.*	*III.*	*IV.*
Moisture at 100° C.,	20.97	12.97	1.65	27.12
Potassium oxide,	3.92	4.62	3.48	3.08
Phosphoric acid,	1·28	2.05	2.24	1.66
Calcium oxide,	32.21	33.65	33.65	32.54
Insoluble matter,	13.20	11.97	20.82	5.44

463—466.

I. Received from Sunderland, Mass.
II. Received from Sunderland, Mass.
III. Received from Carlisle, Mass.
IV. Received from Bemis, Mass.

	Per Cent.			
	I.	*II.*	*III.*	*IV.*
Moisture at 100° C.,	8.42	6.65	18.40	1.70
Potassium oxide,	5.37	5.63	2.98	7.69
Phosphoric acid,	1.02	1.15	1.66	2.81
Calcium oxide,	42.84	44.73	30.89	37.81
Insoluble matter,	5.31	5.58	13.54	11.38

467—470.

I. Received from North Amherst, Mass.
II. Received from Boston, Mass.
III. Received from Sunderland, Mass.
IV. Received from South Amherst, Mass.

	Per Cent			
	I.	*II.*	*III.*	*IV.*
Moisture at 100° C.,	13.87	21.53	25.25	24.62
Potassium oxide,	3.87	4.11	4.15	4.02
Phosphoric acid,	1.79	1.41	1.28	0 83
Calcium oxide,	30.27	29.21	35.22	33.62
Insoluble matter,	17.20	8.66	4.17	10.81

471 -475.

I. Received from South Poland, Maine.
II. Received from Concord, Mass.
III. Received from Concord, Mass.
IV. Received from Lexington, Mass.
V. Received from Lexington, Mass.

	Per Cent.				
	I.	*II.*	*III.*	*IV.*	*V.*
Moisture at 100° C.,	2.82	5.97	6.07	4.05	15.27
Potassium oxide,	4.54	7.60	7.19	7.47	7.47
Phosphoric acid,	1.34	1.47	1.60	1.66	1.66
Calcium oxide,	40.32	35.83	13.75	30.48	32.54
Insoluble matter,	12.26	14.70	8.56	9.86	9.03

476. MIXED ASHES.

Received from North Brookfield, Mass.

(COAL, WOOD, AND LEATHER.)

	Per Cent.
Moisture at 100° C.,	5.77
Potassium oxide,	1.04
Phosphoric acid,	0.58
Nitrogen,	0.53
Calcium oxide,	4.90
Insoluble matter,	67.84

466- 478. GROUND TOBACCO STEMS.

I. and II. Received from Boston, Mass.

	Per Cent.	
	I.	*II.*
Moisture at 100° C.,	10.87	12.35
Ash,	20.20	*
Nitrogen,	0.99	1.13
Potassium oxide,	4.85	5.19
Phosphoric acid,	0.51	0.56

479—480. COTTON SEED MEAL.

I. Received from Sunderland, Mass.
II. Received from Montague, Mass.

	Per Cent.	
	I.	*II.*
Moisture at 100° C.,	10.83	7.72
Nitrogen,	3.24	6.48
Potassium oxide,	1.58	*
Phosphoric acid,	2.23	*

*Not determined.

481—482. GROUND FISH AND WHALE BONE SCRAPINGS.

I. Ground fish received from North Hatfield, Mass.

II. Whale-bone scrapings received from New Bedford, Mass.

	Per Cent.	
	I.	II.
Moisture at 100° C.,	7.32	6.9
Nitrogen,	7.98	13.01
Total Phosphoric acid,	13.82	0.26
Reverted Phosphoric acid,	7.74	*
Insoluble Phosphoric acid,	6.08	*

483—487. MUCK.

I. II. III. Received from Boston, Mass.

IV. Received from Tewksbury, Mass.

V. Received from East Weymouth, Mass.

	Per Cent.				
	I.	II.	III.	IV.	V.
Moisture at 100° C.,	11.67	5.8	2.67	50.25	12.75
Ash,	47.60	77.40	83.93	4.48	69.52
Nitrogen,	1.19	0.37	0.48	1.10	1.57
Phosphoric acid,	Trace	Trace	Trace	Trace	Trace
Calcium oxide,	Trace	Trace	Trace	Trace	Trace

488—490. COMPLETE FERTILIZERS.

I. Received from Newbury, Mass.

II. Received from Sunderland, Mass.

III. Received from Sunderland, Mass.

	Per Cent.		
	I.	II.	III.
Moisture at 100° C.,	11.50	14.18	13.98
Nitrogen,	3.23	3.17	1.58
Total phosphoric acid,	9.54	10.03	9.21
Soluble phosphoric acid,	4.76	4.09	2.88
Reverted phosphoric acid,	2.22	3.79	4.29
Insoluble phosphoric acid,	2.56	2.15	1.41
Potassium oxide,	7.92	5.85	3.98

491—494. BARNYARD MANURES.

I. II. III. IV. Received from Amherst, Mass.

	Per Cent.			
	I.	II.	III.	IV.
Moisture at 100° C.,	80.45	77.45	62.85	70.43
Nitrogen,	0.28	0.57	0.53	0.44
Phosphoric acid,	0.17	0.34	0.31	0.33
Potassium oxide,	0.46	0.79	0.85	0.82

*Not determined.

II. ANALYSES OF COMMERCIAL FERTILIZERS COLLECTED DURING 1897, IN THE GENERAL MARKETS BY THE AGENT OF THE HATCH EXPERIMENT STATION OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

Laboratory No.	Name of Brand.	Name of Manufacturer.	Sampled at
	Compound Fertilizers.		
12	All Soluble,	Armour & Co., Chicago, Ill.,	Amherst.
15	Bone and Blood,	Armour & Co., Chicago, Ill.,	Amherst.
16	Acidulated Bone,	Armour & Co., Chicago, Ill.,	Amherst.
51	Complete Manure for Tobacco,	Bowker Fertilizer Co., Boston, Mass.,	Northampton.
61	Acid Phosphate,	Bowker Fertilizer Co., Boston, Mass.,	Northampton.
63	Fine Dry Ground Fish,	Bowker Fertilizer Co., Boston, Mass.,	Northampton.
97	Potato Fertilizer,	Bradley Fertilizer Co., Boston, Mass.,	Holyoke.
98	Corn Phosphate,	Bradley Fertilizer Co., Boston, Mass.,	Holyoke.
103	Acidulated Bone,	Armour & Co., Chicago, Ill.,	Springfield.
109	Root Fertilizer,	National Fertilizer Co., Bridgeport, Conn.,	Sunderland.
112	Grain Grower,	Armour & Co., Chicago, Ill.,	Springfield.
113	Cereal Brand,	Mapes Formula & Peruvian Guano Co., New York, N.Y.	Greenfield.
129	Lawn and Garden Dressing,	Bowker Fertilizer Co., Boston, Mass.,	Haverhill.
142	Rawson's Formula,	Bowker Fertilizer Co., Boston, Mass.,	Boston.
168	Complete Manure for Potatoes and Vegetables,	Bradley Fertilizer Co., Boston, Mass.,	Haverhill.
183	Essex Odorless Lawn Dressing,	Russia Cement Co., Gloucester, Mass.,	Athol.
210	Lawn and Garden Dressing,	Joseph Breck & Son, Boston, Mass.,	Boston.
224	Ground Bone with Potash "O Brand,"	Bradley Fertilizer Co., Boston, Mass.,	Middleboro.
237	Bone and Blood,	Armour & Co., Chicago, Ill.,	Taunton.
239	Tankage,	Bartlett & Holmes, Springfield, Mass.,	Springfield.
259	All Soluble,	Armour & Co., Chicago, Ill.,	Springfield.
348	Corn Phosphate,	Bradley Fertilizer Co., Boston, Mass.,	Fitchburg.
385	Complete Potato Manure,	H. J. Baker & Bro., New York, N. Y.,	Worcester.

Laboratory Number.	Name of Brand.	Moisture.	Nitrogen in 100 lbs.		Phosphoric Acid in 100 lbs.							Potassium Oxide in 100 lbs.	
								Total.		Available.			
			Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
	Compound Fertilizers.												
12-259	All Soluble,	2.42	3.29	2.47-3.30	3.71	4.81	3.38	11.90	11-15	8.52	8-11	4.71	4-5
15-237	Bone and Blood,	5.37	7.19	5.76-6.58	—	5.60	5.78	11.38	10-12	5.60	5-7	—	—
16-103	Acidulated Bone,	8.22	2.86	1.64-2.47	3.07	9.67	8.12	20.86	18-22	12.74	11-14	—	—
51	Complete Manure for Tobacco,	4.47	6.29	5.50-6.50	2.56	2.70	4.20	9.46	6-7	5.26	4-5	10.84	10-12*
61	Acid Phosphate,	8.12	—	—	6.70	5.25	4.17	16.12	13-16	11.95	11-13	—	—
63	Fine Dry Ground Fish,	7.47	8.37	8-10	—	3.64	4.04	7.68	6-8	3.64	—	—	
97	Potato Fertilizer,	11.00	2.44	2.06-2.88	5.99	3.19	2.46	11.64	11-14	9.18	9-11	3.70	3.25 4.35
98-348	Corn Phosphate,	10.52	2.40	2.06-2.88	6.98	.61	4.43	12.02	10-14	7.59	9-12	1.59	1.50-2.50
109	Root Fertilizer,	9.75	3.57	3.30-4.10	7.02	3.20	.52	10.74	10-12	10.22	8-11	6.37	6-8
112	Grain Grower,	5.92	2.01	1.64-2.47	6.37	8.59	—	14.96	10-12	14.96	8-10	1.55	2-3
113	Cereal Brand,	8.12	2.31	1.65-2.47	5.66	2.78	1.28	9.72	8-10	8.44	6-8	2.93	3-3.50
129	Lawn and Garden Dressing,	8.35	3.74	3-4	6.70	2.12	—	8.82	8-10	8.82	6-8	5.56	5-6
142	Rawson's Formula,	8.02	3.31	3.50-4.50	8.65	1.50	.97	11.12	8-10	10.15	6-8	7.72	7-8
168	Complete Manure for Potatoes & Vegetables	9.27	3.94	3.73-4.52	5.35	4.04	1.87	11.26	9-12	9.39	8-11	6.18	6-7
183	Essex Odorless Lawn Dressing,	2.97	3.74 †	3.71-4.53	.56	3.54	5.76	9.86	7-8	4.10	5.50-6.50	7.56	7-8
210	Lawn and Garden Dressing,	4.92	4.36	4.12-4.94	2.43	3.74	1.89	8.06	5-6	6.17	—	4.25	5-6
224	Ground Bone with Potash O Brand,	5.72	1.86	1.85-2.67	4.02	1.71	6.93	12.66	10-13	5.73	6-8	2.24	2-3
249	Tankage,	3.47	5.13	4.12-4.94	—	9.45	8.21	17.66	17-18	9.45	—	—	—
385	Complete Potato Manure,	8.22	3.80	3.30-4.12	3.35	3.18	.77	7.30	6.75-8.00	6.53	5.75-7.00	10.58	10-12

*Sulphate of potash the source of potash.
†Corrected from Bulletin No. 49.

II. ANALYSES OF COMMERCIAL FERTILIZERS COLLECTED DURING 1897, IN THE GENERAL MARKETS BY THE AGENT OF THE HATCH EXPERIMENT STATION OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

Laboratory No.	Name of Brand.	Name of Manufacturer.	Sampled at
	Compound Fertilizers.		
136	Complete Fertilizer for Tobacco,	National Fertilizer Co., Bridgeport, Conn.,	Sunderland.
143	Fish and Potash,	National Fertilizer Co., Bridgeport, Conn.,	Sunderland.
147	Peruvian Guano,	Lucien Sanderson, New Haven, Conn.,	Boston.
202	Bay State Special,	H F. Tucker, Boston, Mass.,	Leominster.
207	Fertilizer for all Crops,	Cleveland Dryer Co., Boston, Mass.,	West Andover
209	Farm Favorite,	L. B. Darling Fertilizer Co., Pawtucket, R. I.,	Lowell.
214	Gold Brand Excelsior Guano,	E. Frank Coe Co , New York, N. Y.,	Sunderland.
294	Tobacco Starter,	Mapes Formula & Peruvian Guano Co., New York, N.Y.	Springfield.
295	Cotton Seed Meal,	The American Cotton Oil Co., New York City,	Springfield.
311	Special Manure with 10 per cent. Potash,	Quinnipiac Co., Boston, Mass.,	Williamstown.
313	Corn Fertilizer,	Cumberland Bone Phosphate Co., Boston, Mass.,	Greenfield.
314	Bay State Grass Fertilizer,	Clark's Cove Fertilizer Co., Boston, Mass.	Westfield.
316	Complete Fertilizer for Tobacco,	National Fertilizer Co., Bridgeport, Conn.,	Hadley.
318	Grass and Oats Fertilizer,	Great Eastern Fertilizer Co., Rutland, Vt.,	Greenfield.
324	Tobacco Stems,	F. C. Sturtevant, Hartford, Conn.,	Worcester.
353	Truck Fertilizer,	M. E. Wheeler & Co., Rutland, Vt.,	Concord.
392	Tobacco Stems,	F. C. Sturtevant, Hartford, Conn.,	Amherst.
396	Whittemore's Complete Manure,	I. S. Whittemore, Wayland, Mass.,	Amherst.
397	Church's B. Special,	Daniel T. Church, Providence, R. I.,	Amherst.
398	Church's C. Standard,	Daniel T. Church, Providence, R. I.,	Amherst.
399	Grass and Grain Fertilizer,	Rogers & Hubbard Co., Middletown, Conn.,	Amherst.
400	Soluble Tobacco Manure,	Rogers & Hubbard Co., Middletown, Conn.,	Amherst.
402	Fertilizer for all Soils and all Crops,	Rogers & Hubbard Co., Middletown, Conn.,	Amherst.
403	Corn and Grain Crop Manure,	Rogers & Hubbard Co., Middletown, Conn.,	Amherst.
404	Grain and Grass Grower,	Niagara Fertilizer Co., Buffalo, N. Y.,	Amherst.

Laboratory Number.	Name of Brand.	Moisture.	Nitrogen in 100 lbs.		Phosphoric Acid in 100 lbs.							Potassium Oxide in 100 lbs.	
								Total.		Available.			
			Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
	Compound Fertilizers.												
36-316	Complete Fertilizer for Tobacco,	9.91	4.20	3.30-4.10	6.22	2.59	.38	9 19	10-12	8.81	8-10	7.90	6-8†
143	Fish and Potash,	5.77	3.24	3.00-3.50	.90	3.98	5.62	10.50	6-8	4.88	—	5.21	4-5
147	Peruvian Guano,	9.35	5.05	2.50-3.50	.38	5.38	4.60	10.36	15-20	5.76	—	—	2-4
202	Bay State Special,	10.87	3.24	3.30-4.12	4.86	6.26	1.40	10.24	9-13	11.12	8-11	7.36	7-8
207	Fertilizer for all Crops,	12.52	1.18	1.03-1.65	5.76	2.30	1.80	9.86	9-13	8.06	8-11	2.39	2-3
209	Farm Favorite,	7.02	3.61	2.-2.50	2.56	5.10	3.84	11.52	8-9	7.66	6-7	5.71	5-6
214	Gold Brand Excelsior Guano,	10.74	2.47	2-3	6 24	2.36	1.74	10.34	9-13	8.60	8-11	5.99	6†
294	Tobacco Starter,	10.95	2.97	2.47-3.30	7.68	3.84	2.04	13.56	12-16	11.52	8-10	3.33	2.5-3.5*
295	Cotton Seed Meal,	7.37	7.13	6 80	—	—	—	—	—	—	—	—	—
311	Special Manure with 10 per cent. Potash,	7.00	2.79	2.47-3.30	4.00	4 18	2.56	10.74	7-11	8,18	6-9	10.89	10-11
313	Corn Fertilizer,	13.07	2.26	1.65-2.40	5.88	1.80	1.40	9.08	9-13	7.68	8-10	2.83	2-3
314	Bay State Grass Fertilizer,	5.72	4 49	3.01-4.76	1.28	4.08	1.54	6.90	6-9	5.36	5-7	2.54	2-3
318	Grass and Oats Fertilizer,	13.06	—	—	4.10	6.00	2.30	12.40	—	10.10	11-13	2.04	2-2.50
24-392	Tobacco Stems,	9.15	2.72	1.96	—	—	—	1.15	.75	—	—	6.76	7.66
353	Truck Fertilizer,	9.65	3 63	3.30-4.12	4.60	1.54	1.28	7.42	8-11	6.14	7-9	8.61	8-10
396	Whittemore's Complete Manure,	4.82	3 38	2.47-3.30	6.02	7.42	1.02	14.46	12-14	13.44	8-12	4 58	3-4
397	Church's B. Special,	10.92	3.37	3.7-4 53	4.74	6.54	1.80	10.16	9-12	11.28	8-10	6.68	6-7
398	Church's C. Standard,	10.30	2.65	2.47-3.30	4.60	2 06	2.04	8.70	8-11	6.66	6-8	5.68	5-6
399	Grass and Grain Fertilizer,	6.15	3.16	2.5-3.00	—	6.14	10.74	16.88	16.5-18.	6.14	—	11.16	12.5-13.5
400	Soluble Tobacco Manure,	7.90	5.51	5-6	.76	6.66	3.20	10 62	10-12	7.42	7-8.5	10.02	10-11*
402	Fertilizer for all Soils and all Crops,	11.82	2.54	2.30-3.00	7.50	3.88	2.30	13.68	12-14	11.38	10-12	3.19	3-4
403	Corn and Grain Crop Manure,	7.70	5.54	5.50-6.50	—	6.28	7.80	14.08	12-13	6.28	—	12.20	12.5-13.5
404	Grain and Grass Grower,	12.52	1.13	.82-1.64	5.24	1.66	1.16	8.06	8-11	6.90	7-9	1.50	1.08-2.16

*Sulphate of potash the source of potash.
†Corrected from Bulletin No. 49.

II. ANALYSES OF COMMERCIAL FERTILIZERS COLLECTED DURING 1897, IN THE GENERAL MARKETS BY THE AGENT OF THE HATCH EXPERIMENT STATION OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

Laboratory No.	Name of Brand.	Name of Manufacturer.	Sampled at
	Compound Fertilizers.		
405	Wheat and Corn Producer,	Niagara Fertilizer Co., Buffalo, N. Y.,	Amherst.
407	A. A. Complete Manure,	Crocker Fertilizer and Chemical Co., Buffalo, N. Y.,	Amherst.
408	New England Tobacco and Potato Grower,	Crocker Fertilizer and Chemical Co., Buffalo, N. Y.,	Amherst.
409	Coolidge Bros. Special Truck Fertilizer,	Crocker Fertilizer and Chemical Co., Buffalo, N. Y.,	Amherst.
410	Grass Manure,	Williams & Clark Fertilizer Co., Boston, Mass.,	Easthampton.
412	Star Brand Fertilizer,	Parmenter & Polsey Fertilizer Co., Peabody, Mass.,	Peabody.
	Chemicals.		
411	Muriate of Potash,	Parmenter & Polsey Fertilizer Co., Peabody, Mass.,	Peabody.
414	Sulphate of Ammonia,	Parmenter & Polsey Fertilizer Co., Peabody, Mass.,	Peabody.
415	High Grade Sulphate of Potash,	Parmenter & Polsey Fertilizer Co., Peabody, Mass.,	Peabody.
	Ground Bones.		
11	Bone Meal,	Armour & Co., Chicago, Ill.,	Amherst.
92	Animal Fertilizer,	W. H. Abbott, Holyoke, Mass.,	Holyoke.
160	Bone Meal,	Armour & Co., Chicago, Ill.,	Springfield.
164	Ground Bone,	Lowell Fertilizer Co., Boston, Mass.,	Taunton.
296	Ground Bone,	Lowell Fertilizer Co., Boston, Mass.,	Springfield.
321	Abattoir Bone Dust,	Bradley Fertilizer Co., Boston, Mass.,	Worcester.
330	Animal Fertilizer,	W. H. Abbott, Holyoke, Mass.,	Amherst.
395	Ground Bone,	Edmund Hersey, Hingham, Mass.,	Amherst.
401	Pure Fine Bone,	The Rogers & Hubbard Co., Middletown, Conn.,	Amherst.
406	Pure Fine Bone,	Crocker Fertilizer and Chemical Co., Buffalo, N. Y.,	Amherst.
413	Pure Ground Bone,	Parmenter & Polsey Fertilizer Co., Peabody, Mass.,	Peabody.

Laboratory Number.	Name of Brand.	Moisture.	Nitrogen in 100 lbs. Found.	Nitrogen in 100 lbs. Guaranteed.	Phosphoric Acid in 100 lbs. Soluble.	Reverted.	Insoluble.	Total. Found.	Total. Guaranteed.	Available. Found.	Available. Guaranteed.	Potassium Oxide in 100 lbs. Found.	Potassium Oxide in 100 lbs. Guaranteed.	
	Compound Fertilizers.													
405	Wheat and Corn Producer,	12.20	1.46	1.23-2.05	6.78	1.66	.90	9.34	9-12	8.44	8-10	2.38	2 16-3.24	
407	A. A. Complete Manure,	10.27	3.26	3.28-4.10	7.16	1.54	.52	9.22	9-12	8.70	8-10	7.30	7.56-8.65	
408	New England Tobacco and Potato Grower,	8.30	3.58	3.29-5.00	4.98	1.68	.38	7.04	7-10	6.66	6-8	5.90	5.4-6.5	
409	Coolidge Bros. Special Truck Fertilizer,	9.77	4.57	4.10-5.00	6.26	1.68	.38	8.32	8-11	7.94	7-9	6.75	6.92-8.	
410	Grass Manure,	5.65	4.48	3.99-4.73	1.34	3.78	1.40	6.52	6-9	5.12	6-8	3.43	2-3	
412	Star Brand Fertilizer,	8.15	1.89	1.65-2.47	3.70	4.72	1.02	9.46	8.11	8.42	7-9	2.40	2.5-3.5	
	Chemicals.													
411	Muriate of Potash,	1.79	—	—	—	—	—	—	—	—	—	51.12	50-52	
414	Sulphate of Ammonia,	.11	19.93	20.60	—	—	—	—	—	—	—	—	—	
415	High Grade Sulphate of Potash,	.42	—	—	—	—	—	—	—	—	—	51.60	50-51	
												Mechanical Analyses. Fine Bone.	Fine Med.	Medium.
	Ground Bones.													
11-160	Bone Meal,	8.55	3.05	2.47-3.30	—	10.80	14.66	25.46	25-28	10.80	10-13	47.32	30.25	22.43
92-330	Animal Fertilizer,	9.62	3.59	3.50-4 00	—	6.43	17.65	24.08	20 21	6.43	—	32.90	29.60	37.50
164-296	Ground Bone,	3.47	2.16	2.47-3.30	—	8.84	20 72	29.56	20.61-25.19	8-84	—	58.21	27.27	14.52
321	Abattoir Bone Dust,	9.25	1.37	1.65-3.30	—	4.95	11.23	16.18	14-18	4.95	—	—	—	—
395	Ground Bone,	3.10	3.23	3-4	—	8 58	14.84	23.42	22-24	8.58	—	51.63	24.10	15.27
401	Pure Fine Bone,	6.97	3.45	3.5-4.00	—	8.58	16.12	24.70	22-23	8.58	—	52.65	30.30	17.05
406	Pure Fine Bone,	4.82	3.80	3.28-4.10	—	5.64	20.72	26.36	25-27	5.64	—	33.24	32.39	34.37
413	Pure Ground Bone,	5.07	1.72	1.65-2.47	—	8.32	17.40	25.72	16-20	8.32	—	59.59	25.08	15.43

TRADE VALUES OF FERTILIZING INGREDIENTS IN RAW MATERIALS AND CHEMICALS.

	1897. Cents per pounds.
Nitrogen in ammonia salts,	13.5
" nitrates,	14.
Organic nitrogen in dry and fine ground fish, meat, blood, and in high-grade mixed fertilizers,	14.
" " " cotton-seed meal, linseed meal and in castor pomace,	12.
" " " fine ground bone and tankage,	13.5
" " " medium ground bone and tankage,	11.
" " " coarse bone and tankage,	8.
Phosphoric acid soluble in water,	5.5
" " soluble in ammonium citrate,	5.
" " in fine bone and tankage,	5.
" " in medium bone and tankage,	4.
" " in coarse bone and tankage,	2.5
" " in fine ground fish, cotton-seed meal, linseed meal, castor-pomace and wood ashes,	5.
" " insoluble (in am. cit.) in mixed fertilizers,	2.
Potash as Sulphate, free from Chlorides,	5.
" " Muriate,	4.5

The market value of low priced materials used for manurial purposes, as salt, wood ashes, various kinds of lime, barnyard manure, factory refuse and waste materials of different description, quite frequently does not stand in a close relation to the current market value of the amount of essential articles of plant food they contain. Their cost varies in different localities. Local facilities for cheap transportation and more or less advantageous mechanical conditions for a speedy action, exert as a rule, a decided influence on their selling price.

The market value of fertilizing ingredients like other merchandise is liable to changes during the season. The above stated values are based on the condition of the fertilizer market in centers of distribution in New England, during the six months preceding March 1897.

HATCH EXPERIMENT STATION

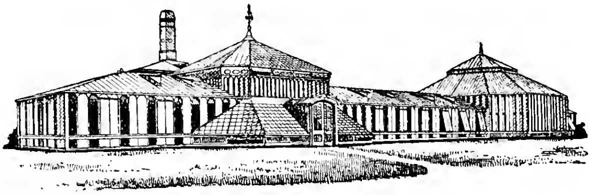
—OF THE—

MASSACHUSETTS

AGRICULTURAL COLLEGE.

BULLETIN NO. 52.

Variety Tests of Fruits. Spraying Calendar.



DURFEE PLANT HOUSE.

MARCH, 1898.

The Bulletins of this Station will be sent free to all newspapers in the State and to such individuals interested in farming as may request the same.

AMHERST, MASS.:
PRESS OF CARPENTER & MOREHOUSE,
1898.

HATCH EXPERIMENT STATION

OF THE

Massachusetts Agricultural College,

AMHERST, MASS.

By act of the General Court, the Hatch Experiment Station and the State Experiment Station have been consolidated under the name of the Hatch Experiment Station of the Massachusetts Agricultural College. Several new divisions have been created and the scope of others has been enlarged. To the horticultural, has been added the duty of testing varieties of vegetables and seeds. The chemical has been divided, and a new division, "Foods and Feeding," has been established. The botanical, including plant physiology and disease, has been restored after temporary suspension.

The officers are :—

HENRY H. GOODELL, LL. D.,	*Director.*
WILLIAM P. BROOKS, PH. D.,	*Agriculturist.*
GEORGE E. STONE, PH. D.,	*Botanist.*
CHARLES A. GOESSMANN, PH. D., LL. D.,	*Chemist* (Fertilizers).
JOSEPH B. LINDSEY, PH. D.,	*Chemist* (Foods and Feeding).
CHARLES H. FERNALD, PH. D.,	*Entomologist.*
SAMUEL T. MAYNARD, B. SC.,	*Horticulturist.*
J. E. OSTRANDER, C. E.,	*Meteorologist.*
HENRY M. THOMSON, B. SC.,	*Assistant Agriculturist.*
RALPH E. SMITH, B. SC.,	*Assistant Botanist.*
HENRI D. HASKINS, B. SC.,	*Assistant Chemist* (Fertilizers).
CHARLES I. GOESSMANN, B. SC.,	*Assistant Chemist* (Fertilizers).
GEORGE D. LEAVENS, B. SC.,	*Assistant Chemist* (Fertilizers).
EDWARD B. HOLLAND, B. SC.,	*Ass't Chemist* (Foods and Feeding).
FRED W. MOSSMAN, B. SC.,	*Ass't Chemist* (Foods and Feeding).
BENJAMIN K. JONES, B. SC.,	*Assistant in Foods and Feeding.*
ROBERT A. COOLEY, B. SC.,	*Assistant Entomologist.*
G. A. DREW, B. SC.,	*Assistant Horticulturist.*
H. D. HEMENWAY, B. SC.,	*Assistant Horticulturist.*
H. H. ROPER, B. SC.,	*Assistant in Foods and Feeding.*
A. C. MONAHAN,	*Observer.*

The co-operation and assistance of farmers, fruit-growers, horticulturists, and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the

HATCH EXPERIMENT STATION, Amherst, Mass.

Summary of the Work

OF THE

Horticultural Division for 1897.

S. T. MAYNARD.

VARIETY TESTS OF FRUITS.

In former bulletins we have given full reports of all the varieties of fruits tested in a tabulated form, but as most of these proved of little value, although offered by nurserymen and others as possessing decided merit, we therefore for this season at least report only upon those that have been found to possess very superior qualities.

APPLES.

Number of Varieties in Orchards 194, Distance of Planting 30x30 ft.

The apple crop in college and station orchards during the past season was fairly abundant, but in quality rather below the average except with a few varieties.

Records were made of each variety during the growing season and, when in the best condition for marketing, specimens were gathered and placed in the cold storage to determine their keeping qualities. The following varieties grown in 1896 were in good condition July 1, 1897: Ben Davis, Delaware Winter or Lawver, Ord Beni, Willow-twig, Whinnerys Late, Langford and Walbridge. In good condition at the present date, Feb. 10, 1898, Ben Davis, Delaware Winter and Walbridge.

Results of Spraying. All the trees except a few checks, were sprayed to prevent the ravages of insect and fungous pests which the past season were rather more abundant than usual. The trees sprayed were much less injured by insects and apple scab, and the fruit was fairer and freer from worms than upon those not sprayed. The Bordeaux mixture combined with Paris green was principally used, but trials were made with laurel green and arsenate of lead. The laurel green did not give satisfactory results, but arsenate of lead was effective in destroying insects, and no injury to the foliage resulted. The cost of the latter was however considerably greater than Paris green.

Fertilizers. The following formula was used on each tree, well spread under the branches.

Large trees—Sulfate potash 5 lbs.	Small trees—2 lbs.
" " Nitrate of soda 2 lbs.	" " 1 lb.
" " Acid phosfate 3 lbs.	" " 2 lbs.

In applying fertilizers to fruit trees and plots the quantity of the three fertilizing elements, i. e., nitrogen, phosphoric acid and potash, used varied according to the soil, season or condition of growth the previous season. When no fruit was produced and the growth of tree or plant has been large, less fertilizer is applied than when the crop has been large and the growth rather small. If the soil is naturally poor more fertilizer is needed than if it is naturally fertile.

Pears.

Number of Varieties 32, Distance Planted 20x20 ft.

The pear crop was very small owing to the fact that most of the trees were young; most of the varieties were of the newer introductions; only a few of the standard sorts having been grown for comparison. Many of the young trees were seriously injured by aphides and the pear "blister mite," a remedy for which is found in kerosene emulsion.

Plums.

Number of Varieties 94, Distance Planted 15x15 ft.

No fruit on the grounds was so abundant and fine as the plum crop. Of the 50 varieties that fruited 10 were of the Japanese varieties.

The fruit on all of the trees was thinned, resulting in larger size, and most of the varieties ripened, though some of the fruit rotted badly. Of the varieties most affected by the "brown rot" or monilia were the Lombard, Ponds' Seedling, Yellow Egg, Imperial Gage, Washington, McLaughlin and Spaulding. The fruit on those trees most closely planted or growing in sheltered, rather moist situations was most injured by the rot; that on trees growing the most rapidly rotted more than that grown on trees of only a moderate growth.

Black-Knot. One of the results of the use of fungicides on the plum trees in the station orchard has been that scarcely a specimen of the black knot can be found on any of the trees, though no knots have been removed for about a year. For treatment of the plum, see Spraying Bulletin.

Summer vs. Winter Pruning.

To determine whether heading in plum trees while dormant or in the early stages of summer growth would give the best results 10 trees, two each of five kinds were selected. The first tree of each variety was severely headed on March 30 and the second May 22, with the following results:

The *winter* pruned trees made a vigorous growth of a few shoots.
" *summer* " " " fair " " many "
" *winter* " " developed a fair quantity of fruit buds.
" *summer* " " " large " " "

The following new varieties have given the best results.

DOMESTICA.

Thomas (Peach?) ripened July 31, large yellow, shaded with red, freestone, fair quality.
Czar, ripened, July 31, large purple, fine quality.
Lincoln, " Aug. 5, medium to large, purple, good quality.
German Prune, " Aug. 29, " " " freestone " "
Kingston, " Sept. 15, large rather acid, late.

JAPANESE.

Red June, ripened, July 26, medium to large, fair quality.
Abundance, " July 30, large, good quality.
Georgeson, " July 30, medium to large, fair quality.
Burbank, " Aug. 14, large, firm, fair quality.
Chebot, " Sept. 1, medium to large, good quality.
Satsuma, " Sept. 10, large, valuable for canning.

The Abundance ripened fruit prematurely on some of its branches. The Georgeson and Chebot were severely injured by the shot-hole fungus. Fertilizers used on the plum trees were:

2 to 3 lbs. sulfate of potash, 1 to 2 lbs. nitrate of soda, 2 to 4 lbs. acid phosfate.	According to size and vigor of tree.

Cherries.

Varieties 55, Distance Planted, 20x20 ft.

The crop of cherries was not as large the past season as usual and was of rather poor quality. No means has yet been found to wholly prevent the work of the plum curculio that causes the wormy fruit, and the brown fruit rot that so often attacks the blossoms and fruit. The use of Paris green combined with the Bordeaux mixture in almost every case caused more or less burning of the foliage.

The black cherry aphides or plant lice came on in such numbers early in the summer as to do considerable damage. We were unable to see very decided improvement in any new variety fruited over the old standard sorts, the most satistactory of which are E. Richmond, Montmorency, Royal Duke, Black Tartarian, Napoleon, Governor Wood, Smidt and Windsor.

The fertilizers used, 2 lbs. sulfate of potash, 1 lb. nitrate soda, 2 lbs. acid phosfate. per tree.

The growth notwithstanding the abundance of insects and fungous pests has been good and an unusually large number of fruit buds have been formed for next season's fruiting.

The Grape.

Varieties 200, Distance Planted, College Vineyard, 6x8 ft., Station Vineyard, 8x10 ft.

The experiments with this fruit have been conducted in the college vineyard planted in 1868 and 1869 and in the station vineyard, where the vines are from 1 to 10 years old and, where each year the decidedly promising new varieties, offered in the market are planted. The former consists principally of the Concord variety with a few vines each of some of the leading commercial kinds.

The crop in the station vineyard was more uneven than for many years, largely due to the continued wet weather in July. Some varieties proved entire failures while others were especially fine.

The crop in the college vineyard was exceptionally fine in quality but not quite as large as in 1896. The fruit sold readily in the local market for five cents per pound.

Results of Spraying. The college vineyard, except check rows, and one vine of the two of each variety planted for experiment in the station vineyard were sprayed according to the calendar for 1897 with decidedly favorable results, but not with the benefit of previous years.

Method of Training. The vines in both vineyards are trained according to the one arm renewal system Fig. 1, which proves very satisfactory, requiring much less labor and skill to produce superior fruit than any other. Thinning the fruit is practiced, all small bunches being removed as soon as well set, leaving only a limited number of large bunches on each vine.

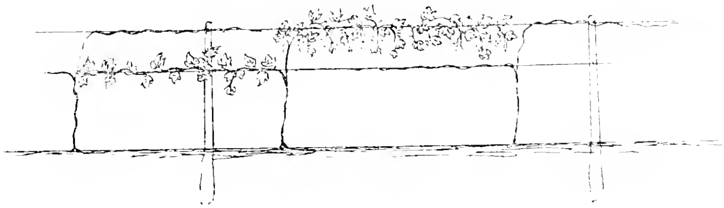


Fig. 1

The varieties that we would recommend for general planting for market and home use are Green Mountain, Herbert (Rogers No. 44) Worden, Moore's Early, Concord, Delaware, and Brighton if planted near other varieties that produce an abundance of pollen.

Campbell's Early. This new variety, introduced with so much praise is growing in the vineyards and shows a vigorous habit and firm healthy foliage. From samples of the fruit sent us for testing and from the many reports of disinterested parties we are led to think if it develops no weakness, that it will be one of the best grapes ever introduced for home use or market in New England. It should be closely watched by all grape growers in Massachusetts for we are in need of an earlier grape than the Concord or Worden and one of much better quality than Moore's Early to make grape growing a success.

Fertilizers Used. On college vineyard, 200 pounds sulfate of potash, 100 pounds nitrate of soda, 150 pounds acid phosfate, per acre. On station vineyard, $1\frac{1}{2}$ tons Canada ashes per acre.

Currants.

Number of Varieties 25.

The currant crop has been one of considerable profit above the cost of cultivation, although the proceeds from it are not large. The area planted covers about three-fourths of an acre. They are grown among quince bushes that are planted 10x12 feet, with the currants 5x6 feet between the rows.

In addition to the three standard sorts, the Cherry, Fays Prolific and Versailles that are commonly grown, may be mentioned the Red Cross, President Wilder, Pomona and White Imperial, all of which are of good size and apparently productive. The fruit of the Wilder and Pomona perhaps being larger than the Red Cross, and the Pomona better in quality than either.

The best currant in quality without doubt is the White Imperial, being less acid and possessing a peculiar spicy, aromatic flavor.

The Currant Leaf Blight appeared in many locations and did great damage where the plants were not well sprayed, the leaves nearly all falling off before the fruit was ripe. This disease can be prevented by spraying with the Bordeaux mixture, just before the blossoms open, and again as soon as the fruit has been gathered.

Currant Worms. The common currant worm was destroyed by hellebore and insect powder (Pyrethrum) at the rate of one-half pound to 50 gallons or one tablespoonful to a common pailful of water, or by using these insecticides with the common bellows or Paris green gun when the foliage was wet. Fertilizers used for both currants and quinces, 200 pounds sulfate of potash, 100 pounds nitrate of soda, 300 pounds acid phosfate.

Gooseberries.

Number of Varieties 23, planted among trees at varying distances.

This crop was not as abundant or satisfactory as usual on account of the extremely wet weather during July, and mildew appeared on many varieties. Among those that show the most merit are Chautauqua, Columbus, Triumph, Downing, Pale Red and Lancashire Ladd. The Industry while one of the best in quality and of the largest size has been very weak in growth.

Blackberries.

Number of Varieties, 28, Distance Planted 5x7 ft.

The conditions of the past season were in many particulars favorable for a large crop and that from the station plots was much above the average.

The older varieties retain about their former standing as to size, productiveness, quality and hardiness. The Snyder and Taylors being the most certain of producing paying crops.

The Eldorado made a fine showing of fruit that was of good size and quality. The plants so far have proved very hardy vigorous and productive and unless some weakness is developed it will be safe and profitable to plant it.

The *Rathbun* fruited for the first time the past season and while it shows decided merits, must be grown one or two seasons more before its real value can be determined.

Ohmer. Only a few plants of this variety fruited, but the yield was remarkable, the size large and quality about the average.

Erie. This variety, until the present season has badly winter killed and produced little or no fruit. This year's fruit was of large size, and good quality. The following table shows the comparative record of six varieties:

	Date of blooming.	Date of ripening.	Vigor.	Quality.	Size.	% Winter killing.	Yield for 25 hills.
Erie	June 5	July 16	8	8.5	l.	18	34 qts.
Ohmer	" 7	" 20	8.5	8	v. l.	13½	70¾ "
Minnewaski	" 2	" 18	9	8.5	m.	12	33 "
Eldorado*	May 30	" 18	9	9	l.	5	21½ "
Snyder	" 28	" 17	8	8	m. l.	0	45 "
Stone's Hardy	June 5	" 16	8.5	8.5	m.	15	32 "

*Rather young plants.

Explanation of tables.—Vigor and quality are based on a scale of 1 as the lowest grade, 10 the highest. Winter killing, on the scale of 100, 0 indicating perfect hardiness. Sizes, m. medium, l. large, v. l. very large, m. l. medium large.

The Orange Rust. In addition to the application of fungicides according to the calendar for 1897, all rusted canes were cut out as soon as they appeared, with the result that little or no injury was done by this disease.

Fertilizers used were as follows, 150 pounds nitrate of soda, 150 pounds acid phosfates, 150 pounds sulfate of potash per acre.

Red Raspberries.

Number of Varieties 25, Distance Planted 5x7 ft.

The red raspberry plants came through the winter of 1896—97 with little injury and the crop was unusually good. The heavy and continued rains during harvesting made it very difficult to secure the crop in a good condition for market. Of the old varieties the Cuthbert may still be considered the most valuable though the canes are tender and must be covered during the winter to ensure a full crop every year.

The two varieties of more recent introduction giving the greatest promise, are the King, an early variety, reported in former bulletins as Thompson's Pride, and the Loudon, ripening with the Cuthbert. Thus far they have proved hardy, vigorous, productive and of good quality.

The Miller or Miller's Early has done fairly well but has fruited only two seasons, so that further trial is needed to determine its value. It is reported in many sections of the country as valuable while in others as of no more value than the Hansel and Thompson's Early Prolific.

The following table shows the standing of the above four varieties :

	Date of blooming.	Date of ripening.	Vigor.	Quality.	Size.	% Winter killing.	Yield of 25 hills.	Firmness.
Cuthbert	June 5	July 5	10	8	l.	20	37.3 qts.	m.f.
King	May 30	June 29	9	9	m. l.	20	26.3 "	f.
London	May 5	July 10	10	9.5	l.	5	37½ "	f.
Miller's Early*	May 5	June 25	8.5	9	m. l.	10	14.3* "	m.f.

*Young plants.

Explanation of table.—Vigor and quality are expressed on a scale of 1 to 10, 10 indicating the highest grade. Size and winter killing by same terms as in former tables. Firmness, f. firm, m. f. medium firm.

The different varieties received the same treatment as to fertilizers and spraying for fungous diseases as the blackberries previously reported. The part of the plantation sprayed, showing much less leaf blight and anthracnose than that not sprayed.

Blackcap Raspberries.

Number of Varieties 26, Distance Planted 5x7 ft.

This crop was the largest for many years. Most of the varieties came through the winter uninjured, and the early summer was favorable to a perfect growth. As with the red raspberry however considerable fruit was destroyed by the heavy rains. The varieties ripened their fruit this season more nearly at the same time than usual. The following table shows the standing of a few of the best varieties :

	Date of blooming.	Date of ripening.	Vigor.	Quality.	% Winter killing.	Size.	Yield 25 hills.	Firmness.
Cromwell	June 5	June 28	7	8.5	2	m.	33.9 qts.	f.
Brackett's Seedling	" 3	July 4	8.5	8	5	l.	29.7 "	f.
Eureka	May 28	" 6	8.5	9	10	m.	48.8 "	f.
Hilborn	June 5	" 4	9.5	9.5	8	l.	31.7 "	f.
Kansas	" 1	" 2	9.5	7.5	15	m. l.	35 "	f.
Lovett	May 28	" 4	8	9	0	m.	39¾ "	f.
Older	" 28	" 4	8.5	8	5	l.	45 "	f.
Souhegan	" 31	June 27	9	8.5	10	m.	20.7 "	f.

Shaffer Seedling Raspberries.

A collection of some 350 varieties of seedlings of the above purple cap or hybrid variety have fruited the past season with most interesting results. The seed was selected from the finest berries from a row of this purple cap or hybrid variety which stood between a field of Marlboro's on the one side and Thompson's Prolific on the other. More than half of the seedlings are of the red raspberry type (*Rubus strigosus*) the majority of the fruits however being purple in color like the parent or like that of the old variety Philadelphia and nearly all were of good size and quality.

Many of the plants produced large, well formed berries of a bright scarlet color and of the best quality. Some show great promise. Among these seedlings were found almost every style of development between the nearly typical form of the Blackcap (*Rubus occidantilis*) and that of the wild red raspberry (*R. strigosus*) and also a few albino or white or yellow forms of both species.

Another lot of seedlings of about the same number, from the same source will fruit the coming season for the first time.

New Species of the Genus Rubus.

The *Logan berry*. *Salmon berry*, *Musk berry*, *Strawberry-raspberry*, *Golden Mayberry*, etc., have not been tested long enough to prove if they have any value in New England.

Of these, the Logan berry seems to possess the greatest merit, but as yet its habits of growth and the special treatment that will give the best results have not been determined. It is not generally hardy, requiring covering with soil or mulch during the winter and probably will give the best results when treated like the dewberry.

The Strawberry-raspberry, an herbaceous perennial, the tops of which die down every winter and reproduce numerous shoots in the spring, has fruited abundantly in some places, but the quality is poor. The fruit is large and showy and something valuable may be hoped from seedlings of this species or from hybrids with it and some of our hardy species of Rubus, now in cultivation. A covering of coarse straw, or manure about this and the Logan berry will be undoubtedly best for winter protection.

Strawberry.

Number of Varieties 200. Distance Planted 3x2 ft.

The new varieties of strawberries on the station grounds are grown in plots, 25 plants of each kind being planted in each plot or row. They were planted in April and one-half of each row allowed to produce only two runners, thus :

```
   *    *    *    *    *    *    *    *    *
 o    o    o    o    o    o    o    o    o    o
   *    *    *    *    *    *    *    *    *
```

While the other half made five runners each thus

```
* * * * * * * * * * * * * * * * * * * * * * *
o * o * o * o * o * o * o * o * o * o * o * o
* * * * * * * * * * * * * * * * * * * * * * *
```

* New plants. o Old plants.

Enough of the runners that were to be removed of each kind were allowed to become nearly rooted before taking them off to supply stock plants for future trials. These plants were heeled in closely in well prepared beds, and if the weather was dry, well shaded for a few days until well rooted. If runners are thrown into a pail of water as they are taken off they are more certain to grow than if kept in a basket until they can be set out in the bed.

Varieties showing decided merit in the plots are then planted in the field and are grown in both the *close* and the *open* matted row. In the former the plants are allowed to produce all the runners they will until August or September when they are thinned out to from three to five inches apart, while in the latter the plants are located as they grow at a distance of from four to six inches apart and all other runners are removed as soon as the rows are full.

The runners of desirable varieties are removed from beds grown under either system and are heeled in and rooted for the next season's planting or for sale and we consider them much more valuable than plants that have not been transplanted. This practice is a great advantage, for the field crop is very much improved by the removal of the surplus runners and if the plants are not needed for setting in the spring they will produce a larger crop of fruit that will more than pay the cost of transplanting and winter's care. In case they are to be fruited it would be best to set them in rows or beds not over three feet wide with paths of about two feet wide between them.

Fertilizers used. The plots were fertilized, first by deeply ploughing under about eight cords of stable manure to the acre and then thoroughly fitted, using 200 pounds sulfate of potash, 200 pounds acid phosfate and 150 pounds nitrate of soda per acre. The strawberry field was fertilized with about five cords of stable manure deeply ploughed under, then dressed with two tons of Canada ashes and 100 pounds nitrate of soda, 165 pounds sulfate of potash and 165 pounds acid phosfate, per acre. The following table gives the behavior of the ten varieties that show the best results :

Variety.	Sex.	Vigor.	Blooming, May.	Ripening first berry, June.	Best picking, June.	Productiveness.	Size.	Form.	Color.	Firmness.	Quality.	Yield qts. per acre.
Clyde	st.	9	1	6	23	10	l.	r.c.	l.sc.	f.	8.5	8,441
Brandywine*	st.	8.5	1	12	27	8.5	l.	r.c.	sc.	f.	9.5	4,513
Boynton	p.	8	6	13	30	9.5	m.	c.	sc.	s.	7.5	5,201*
Howard's No. 14	p.	9.5	6	8	19	9	l.	c.	sc.	m.	9	5,043
Haverland	p.	8.5	1	7	19	9	m.	c.	l.sc.	m.	7.5	4,486
Aroma	st.	8.5	7	12	25	8	m.	irreg.	sc.	m.	8.5	4,336
Bisel	p.	9	15	12	22	8	m.	c.	d.sc.	m.	7.5	4,200
Howard's No. 36	p.	8.5	4	6	19	8	m.l.	l.c.	l.sc.	m.	8	4,133
Greenville	p.	8	7	14	23	8	l.	c.	sc.	s.	8.5	3,835
Glen Mary	st.	8.5	13	14	25	8	v.l.	irreg.	d.sc.	f.	8.5	3,765
Parker Earle*	st.	9	10	13	28	9	l.	c.	l.sc.	f.	9	6,525*

*In field.

Explanation of table.—St. indicates staminate. P. indicates pistillate. Vigor, production and quality are indicated by 10 as perfect and 1 as worthless. Size and firmness same as red raspberry. Form, r. round, c. conical, irreg. irregular. Color, l. light, sc. scarlet, d. dark.

The Brandywine, Howard's No. 41 and Parker Earle did not show the yield in the plots that they did in the field. The Bubach did not keep up to its former yield and the Marshall while producing large and very fine berries did not yield more than one-half the quantity of any of the variety reported in the above table.

The Bismarck resembles the Bubach in growth of plant, with berries of a large size, of lighter color, better form and quality. A very promising variety but will require another season's trial to determine its value for general planting. The Sample and a large number of highly praised varieties were planted last spring, but as only the growth of the plants can be reported they are not mentioned. Something over 500 varieties of seedling strawberries are being tested many of which show decided merit. None of these will be propagated for distribution unless they show very decidedly qualities superior to those varieties already introduced.

Spraying for the Destruction of Insects and Fungous Growths.

The results of spraying during the past season to protect crops from insects and fungous pests, again show the great benefits derived from this work.

All of the fruit and vegetable crops grown on the college grounds generally injured by the above pests, were treated according to the spraying calendar of 1897 and in most cases with marked beneficial results.

PUMPS AND NOZZLES.

There has been considerable improvement made in the pumps and nozzles put upon the market in the past year, and many new pumps have been offered. Whatever the kind of pump purchased it is important that it be used carefully, that the spraying material, if containing coarse particles, be carefully strained before use, that all parts be kept well oiled and after using that the pump be cleaned by pumping sufficient clear water through it to clear it of corroding materials.

Good judgment and considerable mechanical skill must be exercised to get the best results with any complicated machine, and only those persons possessing these qualifications should be allowed to use the pumps.

INSECTICIDES.

While there are many new insecticides offered, there is so little exact knowledge of their effect upon farm and garden crops that until further trial is made we can only recommend for general use *Paris green* and *hellebore* for chewing insects and *kerosene emulsion* for sucking insects, with *pyrethrum* or insect powder in a very few cases.

KEROSENE EMULSION.

Formula. ½ lb. common bar soap,
2 gallons common kerosene.

Cut the soap into small pieces or shavings and dissolve in about two gallons of hot water. While still hot, pour in the kerosene and with the hand pump or syringe, pump it back and forth until a thick cream-like substance is formed. In this conditon the kerosene is divided into very minute globules and will be readily diluted or suspended in water.

Before using, add water enough to make

(A) 10 gallons of emulsion
(B) 20 " " "

Formula A, to be used when the insects are in large numbers and the foliage is known not to be easily injured by it.

Pyrethrum Powder and *Hellebore* should be obtained in a perfectly fresh condition and be kept in glass stoppered jars.

FUNGICIDES.

BORDEAUX MIXTURE.

Formula. 4 lbs. Copper Sulfate, (*Blue Vitriol*).
4 lbs. Caustic Lime (Unslaked Lime.)

Dissolve the copper in hot water. (If suspended in a basket or sack in a tub of cold water it will however dissolve in from two to three hours.)

The lime is then slaked in another vessel adding water slowly that it may be thoroughly slaked. When both are cool, pour together, straining the lime through a fine mesh sieve or burlap strainer, and thoroughly mix. Before using, add water enough to make 50 gallons of the mixture.

The active agent in this mixture is the copper, the lime being used simply to hold it in place upon the foliage and branches of the plants sprayed. Here it is given up gradually, destroying the spores of the fungi as they are brought in contact with it by the surrounding atmosphere.

Should the lime be air slaked at all more than four pounds may be needed as it will have lost much of its strength.

This fungicide is recommended as more satisfactory than any other, from the fact that it adheres a long time to the branches, buds and leaves and seldom causes any injury to the foliage.

It has been found more effectual if made up fresh for each application. Two or three thorough applications give better results than many light ones.

When both fungous growths and insects attack a crop, Paris green should be applied with the Bordeaux, as in a combined state both are as effective as if used singly, one-half of the labor is saved and there is less danger from injury to the foliage by the Paris green than if used alone.

DILUTE COPPER SULFATE SOLUTION.

After the fruit has nearly matured it is often disfigured by the adhesion of the Bordeaux mixture, and in place of the Ammoniacal carbonate of copper recommended in Bulletin No. 37, we would advise the use of copper sulfate 2 oz. to 50 gallons of water. The foliage of many plants will stand a much stronger solution, but this is as concentrated as can be generally used.

SPRAYING CALENDAR.

PLANT.	FIRST APPLICATION.	SECOND APPLICATION.
APPLE . . . . (*Scab, codlin moth, bud moth. Tent caterpillar, canker worm, plum curculio.*)	When buds are swelling, Bordeaux.	If canker worms are abundant just before blossoms open, Bordeaux and Paris green.
BEAN . . . . (*Anthracnose.*)	When third leaf expands, Bordeaux.	10 days later, Bordeaux.
CABBAGE . . . . (*Worms.*)	Insect powder.	7-10 days later Insect powder.
CHERRY* . . . . (*Rot, aphis, slug. Black Knot.*)	As buds are breaking, Bordeaux; when aphis appears, kerosene emulsion.	When fruit has set, Bordeaux. If slugs appear, dust leaves with air slaked lime or Hellebore.
CURRANT / GOOSEBERRY . . . . . (*Worms. Leaf Blight.*)	At first sign of worms, hellebore.	10 days later, hellebore. Bordeaux.
GRAPE . . . . (*Fungous diseases. Rose bug.*)	In Spring when buds swell, Bordeaux.	Just before flowers unfold, Bordeaux.
NURSERY STOCK . . . . (*Fungous diseases.*)	When first leaves appear, Bordeaux.	10-14 days, repeat first.
PEACH, NECTARINE . . (*Rot, mildew.*)	As the buds swell, Bordeaux.	When fruit has set, Bordeaux.
PEAR . . . . (*Leaf blight, scab, psylla, codlin moth, blister mite.*)	As buds are swelling, Bordeaux.	Just before blossoms open, Bordeaux. Kerosene emulsion when leaves open for psylla.
PLUM* . . . . (*Curculio. Black knot, leaf blight, brown rot.*)	When buds are swelling Bordeaux.	When blossoms have fallen, Bordeaux and Paris green. Begin to jar trees for curculio.
QUINCE . . . . (*Leaf and fruit spot.*)	When blossom buds appear, Bordeaux.	When fruit has set, Bordeaux.
RASPBERRY, BLACKBERRY, DEWBERRY, ... (*Rust, anthracnose, leaf blight.*)	Before buds break, Bordeaux.	Bordeaux, just before the blossoms open.
STRAWBERRY . . . . . . (*Rust.*)	As soon as growth begins, with Bordeaux.	When first blossoms open. Spray young plantation, Bordeaux.
TOMATO . . . . (*Rot, blight, flea beetle.*)	Before appearance of blight or rot, Bordeaux.	Repeat first if diseases are not checked. Fruit can be wiped if disfigured by Bordeaux.
POTATO . . . . (*Flea beetle, Colorado beetle, blight and rot.*)	Spray with Paris green and Bordeaux when ½ grown.	Repeat before insects become numerous.

*Black knot on plums or cherries should be cut and burned as soon as discovered.

THIRD APPLICATION.	FOURTH APPLICATION.	FIFTH APPLICATION.
When blossoms have fallen, Bordeaux and Paris green.	8-12 days later, Bordeaux and Paris green.	10-14 days later, Bordeaux.
14 days later, Bordeaux.	14 days later, Bordeaux.	Spraying after the pod is one-half grown will injure them for market.
7-10 days later, Insect powder.	Repeat third in 10-14 days if necessary.	
10-14 days if rot appears, Bordeaux.	10-14 days later, weak solution of copper sulphate.	
If worms persist, hellebore.	After fruit is gathered, Bordeaux.	
When fruit has set, Bordeaux.	2 to 4 weeks later, Bordeaux.	2 to 4 weeks later, if any disease appears, weak solution of copper sulphate.
10-14 days repeat first.	10-14 days repeat first.	10-14 days, repeat first.
When fruit is one-half grown, Bordeaux.	5-7 days later, weak solution of copper sulphate.	5-7 days later, repeat fourth.
After blossoms have fallen, Bordeaux and Paris green. Kerosene emulsion, if necessary.	8-12 days later, repeat third.	10-14 days later, Bordeaux.
10-14 days later, Bordeaux.	10-20 days later, Bordeaux.	10-20 days later, weak solution of copper sulphate.
10-20 days later, Bordeaux.	10-20 days later, Bordeaux.	10-20 days later, Bordeaux.
(Orange or red rust is treated best by destroying the plant.)	Spray after fruit is gathered with Bordeaux.	
Spray young plantation Bordeaux.	Repeat third if foliage rusts.	
Repeat first when necessary.		
Repeat for blight, rot and insects as potatoes approach maturity.		

*For aphides or plant lice use kerosene emulsion on all plants.

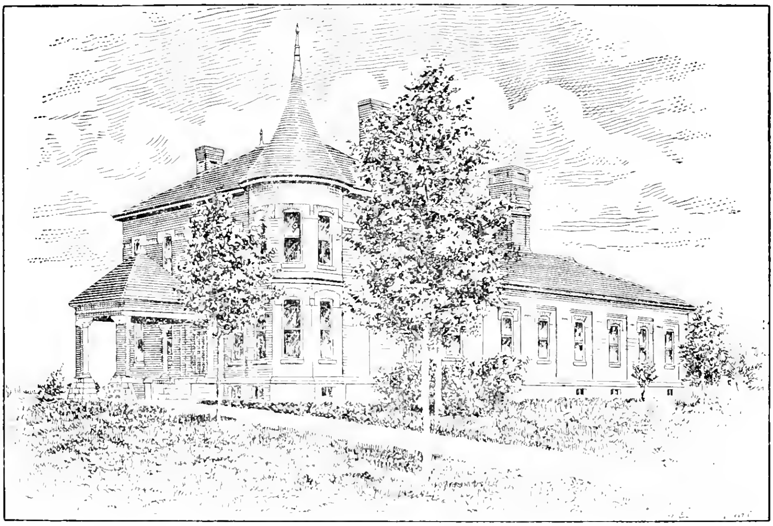
HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

BULLETIN NO. 53.

CONCENTRATED FEED STUFFS.



CHEMICAL LABORATORY.

APRIL, 1898.

The Bulletins of this Station will be sent free to all newspapers in the State and to such individuals interested in farming as may request the same.

AMHERST, MASS.:
PRESS OF CARPENTER & MOREHOUSE,
1898.

HATCH EXPERIMENT STATION

OF THE

Massachusetts Agricultural College,

AMHERST, MASS.

By act of the General Court, the Hatch Experiment Station and the State Experiment Station have been consolidated under the name of the Hatch Experiment Station of the Massachusetts Agricultural College. Several new divisions have been created and the scope of others has been enlarged. To the horticultural, has been added the duty of testing varieties of vegetables and seeds. The chemical has been divided, and a new division, "Foods and Feeding," has been established. The botanical, including plant physiology and disease, has been restored after temporary suspension.

The officers are :—

HENRY H. GOODELL, LL. D.,	*Director.*
WILLIAM P. BROOKS, PH. D.,	*Agriculturist.*
GEORGE E. STONE, PH. D.,	*Botanist.*
CHARLES A. GOESSMANN, PH. D., LL. D.,	*Chemist* (Fertilizers).
JOSEPH B. LINDSEY, PH. D.,	*Chemist* (Foods and Feeding).
CHARLES H. FERNALD, PH. D.,	*Entomologist.*
SAMUEL T. MAYNARD, B. SC.,	*Horticulturist.*
J. E. OSTRANDER, C. E.,	*Meteorologist.*
HENRY M. THOMSON, B. SC.,	*Assistant Agriculturist.*
RALPH E. SMITH, B. SC.,	*Assistant Botanist.*
HENRI D. HASKINS, B. SC.,	*Assistant Chemist* (Fertilizers).
CHARLES I. GOESSMANN, B. SC.,	*Assistant Chemist* (Fertilizers).
EDWARD B. HOLLAND, B. SC.,	*Ass't Chemist* (Foods and Feeding).
FRED W. MOSSMAN, B. SC.,	*Ass't Chemist* (Foods and Feeding).
BENJAMIN K. JONES, B. SC.,	*Assistant in Foods and Feeding.*
ROBERT A. COOLEY, B. SC.,	*Assistant Entomologist.*
G. A. DREW, B. SC.,	*Assistant Horticulturist.*
H. D. HEMENWAY, B. SC.,	*Assistant Horticulturist.*
H. H. ROPER, B. SC.,	*Assistant in Foods and Feeding.*
A. C. MONAHAN,	*Observer.*

The co-operation and assistance of farmers, fruit-growers, horticulturists, and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the

HATCH EXPERIMENT STATION, Amherst, Mass.

DIVISION OF FOODS AND FEEDING.

JOSEPH B. LINDSEY.*

SUMMARY OF RESULTS.

I. This bulletin contains, in addition to a classification of feed stuffs and a description of methods of preparation, *the results of the first official inspection.*

II. There were found 4 different brands of gluten meal, 5 brands of gluten feeds, 10 different makes of wheat bran, 19 distinct brands of middlings, 22 different mixed feeds, besides a great variety of other feed stuffs, many without manufacturer's name or brand. The total number of analyses reported are 265.

III. The inspection shows the feed stuffs to be comparatively free from serious adulteration. Some show rather wide variations in composition, which it is hoped will be corrected in the future.

IV. Many new materials, by-products from various industries, are constantly appearing, frequently without name, brand or guaranty. This leads to much confusion as to feeding and actual commercial value on the part of the buyer. Materials of this character ought not to be purchased without a guaranty of quality. Guaranteed articles ought always to be given the preference.

V. To get a clear idea of the evenness in composition of the different feeds, the reader should carefully note the *average* composition and then the *variations* from this average.

VI. Particular attention is called to the comparative commercial values of the different feed stuffs on page 23.

* Assisted by E. B. HOLLAND, B. K. JONES and F. W. MOSSMAN.

CONCENTRATED FEED-STUFFS.

A. What concentrated feeds are, and why used.

B. Classification.

C. Preparation.

D. Inspection law.

E. Results of inspection.

F. Comparative commercial values.

G. Mixtures of concentrated feeds for dairy cows.

A. The term "concentrated feed," taken in its broadest sense, is meant to include the grains and other seeds of agricultural plants, as well as their manifold by-products left behind in the process of oil extraction and in the preparation of human foods.

All cattle feeds, either concentrated or coarse, are made up of six groups of substances: Water, ash, cellulose or fiber, fat, protein and non-nitrogenous extract matter.

Water.—The several grains and by-products contain when placed upon the market from 8 to 15 per cent of water.

Crude Ash represents the mineral ingredients of the seed. It will remain behind as ashes should the seed be burned. These ashes consist of lime, potash, soda, magnesia, iron, phosphoric acid and sulfuric acid.

Crude Cellulose or Fiber is the coarse or woody part of the plant. It may be called the plant's framework. It is present as a rule only to a limited extent in the grains and by-products.

Crude Fat includes not only the various fats and oils found in different feed stuffs, but also waxes, resins and coloring matters. It is sometimes termed ether-extract, because it represents that portion of the plant soluble in ether. Fat found in grains and seeds is comparatively free from foreign substances (waxes, resins, etc.).

Crude Protein is the general name for all of the nitrogenous matters of the seed. It corresponds to the lean meat in the animal, and may be termed "vegetable meat." It has the same elementary composition as animal flesh, and is considered the most valuable part of concentrated feeds.

Non-nitrogenous Extract Matter consists of sugars, starch and gums. The grains are very rich in starch and similar substances.

Carbohydrates.—The fiber and extract matter have the same functions in the process of nutrition, and collectively they are termed carbohydrates.

Nutritive Ratio.—The numerical relation which the protein of a feed bears to the carbohydrates (and fat reduced to carbohydrates) is termed its nutritive ratio. Fat is multiplied by $2\frac{1}{2}$ to convert it into carbohydrates. If a ton of feed should contain 96 pounds of digestible protein, and 928 pounds of digestible carbohydrates, it would have 9.4 times as much carbohydrates as protein or 1 : 9.4, which is its nutritive ratio.

Digestibility.—Any feed-stuff is valuable as a source of nourishment only so far as its various parts can be digested and assimilated. That the concentrated feeds are much more digestible than the coarse fodders may be shown from the following table :—

	100 Pounds Timothy Hay Contains:			100 Pounds Cotton-seed Meal Contains:		
	Composition.	Per Cent. Digestible	Pounds Digestible	Composition.	Per Cent. Digestible	Pounds Digestible
Water,	15.0	—	—	8.0	—	—
Crude ash,	4.3	—	—	6.9	—	—
Crude fiber,	28.4	58	16.47	6.8	32	2.2
Crude fat,	2.4	61	1.46	10.7	93	10.0
Crude protein,	6.3	48	3.02	41.6	88	36.6
Extract matter,	43.60	63	27.46	26.0	64	16.5
Total,	100.00	—	48.41	100.00	—	65.3

The timothy hay has only 48.4 pounds of digestible matter, while the cotton-seed has 65.3 pounds.

Reasons for feeding concentrated feeds. Most of the home grown coarse feeds are high in carbohydrates, low in protein, and comparatively indigestible. Nearly all of the concentrated feeds are very digestible, and a large number are *high* in protein and low to medium in carbohydrates. The concentrated feeds are fed with the home grown coarse feeds therefore, *first to increase the digestible matter, and second to increase the amount of protein in the daily ration.*

B. CLASSIFICATION OF CONCENTRATED FEEDS.

The following classification is made on the basis of the amount of *protein* contained in the several feed stuffs, those in Class I. showing the largest amount, and those in class IV. the smallest quantity.

Division I. Protein Feeds.			Division II. Carbohydrate or starchy feeds.
Class I. *30 to 45% protein.* 50 to 60% *carbohyd's. 75 to 90% digestible.	Class II. *20 to 30% protein.* 60 to 70% *carbohyd's. 80 to 85 digestible.	Class III. *14 to 20% protein.* 70 to 75% *carbohyd's. 60 to 75% digestible.	Class IV. *8 to 14% protein.* 75to 85% *carbohyd's 75 to 90% digestible.
Cottonseed meal. Linseed meals. Chicago, Cream, King and Hammond gluten meals.	Buffalo, Golden, Diamond, Davenport, Climax, Joliet, and Standard gluten feeds made from corn, Atlas meal, dried brewers' grain, and malt sprouts.	Wheat brans and middlings, "mixed feeds" and H. O. dairy feed.	Wheat, barley, rye, oats, corn, cerealine, hominy, and oat feeds, corn and oat chop, corn germ feed, and chop feed.

*Including fat reduced to carbohydrates.

C. PREPARATION OF CONCENTRATED FEEDS.

Class I.

COTTONSEED MEAL.

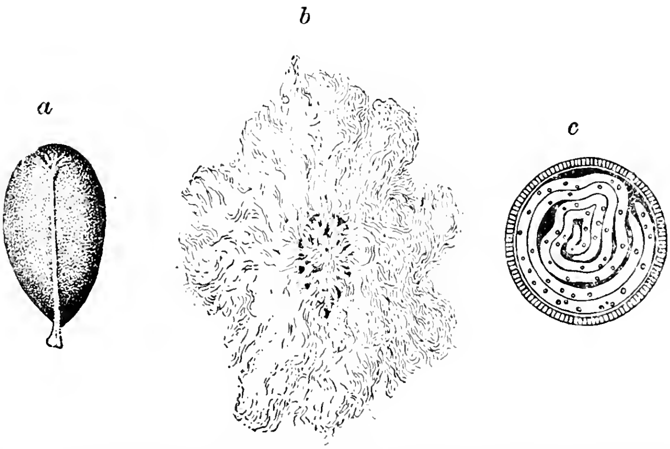


Figure I. a. Seed entirely free from fiber, (delinted) magnified three times. b. Seed covered with cotton, (coma). c. Section of seed showing crumpled embyro, (meat) filling the seed coats.

The seed of the cotton plant as it comes from the gin where the cotton fiber has been removed, is still covered with a coat of white down technically known as "linters." This being removed, the seed itself appears as black in color, and irregular egg-shaped in form. The thick, hard, black seed coat or hull, is filled with the coiled embryo, (meat) which in turn contains a large number of oil containing cells. Machines have been invented to remove the hull. The meat is then cooked in large iron kettles, and while still hot is wrapped in hair cloth, and subjected to a pressure of 3000 to 4000 pounds per square inch, to remove as much of the oil as possible. The pressed cottonseed cake is cracked, ground, and results in the decorticated bright yellow cottonseed meal of commerce. A ton of seed furnishes about 800 pounds of meal. Sometimes a considerable amount of hull is ground fine and mixed with the meal, producing a dark colored article, having not much over one-half the feeding value of the prime material.

LINSEED MEALS.

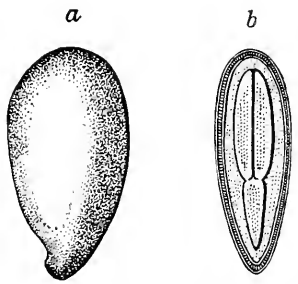


Figure II. Common flax (Linum usitatissimum). a. Seed magnified six times. b. Longitudinal section, showing embryo embedded in the endosperm.

The drawings for Figs. I. and II. from Hicks, in Year Book 1895, Department of Agriculture.

Linseed meal is the ground residue remaining from the flaxseed, after the oil has been removed. The larger part of the flaxseed used in this country is grown in North and South Dakota and in Minnesota. The seeds of the flax plant are flattened, elliptical oval, pointed at the lower end, and of a brown color. They contain in their natural state from 30 to 35 per cent of oil. Twenty to 28 per cent of the oil of the seed is removed by warm pressure. This oil is known as linseed oil, and after being refined is used in the preparation of paints, varnishes printer's ink, or in the manufacture of soap. The pressed cake remaining is dried, cracked and ground, and furnishes the old process linseed meal. A considerable portion of the old process meal is sold by the National Linseed Oil Co.

The so-called "Flax Meal" is made by the Cleveland Linseed and Oil Co. The oil is quite thoroughly extracted from the crushed seeds by means of a solvent, and after the extraction, the meal is treated with steam, which process tends to produce a coarse and flaky product.

Linseed meals are generally known as oil meals. This is an incorrect name, the oil having been to a considerable extent removed.

Gluten Products.

The various products known as gluten meals, gluten feeds, germ feed and the like, are the residues resulting from the manufacture of starch and glucose (grape sugar) from maize or Indian corn.

The average of a large number of analyses of water-free Indian corn shows it to have the following composition:

Crude ash,	1.7 per cent.
Crude fiber,	2.5 per cent.
Crude fat,	5.4 per cent.
Crude protein,	11.5 per cent.
Extract matter (chiefly starch),	78.9 per cent.

It is quite evident that the corn is made up chiefly of starchy matters. The removal of the larger part of the starch naturally increases the proportion of the other ingredients. The constituent contained in the corn next in amount to starch is the protein,—a general name for all albuminoids. In case of corn it is called gluten, and after the removal of the starch, this being by far the most prominent constituent remaining, the feeds have been termed gluten feeds. Even in the best methods of manufacture, the starch is not all removed, the residues being often made up of one-half of starchy matter.

Parts of Indian Corn.—The accompanying enlarged cut* of a corn or maize kernel will assist in locating the four distinct parts which are of interest in this study.

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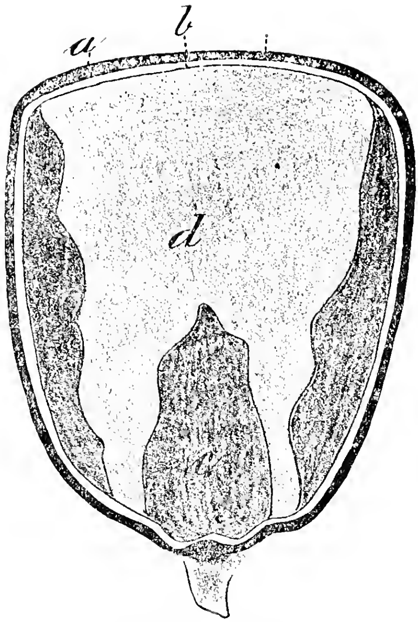
*This cut was kindly loaned by Director E. B. Voorhees of the New Jersey Station. The description of the same is taken from Bulletin 105 of the New Jersey Experiment Station.



a is the husk or skin covering the whole kernel; it consists of two distinct layers, the outer and inner, which when removed constitute the bran and contain practically all of the crude fiber of the whole grain.

b is a layer of gluten cells which lie immediately underneath the husk; it is, as a rule, yellow in color and cannot be readily separated from the remainder of the kernel. This part is richest of any in gluten.

c is the germ, which is readily distinguished by its position and form; it also contains gluten, though it is particularly rich in oil and mineral constituents.

The large portion (*d*) is composed chiefly of starch; the dark color indicates the flinty part in which the starch-holding cells are most closely compacted.

*How the parts are separated.** The corn is first soaked in quite dilute, warm sulfurous acid water. It is then ground by being passed with water through mills to carry off the substance in suspension. Degerminating machinery removes the germs at this point. The germs are dried and crushed through rolls, and the oil pressed out, leaving the residue in cakes. It is largely exported as

Corn Germ Cake.

After degermination, the suspended mass is bolted through sieves, separating the hull, bran and some light weight and broken germs from the starch and gluten. The first materials (hull, bran, broken germs, etc.) are pressed and dried and results in what is known as

Chop Feed.

The starch and gluten are run into concentrating tanks, and then

*The following is a brief outline of the process from which all details have been omitted.

very slowly through long shallow troughs. The starch settles down like wet lime in these troughs, while the hard flinty portion or gluten floats off into receivers, is concentrated, and finally pressed in heavy filter cloths, run through steam dryers, and appears as

Gluten Meal.

The gluten meal and chop feed mixed together, pressed and dried constitutes

Gluten Feed.

Class II.

Gluten feeds. (See above.)

Atlas gluten meal so called, is very different from the ordinary gluten products. The germ is first removed from the Indian corn, and the remainder of the corn kernels are mixed and ground together with rye, barley, wheat, juniper, etc. This product is then heated with a solution of malt, which converts a considerable portion of the starch into sugar. Yeast is then added, the alcohol, etc., resulting distilled, and the refuse remaining in the still is pressed, dried, and placed upon the market under the above name.

Dried Brewers' grain is the kiln dried residue from beer manufacture. It consists of some of the starch, together with the hulls, germ and gluten of the barley. A small portion of the gluten and the larger part of the starch are removed from the barley by the action of diastase and yeast.

Malt sprouts. Malt used in beer manufacture is prepared by moistening barley and allowing it to sprout. The sprouting produces a ferment called diastase, which changes starch into sugar. After the formation of the diastase, which requires a certain number of days, the barley is dried, and the sprouts removed by machinery and sold for cattle feed. The barley is now termed malt.

Class III.

WHEAT PRODUCTS.

The wheat has the same general formation as the corn kernel. The natural divisions of the feed resulting from grinding wheat are bran, middlings and red dog flour.

Bran is the exterior covering and is first removed.

Middlings are removed next after the bran.

Red dog is a very low grade flour, and represents the dividing line between the feed and high grade flour.

Flour middlings is a mixture of middlings and red dog flour.

Mixed feed is generally a mixture of bran, middlings and red dog flour.

H. O. dairy feed consists of oat feed as a basis, mixed with feeds high in protein, such as cottonseed and gluten meals.

Class IV.

Cerealine feed. This feed comprises the hull, and some of the starch of the corn. It is the by-product resulting in the manufacture of the breakfast preparation known as cerealine flakes. It is very coarse. It possesses a feeding value but slightly inferior to corn meal.

Hominy feed or chop. Hominy is the hard part of the corn kernel. The separation of the hull, germ and some of the starch which constitutes the feed, is said to be brought about solely by the aid of machinery and steam.

Chop feed has been described under gluten products.

Oat feed, corn and oat chop, etc. Oat feed is the refuse from factories engaged in the preparation of oat meal and other cereals for human consumption. It consists of poor oats, hulls, and some of the bran and starch removed in the process of manufacture. It is sometimes mixed with corn, as corn and oat chop.

D. LAW CONCERNING CONCENTRATED FEED STUFFS.

The following law was passed by the Massachusetts Legislature at its session of 1897:

[Chap. 117,]

AN ACT RELATIVE TO CONCENTRATED COMMERCIAL FEED STUFFS.

Be it enacted, etc., as follows:

Section 1. The director of the Hatch Experiment Station of the Massachusetts Agricultural College is hereby authorized and directed, in person or by deputy, to take samples not exceeding two pounds in weight from any lot or package of concentrated commercial feed stuff, used for feeding any kind of farm live stock, which may be in the possession of any manufacturer, importer, agent or dealer, cause the same to be analyzed for the amount of crude protein and crude fat contained therein, as well as for other ingredients if thought advisable, and cause the results of the analyses to be published from time to time in specially prepared bulletins, with such additional information as circumstances advise: *provided however*, that in publishing the results of the analyses the names of the jobbers or local dealers selling the said feed stuffs shall not be used, but the commodity analyzed shall be identified and described by the name of the manufacturer and the commercial name or designation by which it is known in the trade.

SECTION 2. Whenever requested said samples shall be taken in the presence of the party or parties in interest or their representative and shall in all cases be taken from a parcel or number of packages which shall not be less than five per cent of the whole lot inspected, shall be thoroughly mixed and then divided into two equal samples and put in glass vessels and carefully sealed, and a label placed on each vessel stating the name or brand of the feed stuff or material sampled, the name of the manufacturer when possible, the name of the party from whose stock the sample was taken, and the time and place of taking; said label shall be signed by the director, or his deputy, and by the party or parties in interest or their representative, if present at the taking and sealing of the samples. One of said duplicate samples shall be retained by the director and the other by the party whose stock was sampled.

SECTION 3. This act shall take effect on the first day of July in the year eighteen hundred and ninety-seven. [*Approved March 5, 1897.*]

E. RESULTS OF INSPECTION.

I. PROTEIN FEEDS.

American Cotton Oil Co.'s Cottonseed Meal.

Guaranty: **Protein 43 per cent. Fat 9 per cent.**

Manufactured by:	Collected at:	Water.	Protein.	Fat.
American Cotton Oil Co., N. Y.	Shelburne Falls,	4.84	43.93	14.23
" " " " "	Lawrence,	5.14	41.76	13.03
" " " " "	Northampton,	5.92	45.21	12.19
" " " " "	South Deerfield,	5.66	43.73	12.37
Average,		**5.39**	**43.67**	**12.96**

Cotton Oil Co.'s Cottonseed Meal.

Guaranty: None.

Manufactured by:	Collected at:	Water.	Protein.	Fat.
Cotton Oil Co. Memphis, Tenn.,	Pittsfield,	6.69	42.18	13.26

Without name or guaranty.

Unknown	Great Barrington,	6.14	46.16	9.98
"	Lee,	6.42	45.95	11.82
"	Shelburne Falls,	7.35	*29.24	6.64
"	Springfield,	6.11	45.30	14.06
"	Marlboro,	6.43	43.53	11.87
"	Southbridge,	7.26	47.28	9.81
"	Bridgewater,	7.01	45.92	9.60
"	Franklin,	4.21	42.98	**18.98
"	Ayer,	7.81	*21.97	6.47
"	Gardner,	6.44	41.96	12.67
"	Greenfield,	6.44	43.09	10.31
"	North Amherst,	5.79	44.79	12.29
"	" "	6.19	46.43	11.86
"	" "	6.31	45.96	11.02
"	" "	5.91	46.15	11.48
"	Holyoke,	3.61	43.29	**18.78
"	"	5.33	47.09	11.21
"	Westfield,	6.11	46.18	11.01
Highest,		**7.82**	**47.28**	**18.98**
Lowest,		**3.61**	**41.96**	**6.47**
Average,		**5.98**	**45.13**	**12.30**

Particular attention is called to the fact that the American Cotton Oil Co. place a guaranty upon their bags. A guaranteed article should always be given the preference.

Cleveland Flax Meal.

Guaranty: **38 to 40 per cent protein.**

Cleveland Linseed and Oil Co.	Greenfield,	8.24	39.21	3.43
" " "	Shelburne Falls,	8.08	40.04	2.14
" " "	Milford,	7.84	42.15	2.92
" " "	Attleboro,	8.75	38·44	2.89
" " "	Northampton,	9.14	40.11	2.92
" " "	Salem,	7.39	39.62	2.50
" " "	Orange,	8.90	40.45	1.94
" " "	Winchendon.	9.01	39.55	2.57
Average,		**8.42**	**39.95**	**2.66**

*The meals marked * were stock carried over from last year. While fully one-third of all samples received at this station during 1897 proved to be seriously adulterated, thus far in 1898 not a single adulterated article has been discovered.

**Excess of oil.

Guaranty: None.

Old process Linseed Meals.

Manufactured by:	Collected at:	Water.	Protein.	Fat
Hamenstein & Co. Buffalo.	Great Barrington,	7.80	36.67	8.92
National Linseed Oil Co. Buffalo.	Hinsdale,	8.35	37.45	6.45
" " " "	Greenfield,	8.26	37.99	7.36
" " " "	Springfield,	7.71	38.55	8.86
" " " "	Southbridge,	7.25	35.09	9.63
" " " "	Ipswich,	7.89	38.88	6.72
Kellogg&Miller Amsterdam, N.Y.	Shelburne Falls,	8.19	35.27	6.90
Average,		**7.92**	**37.13**	**7.83**

Attention is called to the fact that the Cleveland flax meal is sold under a guaranty.

GLUTEN PRODUCTS.

The Glucose Sugar Refining Co. of Chicago, handles gluten meal, gluten feed and chop feed. This concern controls the following factories:

Factory.	Locality.	Brand of Feed.
Chicago Sugar Refining Co.,	Chicago, Ill.	Chicago gluten meal.
" " " "	" "	" chop feed.
American Glucose Co.,	Peoria, Ill.	Buffalo gluten feed.
Rockford Sugar Refining Co.,	Rockford, Ill.	Diamond " "
Davenport Syrup Refining Co.,	Davenport, Iowa.	Davenport " "
Firmenish Manufacturing Co.,	Marshalltown, Iowa.	Golden " "
" " "	" "	Climax " "
" " "	" "	Peerless " "
" " "	" "	Marshalltown chop feed.

Chicago Gluten Meal.*

Guaranty: None.

Manufactured by:	Collected at:	Water.	Protein.	Fat.
Glucose Sugar Refining Co., Chicago.	North Adams,	9.30	33.39	1.36
" " " " "	" "	8.60	35.73	4.37
" " " " "	Pittsfield,	8.70	36.06	2.25
" " " " "	Springfield,	8.34	36.71	4.28
" " " " "	Holyoke,	9.04	34.14	1.30
" " " " "	Palmer,	8.58	35.61	1.99
" " " " "	Spencer,	9.33	37.66	1.79

*A recent letter from the Glucose Sugar Refining Co., contains the following: "We are now printing upon all of our packages in full face type the exact amount of protein and fat contained in each of our feeds, as made by our different refineries. The feeds your inspector met with in his tour, left here in October and early November before your law could be put into execution."

Manufactured by:	Collected at:	Water.	Protein.	Fat.
" " " " "	Uxbridge,	9.80	35.24	2.00
" " " " "	Holden,	11.47	35.10	2.24
" " " " "	Webster,	9.05	34 63	2.55
" " " " "	Worcester,	8.05	35.39	2.63
" " " " "	Ayer,	7.94	31.67	3.92
" " " " "	Fall River,	9.22	36.45	1.73
" " " " "	Taunton,	9.08	35.32	3.04
" " " " "	Newburyport,	8.88	33.74	2.07
" " " " "	Orange,	8.60	36.28	7.63
" " " " "	Templeton,	9.14	35.94	2.37
" " " " "	Fitchburg,	9.44	36.06	2.86
Highest,			37.66	7.63
Lowest,			31.67	1.36
Average,		8.47	35.28	2.80

Cream Gluten Meal.

Guaranty: **Protein 37.12 per cent. Fat 3.20 per cent.**

Chas. Pope Glucose Co., Chicago.	Pittsfield,	7.82	38.88	2.76
" " " " "	Holyoke,	7.14	31.00	3.27
" " " " "	Worcester,	7.72	31.61	4.36
" " " " "	Milford,	7.71	32.47	1.66
" " " " "	Upton,	8.17	33.44	1.75
" " " " "	Ayer,	9.01	35.56	2.25
" " " " "	Concord,	8.34	37.39	2.59
Highest,			38.98	4.36
Lowest,			31.00	1.75
Average,		7.99	34.34	2.66

King Gluten Meal.

Guaranty: None.

National Starch Mfg. Co.	Lee,	8.19	30.68	16.04
" " " "	Hinsdale,	4.77	29.94	14.79
" " " "	Shelburne Falls,	7.43	33.06	14.39
" " " "	Northampton,	7.20	32.43	12.51
" " " "	Westfield,	4.84	31.42	15.47
" " " "	Holyoke,	4.47	31.10	15.41
" " " "	Springfield,	6.67	34.38	13.47
" " " "	Worcester,	7.56	31.74	14.63
" " " "	Southbridge,	6.63	37.06	15.40
" " " "	Attleboro,	7.15	32.11	*2.65
" " " "	Middleboro,	6.68	35.08	12.71
" " " "	Orange,	7.80	33.68	12.86
" " " "	Gardner,	6.14	34.56	16.71
Highest,			37.06	16.71
Lowest,			29.94	2.65
Average,		6.53	32.93	14.53

*Not included in average.

Hammond Gluten Meal.

Guaranty: None.

Manufactured by:	Collected at:	Water.	Protein.	Fat.
Stein Hirsh & Co., Chicago.	Fitchburg,	6.05	36.08	4.54

Buffalo Gluten Feed.

Guaranty: None.

American Glucose Co., Peoria, Ill.,	Shelburne Falls,	8.94	27.34	2.45
" " " " "	Chester,	8.50	28.01	2.34
" " " " "	South Deerfield,	8.73	28.00	2.37
" " " " "	South Framingham,	6.95	22.78*	2.84
" " " " "	Walpole,	9.16	28.04	3.82
" " " " "	Haverhill,	8.92	28.54	2.80
" " " " "	Salem,	8.46	28.78	2.55
" " " " "	Millington,	8.40	27.79	3.43
" " " " "	Furnace,	8.43	29.50	2.44
" " " " "	Westfield,	10.73	27.33	3.01
Average,		**8.92**	**28.15**	**2.80**

Iowa Golden Gluten Feed.**

Guaranty: None.

Firmenish Mfg. Co.,	Ware,	8.53	27.88	8.04
" " "	Milford,	7.59	29.63	2.03
" " "	Lexington,	5.89	29.57	3.22
" " "	Lowell,	7.82	27.69	2.21
" " "	Ipswich,	7.70	28.59	*14.51
" " "	Hingham,	7.91	27.35	3.43
" " "	Fitchburg,	7.50	25.87	2.23
Average,		**7.57**	**28.08**	**3.53**

Climax Gluten Feed.

Guaranty: None.

Firmenish Mfg. Co., Marshalltown, Ia.	Worcester,	7.99	23.79	4.38
" " " " "	Barre,	6.05	21.14	4.32
Average,		**7.02**	**22.47**	**4.35**

Diamond Gluten Feed.

Guaranty: None.

Rockford, Ill. Sugar Refining Co.,	North Adams,	6.58	21.05	2.45
" " " " "	Westfield,	6.18	22.00	2.30
" " " " "	Holyoke,	8.06	21.74	3.33
" " " " "	Spencer,	8.39	20.33	3.04
" " " " "	Springfield,	8.53	22.76	*11.65
" " " " "	Franklin,	7.07	20.74	2.31
" " " " "	Lowell,	7.63	22,62	3.79
Average,		**7.49**	**21.61**	**2.87**

*Not included in average.
**Called gluten meal by manufacturers.

Manufactured by:	Collected at:	Water.	Protein.	Fat.
	Joliet Gluten Feed. *Guaranty: None.*			
Chapin & Co., Boston,	Leominster,	6.88	20.39	3.43
	Atlas Gluten Feed. *Guaranty: None.*			
Atlas Distilling Co., Peoria, Ill.,	Chester.	7.36	28.25	10.83
	Oswego Gluton Feed.** *Guaranty: None.*			
Oswego Gluton Feed Co., Oswego, N. Y.,		38.41	8.03	6.73

The Cream and King gluten meals show wider variations than is desirable. It is hoped that these feed stuffs will in the future run more even in composition. The golden gluten meal so called has been classified as a gluten feed, for the reason that it contains less than 30 per cent of protein and is more bulky than a gluten meal. This in no way detracts from its feeding value. It is evident that the gluten feeds should be separated into two divisions, the first including the Buffalo and golden gluten feeds, having some 28 per cent of protein, and the second including the remainder of the feeds, each brand containing about 22 per cent of protein. "Oswego gluton feed" is evidently the refuse from starch factories and consists of the hulls, bran, etc. of the corn, It is offered in a moist condition at about $3 per ton f. o. b. Oswego. If as dry as the regular chop feed, it would be worth fully as much per ton. While its present feed value fully equals its cost, *its moist condition causes it to spoil rapidly.*

Wheat Brans.

Brand.	Manufactured by:	Collected at:	Water.	Protein.	Fat.
Superior	Daisy Roller Mill Co.,	Pittsfield,	8.88	17.10	4.77
Best clean	J. C. Davis & Co.	Hinsdale,	9.32	16.29	5.57
" "	" " "	Barre,	8.61	16.69	5.27
Cow	Freeman Milling Co.	Hinsdale,	8.72	15.62	5.23
"	" " "	Hudson,	8.19	17.23	5.19
Wheat	Kehlor Bros.	N. Adams,	8.68	15.68	4.28
"	" "	Taunton,	8.32	17.81	4.48
Hiawatha	Wm. Listman Milling Co.,	Springfield,	9.83	16.12	5.09
"	" " " "	NewBedf'd,	5.09	16.44	5.35

*Not included in average.

**Manufacturer's sample.

Brand.	Manufactured by:	Collected at:	Water.	Protein.	Fat.
Best	No'western Cons. Milling Co.,	Warren,	9.31	17.14	5.17
Wheat	Pillsbury, Washburn Co.,	Hinsdale,	8.49	16.29	4.91
"	" " "	Pittsfield,	8.04	16.21	5.20
"	" " "	Franklin,	8.18	16.43	5.21
"	" " "	Gardner,	7.99	16.99	4.74
C.	" " "	Brockton,	8.58	15.98	4.95
Coarse	Washburn, Crosby Co.	N. Adams,	7.57	16.27	4.65
"	" " "	E.Bro'kf'd,	8.15	16.89	5.11
"	" " "	NewBedf'd	8.30	16.65	4.85
"	" " "	Baldwin'le,	8.32	16.81	5.59
Snow's	E. S. Woodworth Co.	Warren,	9.57	17.30	5.26
	Average composition,		**8.41**	**16.60**	**5.04**

The brans run very even in composition, and are evidently free from any adulteration.

Wheat Middlings.

None	Am. Cereal Co.,	North Adams,	9.90	16.43	5.05
Puritan	Brooks, Griffiths Co.,	Haverhill,	9.07	20.99	5.70
Dexter	Chapin & Co.,	Winchendon,	9 89	21.45	4.30
Superior flour	Daisy Roller Mills Co.,	Greenfield,	7.52	19.53	5.20
Choice wheat	J. C. Davis & Co.,	Pittsfield,	8.35	21.87	7.09
White	Freeman Milling Co.,	Holyoke,	9.77	17.79	5.71
"	" " "	Millington,	9.96	18.82	5.36
Silver leaf	Holly Milling Co.,	Westfield,	9.46	17.73	4.77
None	N'weste'n Cons. Mill. Co.	Lawrence,	9.43	19.24	5.64
"A"	" " " "	Middleboro,	9.37	19.48	6.06
"E"	" " " "	Marshfield,	8.86	18.01	5.31
None	Pillsbury, Washburn Co.,	Hinsdale,	8.68	20.40	5.64
"A"	" " "	North Adams,	9.21	21.93	6.31
"	" " "	Pittsfield,	9.38	20.30	5.93
"	" " "	Northampton,	8.43	21.47	7.06
"	" " "	Winchendon,	9.35	21.11	6.24
"B"	" " "	Ware,	11.24	17.03	5.52
"	" " "	Brockton,	8.88	18.22	6.01
Daisy	" " "	Holyoke,	8.90	21.61	5.97
"	" " "	Holden,	10.63	18.67	4.22
"	" " "	Lowell,	8.95	21.61	5.70
"	" " "	Fall River,	8.89	20.99	5.56
"	" " "	Winchendon,	9.61	20.38	4.61
Grand Repub.	Russell & Miller Mill. Co.	Lexington,	9.26	19.30	6.07
Choice	Voigt Milling Co.,	Franklin,	9.16	17.75	4.85
No. 9	Unknown	So. Deerfield,	10.73	16.56	3.69
White	"	Ware,	9 98	17.29	2.57
Spring	"	Upton,	8.72	18.01	5.26
St. Louis	"	Attleboro,	9.23	18.79	4.63

Brand.	Manufactured by:	Collected at:	Water.	Protein.	Fat.
None	Unknown,	Ayer,	7.89	17.88	4.72
"	"	Furnace,	9.92	20.51	4.93
"	"	Orange,	9.23	18.94	4.98
"	"	Lee,	8.38	19.46	5.38
"	"	North Adams,	9.20	16.08	3.29
	Highest,		11.24	21.93	7.09
	Lowest,		7.25	16.08	2.57
	Average,		9.34	19.28	5.27

Red Dog Flour.

Regent	A. E. Eichler & Co.,	Princeton,	9.36	20.01	5.34
Comet	N'western Cons. Milling Co.	Worcester,	8.88	21.18	5.26
None	Unknown,	Southboro,	11.22	16.53	3.69

Wheat middlings with a few exceptions, show a very even composition. They contain a noticeably higher percentage of protein than bran, as well as more digestible matter per ton. This gives them a higher feeding value (see page 23). Middlings having a brand, or at least the manufacturer's name, are to be preferred. Many of those without any marks, show an inferior composition.

Mixed Feeds.

Acme	Acme Milling Co.,	East Brookfield,	9.61	16.21	4.00
Anchor	Anchor Mill Co.,	So. Framingham,	8.65	17.37	5.31
"	" " "	Bridgewater,	8.73	18.08	5.07
"	" " "	Taunton,	8.76	17.12	5.36
"	" " "	Gardner,	9.53	17.14	5.27
None	Blish Milling Co.,	Salem,	8.32	16.86	4.27
Jersey	Brooks, Griffiths Co.,	Newburyport,	8.45	18.13	5.44
Concord	B. W. Brown,	Concord,	8.96	18.08	4.93
Superior	Daisy Roller Mill Co.,	Milford,	8.28	17.28	4.98
"	" " " "	Princeton,	8.53	17.67	5.16
"	" " " "	Taunton,	8.71	17.37	4.59
"	" " " "	Lawrence,	9.05	17.53	5.05
"	" " " "	Orange,	8.35	17.24	5.10
"	" " " "	Fitchburg,	8.71	17.56	4.97
Boston	Duluth Imperial Mill Co.,	Greenfield,	8.94	16·62	4.94
"	" " " "	Concord,	8.62	16.22	4.43
"	" " " "	Newburyport,	8.94	16.89	4.93
"	" " " "	Brockton,	8.46	16.19	4.78
"	" " " "	Leominster,	8.93	16.28	4.48
"	" " " "	Barre,	8.97	17.37	5.00
None	Eldred Mill. Co.,	Danvers,	9.15	15.04	3.96
New England	Freeman Milling Co.,	Hudson,	9.34	16.94	4.81
Columbia	Grafton Roller Mill,	Concord,	8.29	17.68	5.26

Brand.	Manufactured by:	Collected at:	Water.	Protein.	Fat.
Peerless	"R. J. H."	Westfield,	8.00	17.11	5.26
"	" " "	Southboro,	9.02	18.89	5.02
Snowflake	Lawrenceburg R. Mill Co.	Brockton,	8.50	16.89	4.55
"	" "	Danvers,	8.33	17.21	4.47
Snowflake	Lawrenceburg R. M. Co.,	Taunton,	8.05	15.63	4.19
"	" "	Lowell,	9.05	16.55	4.54
Lexington	Lexington R. Mill Co.,	Shelburne Falls,	8.49	14.37	4.59
"	" " "	Westfield,	8.19	13.97	4.04
Fancy	Listman Mill Co.,	Leominster,	7.86	18.51	4.95
"	" " "	Millington,	8.95	18.27	5.05
Hiawatha	Wm. Listman Milling Co.,	Chester,	8.04	17.16	5.29
"	" " " "	Princeton,	8.11	16.77	4.85
"	" " " "	Baldwinsville,	8.88	17.01	5.04
Listmans	" " " "	So. Deerfield,	9.51	17.04	4.91
Northland	" " " "	Gt. Barrington,	8.77	17.60	5.09
"	" " " "	Greenfield,	8.91	16.24	4.70
None	MacKenzie & Winslow,	Fall River,	8.79	19.19	5.09
"	McDaniel & Pittman Co.,	Lexington,	9.01	15.74	4.36
Rex	Rex Mills Co.,	Southbridge,	7.63	18.31	4.48
"	" " "	Fall River,	8.13	18.91	4.97
"	" " "	New Bedford,	8.24	17.36	4.38
"	" " "	Haverhill,	7.09	18.53	5.26
"	" " "	Leominster,	8.14	18.46	4.58
American	J. E. Soper & Co.,	So. Deerfield,	8.65	18.54	5.83
Quincy	Taylor Bros.,	Northboro,	8.64	17.11	3.92
"	" "	Worcester,	7.99	16.39	4.04
"	" "	New Bedford,	8.79	16.56	4.41
"	" "	Fitchburg,	8.15	16.48	4.27
Superior,	Washburn Crosby Co..	Millington,	8.79	17.88	5.30
	Highest,			19.19	5.83
	Lowest,			13.97	3.92
	Average,		8.61	17.16	4.80

Mixed feeds with one exception show no wide variation. That made by the Lexington Roller Mill Co. is certainly below the average of other brands. The feeding value of mixed feed as compared with bran is yet to be determined.

Brewers' Refuse.

Brewers' grains	Unknown,	Princeton,	7.59	29.83	5.48
Malt sprouts	Niagara Falls Brewing Co.	Concord,	11.79	27.57	1.01

Rye Feed.

None	Unknown,	Shelburne Falls,	9.43	14.41	3.38
"	"	Southboro,	8.61	15.56	3.51
"	"	Furnace,	9.03	14.99	3.14

Dairy Feed.

Brand.	Manufactured by:	Collected at.	Water.	Protein.	Fat.
H. O.	H. O. Company, Buffalo,	Holyoke,	6.61	17.88	4.77
"	" " "	Spencer,	6.50	18.21	4.78
"	" " "	Clinton,	6.28	17.94	4.98

This material consists of oat feed as a basis, mixed with feeds rich in protein, such as cotton and gluten meals. It contains about 45 per cent of hulls. Its comparative feeding value will be shown on page 23.

II. Starchy (carbohydrate) Feeds.

Oat Feeds.

Brand.	Manufactured by:	Collected at.	Water.	Protein.	Fat.
Quaker	Am. Cereal Co., Chicago,	Pittsfield,	6.35	11.56	4.09
"	" " " "	Gt. Barrington	6.07	11.70	3.73
"	" " " "	Shelburne Falls,	6.14	12.15	4.16
"	" " " "	Palmer,	7.74	9.45	3.06
"	" " " "	Marlboro,	7.18	9.79	3.57
"	" " " "	Uxbridge.	7.31	9.28	2.71
"	" " " "	Taunton,	6.16	12.42	4.32
"	" " " "	Templeton,	6.53	11.28	4.16
"	" " " "	Fitchburg,	6.23	10.84	3.60
	Average,		**6.63**	**10.94**	**3.71**
None	Unknown,	South Deerfield,	7.20	8.50	3.28
Oatena,	Des Plaines Valley Co.,	Furnace,	7.14	8.66	3.98
C Feed	Am. Cereal Co.	East Brookfield,	8.85	9.94	3.30
Banner	Unknown,	Leominster,	7.74	12.55	2.81
Windsor	"	Chester,	8.37	11.26	4.14
	Average,		**7.86**	**10.18**	**3.50**

Corn and Oat Feed.

Brand.	Manufactured by:	Collected at.	Water.	Protein.	Fat.
Victor	Am. Cereal Co. Chicago,	Milford,	8.91	8.23	3.06
"	" " " "	Lawrence,	8.82	9.16	3.24
"	" " " "	Taunton,	7.66	9.53	3.74
"	" " " "	Gardner,	7.26	9.18	3.45
None	Narragansett Mills, Prov.,	Bridgewater,	10.23	10.31	3.68
	Average,		**8.57**	**9.28**	**3.43**

Corn, Oats and Barley Feeds.

Brand.	Manufactured by:	Collected at.	Water.	Protein.	Fat.
None	Am. Cereal Co., Chicago,	Pittsfield,	8.34	11.38	3.99
"	" " " "	Springfield,	7.00	12.06	4.40
"	" " " "	Worcester,	7.90	11.33	3.96

A great variety of oat refuse is now finding its way into our markets. It has been found to contain from 35 to nearly 60 per cent of hulls. In some cases it is mixed with corn and with barley; it is then quite difficult to ascertain the percentage of hulls the mixture contains. Oat refuse is low in protein, and high in carbohydrates, being of the same nature as corn meal. Material of this kind unquestionably has considerable feeding value. Those articles having a special brand, and containing the manufacturer's name, are to be preferred. In case the farmer is in doubt as to its value he should send a fair sample to us for examination. *Farmers are cautioned against paying excessive prices for material of this kind.* *See its value as compared with corn meal, on page 23.*

Miscellaneous Starchy Feeds.

Brand.	Manufactured by:	Collected at.	Water.	Protein.	Fat.
Banner ground oats	Unknown,	Northboro,	7.35	13.68	3.76
H. O. horse feed	H. O. Company,	Holyoke,	7.96	12.59	3.58
" " "	" "	Clinton,	8.12	12.68	4.13
Germ feed	Pope Glucose Co.,	Newburyport,	7.53	10.09	9.49
Chop feed	Glu. Sugar Refi. Co.,	N. Amherst,	8.41	9.87	5.56
Hominy feed	Cereal Mill Co.,	Salem,	7.03	10.91	7.01
" "	Unknown,	Walpole,	7.29	11.59	4.04
" "	"	Fitchburg,	8.04	10.32	5.78

H. O. horse feed is a mixture of oat feed and corn. Chop or germ feed looks very much like gluten feed, but has considerable less feeding value. Its food value is now being determined.

III. Poultry Feeds.*

American	Am. Cereal Co..	Concord,	9.89	15.12	5.47
H. O.	H. O. Company,	Spencer,	7 57	17.51	5.60
"	" "	Clinton,	7.57	16.67	5.56
"	" "	Danvers,	7.77	16.69	4.82
Animal meal	Bowker Fertilizer Co.,	Gt. Barrington,	5.83	44.83	11.15
" "	Bradley " "	No. Adams.	5.61	39.89	13.72
" "	Darling " Co.,	Southbridge,	2.38	37.69	11.26
Meat scrap	Rogers Mfg. Co.,	Northampton,	7.47	48.16	21.44

The poultry feeds prepared by the American Cereal Co. and the H. O. Company are mixtures of oat feeds, corn, and some nitrogenous feed stuff to increase the percentage of protein to about 17 per cent. Materials of this kind certainly possess considerable feeding value. *It is probable however that the poultryman can secure the nutritive value cheaper, by purchasing the unmixed grains.*

*We have a considerable collection of patent stock and poultry feeds and tonics which will be reported on at a later date.

F. COMPARATIVE COMMERCIAL VALUES OF CONCENTRATED FEEDS.

Starchy (carbohydrate) **feeds,**	**Corn meal,**	**100**
	Hominy meal or chop,	**100**
	Cerealine feed,	**100**
	Chop feed,	**85***
	Quaker oat feed,	**85**
	Oat feeds (excessive hulls),	**75**
	Victor corn and oat feed,	**95**
	H. O. horse feed,	**95**
Protein feeds,	**Wheat bran,**	**85**
	Wheat middlings,	**100—110****
	Mixed feed,	**100***
	Dried brewers' grains,	**100**
	Malt-sprouts,	**100**
	H. O. dairy feed.	**103**
	Buffalo and Golden gluten feeds,	**125**
	Other gluten feeds,	**120**
	Gluten meals,	**152**
	Cleveland flax meal,	**138**
	O. P. linseed meals,	**135**
	Cotton seed meal,	**152**

The above feedstuffs are divided into starchy and protein feeds. The former are purchased primarily to increase the digestible matter in the daily ration, while the latter are bought not alone to give more digestible material but to increase the *protein*, in the ration feed to the animal.

It is not possible in this connection to show the relative effects of the various feed stuffs on the flow of milk or the production of beef. The figures are offered rather as a key to the *comparative commercial values* of the different feeds based on the nutrients contained in them. Thus if corn meal is worth 100, Quaker oat feed would be worth 85; or if wheat bran is worth 85, cottonseed meal would be worth 152. These figures can be easily converted into dollars. Thus if corn meal is worth $16 per ton or 100, Quaker oat feed would be worth 85 per cent of $16 or $13.50, the amount the farmer can afford to pay for the oat feed. Again with cottonseed meal worth $22, what

*Estimated but not actually determined.

**The 110 value refers to fine light-colored middlings with 19 per cent protein.

can the farmer afford to pay for old process linseed meal? Cotton-seed meal equals 152, or $22, and linseed meal 135 or $19.60. We have a case in simple proportion. 152 : 135 : : $22 : x=$19.60, the value of a ton of linseed. It must not be forgotten that these figures do not take into consideration the mechanical condition, or the particularly favorable effect which some feeds are supposed to exert upon the general health of the animal.

G. GRAIN MIXTURES TO BE FED DAILY WITH COARSE FEED.

I.

100 lbs. corn or hominy meal.
100 lbs. bran, mixed, or chop feed.
75 lbs. cotton, gluten or lins'd meal.
Mix and feed 8 to 9 quarts daily.

II.

200 lbs. chop or cerealine feed.
75 lbs. cotton, gluten or linseed meal.
Mix and feed 7 to 8 quarts daily.

III.

100 lbs. oat feed.
100 lbs. Buffalo or Golden glu'n feed.
Mix and feed 8 quarts daily.

IV.

H. O. dairy feed.
Feed 6 to 8 quarts daily.

V.

Gluten feeds.
Feed 5 to 6 quarts daily.

VI.

100 lbs. fine middlings.
100 lbs. brewers' grains or malt sprouts.
Mix and feed 7 to 8 quarts daily.

VII.

50 lbs. linseed meal.
50 lbs. cottonseed meal.
100 lbs. oat feed or chop feed.
Mix and feed 7 to 8 quarts daily.

VIII.

100 lbs. corn meal.
50 lbs. bran.
50 lbs. cottonseed meal.
Mix and feed 7 quarts daily.

SPECIAL NOTICE.

Bulletins containing information concerning Concentrated Feed Stuffs, and analyses of the same, will hereafter be sent only to those especially desiring them. If you wish for these, send your name AT ONCE to the Director, Hatch Experiment Station, Amherst, Mass.

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS

AGRICULTURAL COLLEGE.

BULLETIN NO. 54.

I. ANALYSES OF MANURIAL SUBSTANCES SENT ON FOR EXAMINATION.

II. ANALYSES OF LICENSED FERTILIZERS COLLECTED BY THE AGENT OF THE STATION DURING 1898.

JULY, 1898.

The Bulletins of this Station will be sent free to all newspapers in the State and to such individuals interested in farming as may request the same.

AMHERST, MASS.:
PRESS OF CARPENTER & MOREHOUSE,
1898.

HATCH EXPERIMENT STATION

OF THE

Massachusetts Agricultural College,

AMHERST, MASS.

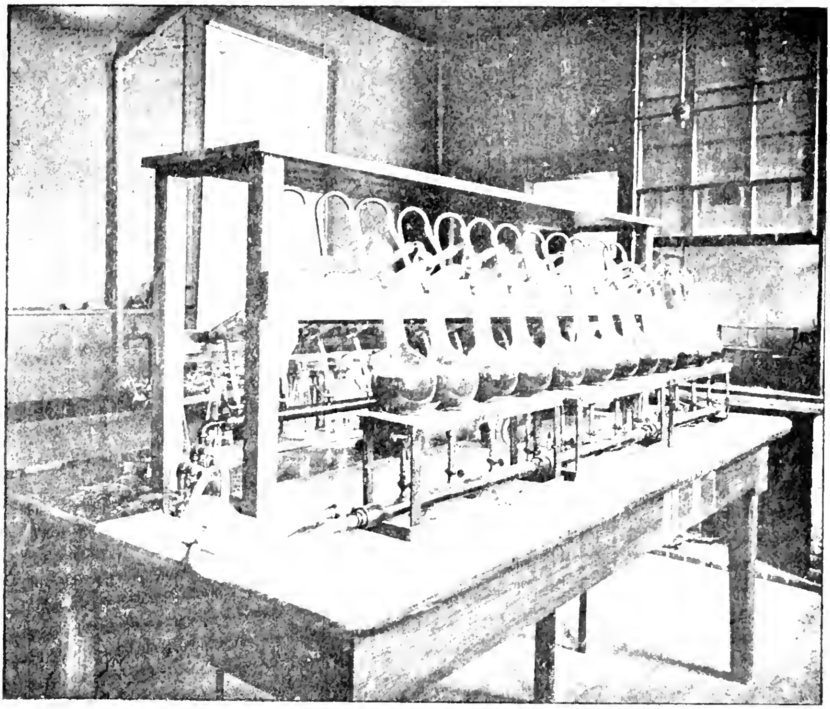
By act of the General Court, the Hatch Experiment Station and the State Experiment Station have been consolidated under the name of the Hatch Experiment Station of the Massachusetts Agricultural College. Several new divisions have been created and the scope of others has been enlarged. To the horticultural, has been added the duty of testing varieties of vegetables and seeds. The chemical has been divided, and a new division, "Foods and Feeding," has been established. The botanical, including plant physiology and disease, has been restored after temporary suspension.

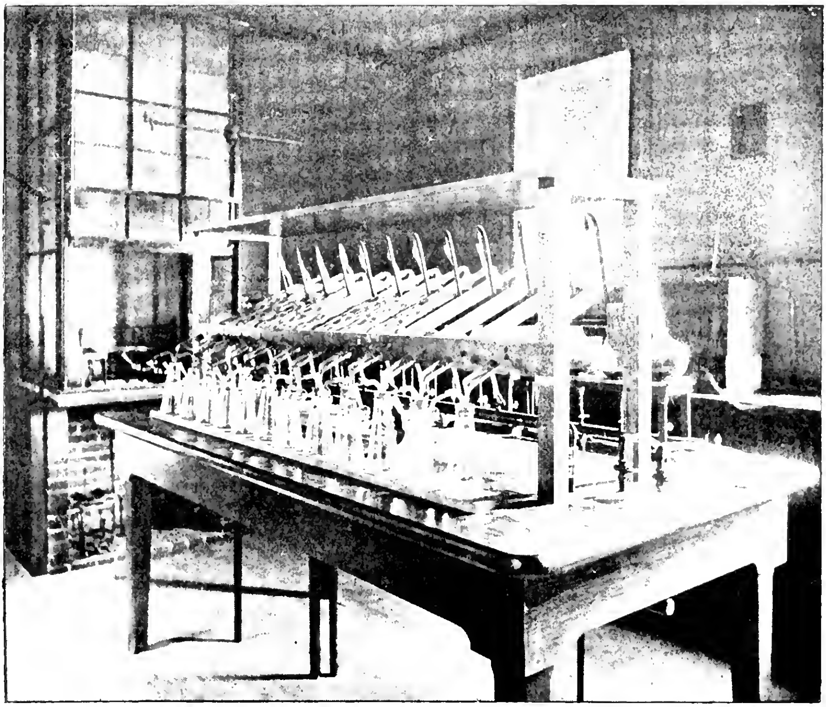
The officers are :—

Henry H. Goodell, LL. D.,	*Director.*
William P. Brooks, Ph. D.,	*Agriculturist.*
George E. Stone, Ph. D.,	*Botanist.*
Charles A. Goessmann, Ph. D., LL. D.,	*Chemist* (Fertilizers).
Joseph B. Lindsey, Ph. D.,	*Chemist* (Foods and Feeding).
Charles H. Fernald, Ph. D.,	*Entomologist.*
Samuel T. Maynard, B. Sc.,	*Horticulturist.*
J. E. Ostrander, C. E.,	*Meteorologist.*
Henry M. Thomson, B. Sc.,	*Assistant Agriculturist.*
Ralph E. Smith, B. Sc.,	*Assistant Botanist.*
Henri D. Haskins, B. Sc.,	*Assistant Chemist* (Fertilizers).
Charles I. Goessmann, B. Sc.,	*Assistant Chemist* (Fertilizers).
Samuel W. Wiley, B. Sc.,	*Assistant Chemist* (Fertilizers).
Edward B. Holland, M. Sc.,	*Ass't Chemist* (Foods and Feeding).
Fred W. Mossman, B. Sc.,	*Ass't Chemist* (Foods and Feeding).
Benjamin K. Jones, B. Sc.,	*Assistant in Foods and Feeding.*
Philip H. Smith, B. Sc.,	*Assistant in Foods and Feeding.*
Robert A. Cooley, B. Sc.,	*Assistant Entomologist.*
George A. Drew, B. Sc.,	*Assistant Horticulturist.*
Herbert D. Hemenway, B. Sc.,	*Assistant Horticulturist.*
Arthur C. Monahan,	*Observer.*

The co-operation and assistance of farmers, fruit-growers, horticulturists, and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the

Hatch Experiment Station, Amherst, Mass.





GLASS APPARATUS USED IN THE DETERMINATION OF NITROGEN ACCORDING TO THE KJELDAHL METHOD.

CONSTRUCTED BY C. I. GOESSMANN AND H. D. HASKINS.

DEPARTMENT OF CHEMISTRY.

C. A. Goessmann.

I.

ANALYSES OF COMMERCIAL FERTILIZERS AND MANURIAL SUBSTANCES SENT ON FOR EXAMINATION.

WOOD ASHES.

495-499. I. Received from Townsend, Mass.
II. Received from Boston, Mass.
III. Received from Boston, Mass.
IV. Received from Concord, Mass.
V. Received from Concord, Mass.

	Per Cent.				
	I.	II.	III.	IV.	V.
Moisture at 100° C.,	0.2	7.27	12.37	11.42	5.17
Potassium oxide,	1.49	6.10	2.98	5.64	6.34
Phosphoric acid,	2.62	1.28	1.28	1.47	1.28
Calcium oxide,	48.81	31.92	27.39	33.16	34.19
Insoluble matter,	7.52	9.54	11.81	4.13	7.35

500-504. I. Received from Concord, Mass.
II. Received from Concord, Mass.
III. Received from Concord, Mass.
IV. Received from Concord, Mass.
V. Received from Concord, Mass.

	Per Cent.				
	I.	II.	III.	IV.	V.
Moisture at 100° C.,	10.52	13.35	13.00	8.06	8.06
Potassium oxide,	4.83	6.14	5.72	7.10	8.86
Phosphoric acid,	1.47	1.15	1.47	.93	1.09
Calcium oxide,	35.04	27.39	35.63	31.68	34.36
Insoluble matter,	9.62	15.07	14.19	18.26	14.12

505-509. I. Received from Concord, Mass.
II. Received from South Acton, Mass.
III. Received from Topsfield, Mass.
IV. Received from South Amherst, Mass.
V. Received from Concord, Mass.

	Per Cent.				
	I.	II.	III.	IV.	V.
Moisture at 100° C.,	10.37	13.60	19.13	7.97	9.06
Potassium oxide,	4.70	4.88	1.12	3.48	8.09
Phosphoric acid,	1.04	.97	.32	2.30	1.62
Calcium oxide,	33.99	30.77	39.72	25.58	33.90
Insoluble matter,	15.30	13.68	6.52	23.07	10.24

510-514. I. Received from South Acton, Mass.
II. Received from South Acton, Mass.
III. Received from Concord, Mass.
IV. Received from Concord, Mass.
V. Received from Wilbraham, Mass.

	Per Cent.				
	I.	II.	III.	IV.	V.
Moisture at 100° C.,	13.23	12.14	11.88	8.10	13.77
Potassium oxide,	5.74	7.20	7.41	5.34	4.18
Phosphoric acid,	1.64	1.47	1.56	1.57	1.54
Calcium oxide,	35.06	36.17	28.84	33.24	30.44
Insoluble matter,	10.57	10.72	10.42	14.21	21.20

515-519. I. Received from Concord, Mass.
II. Received from Shirley, Mass.
III. Received from Concord, Mass.
IV. Received from Sunderland, Mass.
V. Received from South Acton, Mass.

	Per Cent.				
	I.	II.	III.	IV.	V.
Moisture at 100° C.,	9.20	17.47	16.52	9.20	8.62
Potassium oxide,	5.92	5.44	4.42	3.92	5.28
Phosphoric acid,	1.16	1.28	1.28	1.28	.26
Calcium oxide,	34.68	34.42	30.24	31.55	31.55
Insoluble matter,	11.32	4.71	16.49	19.57	20.62

520-524. I. Received from Concord, Mass.
II. Received from Concord, Mass.
III. Received from Concord, Mass.
IV. Received from Concord, Mass.
V. Received from Concord, Mass.

	Per Cent.				
	I.	II.	III.	IV.	V.
Moisture at 100° C.,	6.81	5.95	12.70	11.08	8.72
Potassium oxide,	6.67	5.48	5.77	5.28	5.65
Phosphoric acid,	1.32	1.10	1.09	1.02	1.02
Calcium oxide,	*	*	*	*	*
Insoluble matter,	9.79	10.55	8.52	11.06	13.04

525-529. I. Received from Concord, Mass.
II. Received from East Northfield, Mass.
III. Received from East Leverett, Mass.
IV. Received from North Hatfield, Mass.
V. Received from North Hatfield, Mass.

	Per Cent.				
	I.	II.	III.	IV.	V.
Moisture at 100° C.,	10.75	trace	7.70	2.07	11.77
Potassium oxide,	6.04	3.04	5.64	4.64	4.76
Phosphoric acid,	1.04	1.02	1.28	1.16	.76
Calcium oxide,	*	56.02	36.91	36.90	32.96
Insoluble matter,	11.86	4.13	9.25	14.34	14.24

530-533. I. Received from Bedford, Mass.
II. Received from Sunderland, Mass.
III. Received from Boston, Mass.
IV. Received from East Medway, Mass.

	Per Cent.			
	I.	II.	III.	IV.
Moisture at 100° C.,	16.10	17.67	2.40	13.92
Potassium oxide,	4.28	4.36	4.72	5.92
Phosphoric acid,	1.40	1.28	1.40	1.16
Calcium oxide,	31.50	32.05	38.20	38.40
Insoluble matter,	15.92	12.61	22.59	10.70

* Not determined.

531-537. I. Received from North Hadley, Mass.
II. Received from Sunderland, Mass.
III. Received from Leeds, Mass.
IV. Received from Sunderland, Mass.

	Per Cent. I.	II.	III.	IV.
Moisture at 100° C,	17.46	10.17	13.66	15.80
Potassium oxide,	5.32	5.44	4.93	4.72
Phosphoric acid,	0.46	0.09	trace	0.77
Calcium oxide,	32.58	35.84	36.17	32.25
Insoluble matter,	6.31	10.01	10.47	13.41

538-542. I. Received from Sunderland, Mass.
II. Received from Sunderland, Mass.
III. Received from Sunderland, Mass.
IV. Received from North Amherst, Mass.
V. Received from Amherst, Mass.

	Per Cent. I.	II.	III.	IV.	V.
Moisture at 100° C.,	15.68	20.40	18.74	0.34	18.76
Potassium oxide,	4.70	6.26	5.91	4.97	5.09
Phosphoric acid,	0.82	0.84	0.56	2.41	1.87
Calcium oxide,	32.35	27.81	32.54	24.23	33.57
Insoluble matter,	10.32	10.01	10.99	41.58	14.56

An examination of the results of the above stated forty-eight samples of wood ashes recently sent on for analysis at the station shows the following variations in their composition:

			Number of samples.
Moisture from	1 to 3	per cent.	5
" "	4 to 6	"	2
" "	6 to 10	"	12
" "	10 to 15	"	18
" "	15 to 20	"	11
Potassium oxide above	8	per cent.	2
" "	from 7 to 8	"	1
" "	" 6 to 7	"	6
" "	" 5 to 6	"	16
" "	" 4 to 5	"	18
" "	" 3 to 4	"	4
" "	below 3	"	1
Phosphoric acid above	2	"	3
" "	from 1 to 2	"	34
" "	below 1	"	11

Average of Calcium oxide (lime) amounts to 34.28 per cent., varying from 25.58 to 56.02 per cent. in different samples.

Mineral matter (coal ash, sand,) insoluble in diluted hydrochloric acid :

Below 5	per cent.	2
From 5 to 10	"	7
" 10 to 15	"	19
" 15 to 20	"	8
" 20 to 30	"	4

Samples of wood ashes of late tested at the station are on the whole somewhat inferior, as far as percentage of potash is concerned, to those tested during the preceding year.

LIME KILN ASHES.

543. Received from Greenfield, Mass.

	Per Cent.
Moisture at 100° C.,	25.99
Potassium oxide,	1.45
Phosphoric acid,	0.26
Calcium oxide,	33.99
Insoluble matter,	4.39

ASHES FROM CREMATION OF GARBAGE.

544-546. I. Received from Lowell, Mass.
II. Received from Lowell, Mass.
III. Received from Northboro, Mass.

	Per Cent.		
	I.	II.	III.
Moisture at 100° C.,	.53	1.02	4.48
Potassium oxide,	6.01	5.68	3.72
Phosphoric acid,	10.21	7.16	8.96
Calcium oxide,	20.22	*	*
Magnesium oxide,	1.16	*	*
Ferric and Aluminum oxide,	9.22	*	*
Sodium oxide,	15.65	*	*
Sulphuric acid,	4.57	*	*
Chlorine,	4.75	*	*
Carbonic acid,	10.85	*	*
Insoluble matter,	24.26	32.56	*

* Not determined.

PHOSPHATIC SLAG.

547. Received from Waltham, Mass.

	Per Cent.
Moisture at 100° C.,	1.67
Potassium oxide,	*
Phosphoric acid (total),	15.70
Calcium oxide,	39.24
Insoluble matter,	9.91

Material was represented as imported from England.

BLEACHERY REFUSE.

548-549. I. Received from Bondsville, Mass.
II. Received from Bondsville, Mass.

	Per Cent. I.	Per Cent. II.
Moisture at 100° C.,	5.90	2.49
Potassium oxide,	1.24	0.35
Phosphoric acid,	trace	trace
Calcium oxide,	40.70	30.89
Sodium oxide,	12.65	10.74
Insoluble matter,	15.87	30.31

MEAT MEAL, AND BLOOD AND BONE.

550-551. I. Received from Boston, Mass.
II. Received from Concord, Mass.

	Per Cent. I.	Per Cent. II.
Moisture at 100° C.,	3.22	4.25
Ash,	8.55	*
Nitrogen,	9.23	5.72
Phosphoric acid,	3.08	14.08

TANKAGE AND GROUND BONE.

552-555. I. Received from Concord, Mass.
II. Received from Northborough, Mass.
III. Received from South Deerfield, Mass.
IV. Received from Boston, Mass.

* Not determined.

	Per Cent. I.	II.	III.	IV.
Moisture at 100° C.,	6.62	2.77	13.75	5.60
Nitrogen,	8.12	2.07	2.58	3.89
Phosphoric acid (total),	13.86	30.19	26.30	25.46
Phosphoric acid (reverted),	*	7.67	6.72	*
Phosphoric acid (insoluble)	*	22.52	19.58	*

COTTON-SEED MEAL.

556-557. I. Received from Hatfield, Mass.
II. Received from Hatfield, Mass.

	Per Cent. I.	II.
Moisture at 100° C.,	6.87	7.92
Nitrogen,	7.57	7.08

TOBACCO REFUSE.

558. Received from Boston, Mass.

	Per Cent.
Moisture at 100° C.,	12.35
Nitrogen,	1.13
Potassium oxide,	5.19
Phosphoric acid,	.56

WOOL WASTE (Sweepings).

559. Received from Shirley Center, Mass.

	Per Cent.
Moisture at 100° C.,	7.30
Nitrogen,	3.94
Potassium oxide,	0.29
Phosphoric acid,	trace

TEOPIK FIBRE.

560. Received from Amherst, Mass.,

	Per Cent.
Moisture at 100° C.,	56.54
Nitrogen,	.53
Potassium oxide,	1.26
Phosphoric acid,	.55
Calcium oxide,	5.15
Insoluble matter,	.75

* Not determined.

ANALYSIS OF FEED STUFFS FOR FERTILIZING CONSTITUENTS.

561-562. I. Mixed feed from Boston, Mass.
II. Broom Corn Seed from Hadley, Mass.

	Per Cent. I.	Per Cent. II.
Moisture at 100° C.,	12.23	7.40
Nitrogen,	2.09	1.51
Potassium oxide,	.58	.50
Phosphoric acid,	2.35	.57
Calcium oxide,	1.85	*

ACID PHOSPHATES.

563-565. I. Received from Amesbury, Mass.
II.—III. Received from Amherst, Mass.

	Per Cent. I.	II.	III.
Moisture at 100° C.,	7.52	14.67	15.10
Phosphoric acid (total),	16.38	16.50	15.10
Phosphoric acid (soluble),	1.92	13.56	12.92
Phosphoric acid (reverted),	7.30	2.68	1.92
Phosphoric acid (insoluble),	7.16	.26	0.26

NITRATE OF SODA.

566-568. I. Received from Amherst, Mass.
II. Received from Concord, Mass.
III. Received from Concord, Mass.

	Per Cent. I.	II.	III.
Moisture at 100° C.,	.50	2.10	4.50
Nitrogen,	15.78	15.25	14.56

GERMAN POTASH SALTS.

569-572. I. Muriate of Potash received from Amherst, Mass.
II. Muriate of Potash received from Concord, Mass.
III. Muriate of Potash received from Concord, Mass.
IV. Sulphate of Potash—Magnesia, received from Amherst, Mass.

	Per Cent. I.	II.	III.	IV.
Moisture at 100° C.,	0.85	0.37	0.25	4.91
Potassium oxide,	49.76	50.24	50.80	25.72

* Not determined.

COMPLETE MANURES.

573-577. I. Received from Sunderland, Mass.
II. Received from West Boxford, Mass.
III. Received from East Longmeadow, Mass.
IV. Received from South Amherst, Mass.
V. Received from West Milbury, Mass.

	Per Cent.				
	I.	II.	III.	IV.	V.
Moisture at 100° C.,	13.98	4.90	10.67	8.22	7.00
Nitrogen,	1.58	2.97	2.95	3.57	1.47
Potassium oxide,	3.98	13.13	1.17	7.64	.02
Phosphoric acid (total),	9.21	10.49	8.19	12.02	.13
Phosphoric acid (soluble),	2.88	2.05	0.05	5.88	*
Phosphoric acid (reverted),	4.29	6.46	5.65	2.94	*
Phosphoric acid (insoluble),	1.41	1.98	2.49	3.20	*

578-581. VI. Received from Sunderland, Mass.
VII. Received from Canton, Mass.
VIII. Received from Canton, Mass.
IX. Received from South Sudbury, Mass.

	Per Cent.			
	VI.	VII.	VIII.	IX.
Moisture at 100° C.,	14.18	13.07	10.99	8.89
Nitrogen,	3.17	2.92	4.59	3.56
Potassium oxide,	5.85	6.20	8.78	5.62
Phosphoric acid (total),	10.03	10.92	10.70	11.20
Phosphoric acid (soluble),	4.09	1.36	*	5.30
Phosphoric acid (reverted),	3.79	8.74	9.22	3.34
Phosphoric acid (insoluble),	2.15	.82	1.48	2.56

* Not determined.

II. ANALYSES OF COMMERCIAL FERTILIZERS COLLECTED DURING 1898, IN THE GENERAL MARKETS BY THE AGENT OF THE HATCH EXPERIMENT STATION OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

Laboratory No.	Name of Brand.	Name of Manufacturer.	Sampled at
	Compound Fertilizers.		
1**	Extra Fine Ground Bone with Potash, "Circle Brand,"	Bradley Fertilizer Co., Boston, Mass.,	Middleboro.
2**	Corn Fertilizer,	Bradley Fertilizer Co., Boston, Mass.,	Holyoke.
6	Tobacco Fertilizer,	W. H. Abbott, Holyoke, Mass.,	Sunderland.
7	Complete Tobacco Manure,	H. J. Baker & Bro., New York City.,	Sunderland.
9	Special Potato Manure,	Lister's Agricultural Chemical Works, Newark, N. J.,	Sunderland.
16	Gold Brand Excelsior Guano,	E. Frank Coe Co., New York City,	Sunderland.
20	Darling & Hubbard Mixture,	Bowker Fertilizer Co., Boston, Mass.,	Sunderland.
26	Potato, Hop and Tobacco Phosphate,	M. E. Wheeler & Co., Rutland, Vt.,	Sunderland.
38	Meat and Bone,	Thomas Hersom & Co., New Bedford, Mass.,	Amherst.
42	Top Dressing,	Bowker Fertilizer Co., Boston, Mass.,	Marlboro.
46	Potato Phosphate,	Lowell Fertilizer Co., Boston, Mass.,	Hudson.
62	Great Planet Manure,	Clark's Cove Fertilizer Co., Boston, Mass.,	Hudson.
69	Animal Fertilizer,	C. A. Bartlett, Worcester, Mass.,	Boston.
106	Lawn and Garden Dressing,	Bowker Fertilizer Co., Boston, Mass.,	Lowell.
113	Blood, Bone and Potash,	Armour Fertilizer Works, Chicago, Ill.,	Salem.
155	Columbian Phosphate,	Berkshire Mills Co., Bridgeport, Conn.,	Easthampton.
166	Lawn and Garden Dressing.	Bowker Fertilizer Co., Boston, Mass.,	Taunton.
199	Columbian Phosphate,	Berkshire Mills Co., Bridgeport, Conn.,	Dighton.
219	Blood, Bone and Potash,	Armour Fertilizer Works, Chicago, Ill.,	Springfield.
279	Special Potato Manure,	Lister's Agricultural Chemical Works, Newark, N. J.,	Amherst.
285	Gold Brand Excelsior Guano,	E. Frank Coe Co., New York City,	Amherst.
292	Tobacco Fertilizer,	W. H. Abbott, Holyoke, Mass.,	Amherst.
299	Blood, Bone and Potash,	Armour Fertilizer Works, Chicago, Ill.,	Amherst.
321	Great Planet Manure,	Clark's Cove Fertilizer Co., Boston, Mass.,	N. Amherst.

Laboratory Number.	Name of Brand.	Moisture.	Nitrogen in 100 lbs. Found.	Nitrogen in 100 lbs. Guaranteed.	Phosphoric Acid in 100 lbs. Soluble.	Reverted.	Insoluble.	Total. Found.	Total. Guaranteed.	Available. Found.	Available. Guaranteed.	Potassium Oxide in 100 lbs. Found.	Potassium Oxide in 100 lbs. Guaranteed.
	Compound Fertilizers.												
1**	Extra Fine Bone with Potash "Circle Brand"	6.45	1.86	1.85-2.67	2.18	4.16	6.52	12.86	10-13	6.34	6-8	2.24	2-3
2	Corn Fertilizer, ...	10.00	2.40	2.06-2.88	6.26	3.40	2.44	12.10	10-14	9.66	9-12	1.59	1.50-2.50
6-292	Tobacco Fertilizer, ...	3.97	5.02	4.5-5.5	—	3.82	10.50	14.32	15-16	3.82	9-10	10.26	10-11*
7	Complete Tobacco Manure, ...	7.40	4.85	4.53	4.30	.88	.12	5.30	—	5.18	4.00	10.60	10*
9-279	Special Potato Fertilizer, ...	11.35	1.77	1.65-2.47	5.24	3.54	2.22	11.00	9-11	8.78	8-10	2.96	3-4
16-285	Gold Brand Excelsior Guano, ...	7.82	2.71	2.5-3	6.52	1.60	2.76	10.88	9-11	8.12	8-11	5.78	6-8*
20	Darling & Hubbard Mixture, ...	8.42	3.74	4	4.10	1.46	1.74	7.30	7.40	5.16	5.40	8.32	8.
26	Potato, Hop and Tobacco Phosphate, ...	7.97	1.99	2-3	5.76	2.68	2.94	11.38	11-14	8.44	10-12	4.40	3.25-4.30
38	Meat and Bone, ...	9.60	4.98	4-5	—	4.98	11.90	16.88	16-16.5	4.98	—	—	—
42	Top Dressing, ...	10.05	4.97	4.75-5.75	4.34	2.26	1.98	8.58	6-9	6.60	4-6	6.38	6-7
46	Potato Phosphate, ...	7.45	2.36	2.47-3.30	5.70	2.48	2.18	10.36	9-12	8.18	8-10	7.22	6-7
62-321	Great Planet Manure, ...	5.30	3.58	3.30-4.12	3.96	3.84	2.18	9.98	9-13	7.80	8-11.5	7.00	7-8
69	Animal Fertilizer, ...	3.62	5.95	3.30-4.12	.90	4.48	5.24	10.62	14-17	5.38	—	7.92	7-8
106-166	Lawn and Garden Dressing, ...	8.60	3.97	3-4	3.46	2.16	4.74	10.36	8-10	5.62	6-8	5.08	5-6
113-219-299	Blood, Bone and Potash, ...	10.77	4.38	4.11-4.95	5.12	3.06	1.80	9.98	10-12	8.18	8-10	6.90	7-8
155-199	Columbian Phosphate, ...	6.50	1.34	.82-1.65	2.44	5.62	6.02	14.08	10-12	8.06	8-10	1.08	1-2

*Sulphate of potash the source of potash.

**These analyses are reprinted in corrected form from Bulletin 51. Laboratory Numbers 221 and 98.

II. ANALYSES OF COMMERCIAL FERTILIZERS COLLECTED DURING 1898, IN THE GENERAL MARKETS BY THE AGENT OF THE HATCH EXPERIMENT STATION OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

Laboratory No.	Name of Brand.	Name of Manufacturer.	Sampled at
	Compound Fertilizers.		
10	High Grade Special for Cabbage, Potatoes, &c.,	Williams & Clark Fertilizer Co., Boston, Mass.,	Sunderland.
36	Market Garden Fertilizer,	National Fertilizer Co., Bridgeport, Conn.,	Sunderland.
52	Animal Brand For General Use,	Lowell Fertilizer Co., Boston, Mass.,	Hudson.
55	Corn Phosphate,	Bradley Fertilizer Co., Boston, Mass.,	Hudson.
63	Bay State Fertilizer,	Clark's Cove Fertilizer Co., Boston, Mass.,	Hudson.
76	General Crop Phosphate,	Crocker Fertilizer and Chemical Co., Buffalo, N. Y.,	Lowell.
78	Corn Phosphate,	Bradley Fertilizer Co., Boston, Mass.,	Lowell.
83	Potato Manure,	Mapes Formula & Peruvian Guano Co., New York City,	Fitchburg.
140	High Grade Complete Manure,	Cleveland Dryer Co., Boston, Mass.	Dighton.
141	Market Garden Fertilizer,	National Fertilizer Co., Bridgeport, Conn.,	Dighton.
180	Animal Brand for General Use,	Lowell Fertilizer Co., Lowell, Mass.,	Easthampton.
183	Potato Manure,	Mapes Formula & Peruvian Guano Co., New York City,	Northampton.
189	Market Garden Fertilizer,	Quinnipiac Co., Boston, Mass.,	Fall River.
191	Ammoniated Superphosphate,	H. J. Baker & Bro., New York City,	Fall River.
192	Fish and Potash,	Wm. J. Brightman, Tiverton, R. I.,	Fall River.
210	Potato Manure,	Mapes Formula & Peruvian Guano Co., New York City,	Taunton.
213	Ammoniated Superphosphate,	H. J. Baker & Bro., New York City,	No. Hadley.
230	Ammoniated Superphosphate,	H. J. Baker & Bro., New York City,	Worcester.
250	Bay State Fertilizer,	Clark's Cove Fertilizer Co., Boston, Mass.,	Springfield.
253	Corn Phosphate,	Bradley Fertilizer Co., Boston, Mass.,	Holyoke.
262	Market Garden Fertilizer,	Quinnipiac Co., Boston, Mass.,	Westfield.
271	Market Garden Fertilizer,	Quinnipiac Co., Boston, Mass.,	Pittsfield.
325	Market Garden Fertilizer,	Quinnipiac Co., Boston, Mass.,	So. Amherst.

Laboratory Number.	Name of Brand.	Moisture.	Nitrogen in 100 lbs.		Phosphoric Acid in 100 lbs.							Potassium Oxide in 100 lbs.	
								Total.		Available.			
			Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaran teed.	Found.	Guaran teed.	Found.	Guaran teed.
	Compound Fertilizers.												
10	High Grade Special,	12.46	3.25	3.30-4.13	3.46	3.90	1.98	9.34	9-13	7.36	8-11	7.07	7-8
36-141	Market Garden Fertilizer,	10.23	2 49	2.5-3.00	3.20	4.10	1.92	9.22	9-11	7.30	7-9	6.22	6-8
52 180	Animal Brand for General Use,	9.72	2.73	2.46-3.25	6.22	2 86	1.92	11.00	10-12	9.08	9-12	4.54	4-5
55-78-253	Corn Phosphate,	11.42	2.18	2.06-2.39	6.26	2.96	2.68	11.90	10-14	9.22	9-12	1.46	1.5-2.5
63-250	Bay State Fertilizer,	1.32	3.16	2.47-3.30	5.76	4.98	2.56	13.30	10-14	10.74	9 12	2.13	2-3
76	General Crop Phosphate,	8.20	1.19	.82-1.64	4.10	3.32	1.66	9.08	8-12	7.42	7-10	1.31	1.08-2 50
83-183-210	Potato Manure,	12.22	3.76	3.71-4.12	3.20	3.32	3.84	10.36	8-10	6.52	8.	6.66	6-8
140	High Grade Complete Manure,	11.00	3.63	3.30-4.12	2.94	6.14	2.18	11.26	9-13	9.08	8-11	7 50	7-8
189-262-271-325	Market Garden Fertilizer,	11.05	3.44	3.30 4.12	3.70	4.90	2.48	11.08	9-13	8.60	8-11	7.34	7-9
191-213-230	Ammoniated Superphosphate,	11.00	2.80	2.47-3.29	8.06	1.78	1.16	11.00	11-13	9.81	8-10	3.98	2-3
192	Fish and Potash.	15.80	2.44	2.5-3.5	1.72	3.40	4.10	9.22	7.5-10.5	5.12	6-8	2.26	2-3

II. ANALYSES OF COMMERCIAL FERTILIZERS COLLECTED DURING 1898, IN THE GENERAL MARKETS BY THE AGENT OF THE HATCH EXPERIMENT STATION OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

Laboratory No.	Name of Brand.	Name of Manufacturer.	Sampled at
	Compound Fertilizers.		
14	Blood, Bone and Meat,	Lucien Sanderson, New Haven, Conn.,	Sunderland.
17	Standard Superphosphate,	Read Fertilizer Co., New York City,	So. Deerfield.
21	Onion Manure,	Williams & Clark Fertilizer Co., Boston, Mass.,	Sunderland.
23	Vegetable and Vine Fertilizer,	Read Fertilizer Co., New York City,	So. Deerfield.
74	Potato, Root and Vegetable Manure,	Russia Cement Co., Gloucester, Mass.,	Beverly.
138	Corn, Grain and Grass Fertilizer,	Russia Cement Co., Gloucester, Mass.,	Taunton.
147	Potato, Root and Vegetable Manure,	Russia Cement Co., Gloucester, Mass.,	Taunton.
158	Dry Ground Fish,	Williams & Clark Fertilizer Co., Boston, Mass.,	Northampton.
160	Corn Fertilizer,	M. E. Wheeler & Co., Rutland, Vt.,	Easthampton.
187	Quinnipiac Phosphate,	Quinnipiac Co., Boston, Mass.,	Fall River.
190	Potato, Onion and Tobacco Manure,	Wilcox Fertilizer Works, Mystic, Conn.,	Fall River.
201	Ammoniated Bone Superphosphate,	E. Frank Coe Co., New York City,	Taunton.
204	Dry Ground Fish,	Williams & Clark Fertilizer Co., Boston, Mass.,	North Hadley.
244	Corn, Grain and Grass Fertilizer,	Russia Cement Co., Gloucester, Mass.,	Worcester.
258	Ammoniated Bone Superphosphate,	E. Frank Coe Co., New York City,	Westfield.
264	Corn, Grain and Grass Fertilizer,	Russia Cement Co , Gloucester, Mass.,	Pittsfield.
272	Potato, Root and Vegetable Manure,	Russia Cement Co., Gloucester, Mass.,	Pittsfield.
273	Quinnipiac Phosphate,	Quinnipiac Co., Boston, Mass.,	Pittsfield.
294	Ammoniated Bone Superphosphate,	E. Frank Coe Co., New York City,	Amherst.
317	Special Formula "A,"	L. B. Darling Fertilizer Co., Pawtucket, R. I.,	So. Amherst.
324	Potato, Onion and Tobacco Manure,	Wilcox Fertilizer Works, Mystic, Conn.,	Amherst.

Laboratory Number.	Name of Brand.	Moisture.	Nitrogen in 100 lbs.		Phosphoric Acid in 100 lbs.							Potassium Oxide in 100 lbs.	
								Total.		Available.			
			Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
	Compound Fertilizer.												
14	Blood, Bone and Meat,	5.50	5.99	5.77-7.41	—	2.94	9.46	12.40	10-12	2.94	—	—	—
17	Standard Superphosphate,	12.72	1.10	.83-1.00	5.38	3.20	1.40	9.98	9-11	8.58	8-10	4.19	4-6
21	Onion Manure,	12.11	3 25	3.30-4.12	3.70	4.48	2.32	10.50	9-13	8.18	8-11	7.25	7-8
23	Vegetable and Vine Fertilizer,	12.46	2.00	1.65-2.00	4.82	1.56	1.80	8.18	7-9	6.38	6-8	8.11	8-10
74-147-272	Potato, Root and Vegetable Manure,	7.04	4.49	3.7-4.5	4.42	3.82	3.28	11.52	9-11	8.24	7 8	8.48	8.5-10
138-244-264	Corn, Grain and Grass Fertilizer,	9.73	5.35	3.7-4.5	4.22	3.08	3.58	10.88	9.5-11	7 30	7-8	8.86	9.5-11
158-204	Dry Ground Fish,	9.83	8.50	7.41-9.06	—	2.94	4.10	7.04	7-9	2.94	—	—	—
160	Corn Fertilizer,	13.44	1.69	1.65-2.47	6.14	1.64	2.58	10.36	9-14	7.78	8-12	2.38	2-3
187-273	Quinnipiac Phosphate,	16.69	2.38	2.47-3.30	5.88	3.76	2.44	12.08	10-14	9 64	9-12	2.12	2-3
190-324	Potato, Onion and Tobacco Manure,	13.23	3.92	3.30-4.30	3.58	4.44	2.48	10.50	8-10	8.02	7-9	7.46	6-7
201-258-294	Ammoniated Bone Superphosphate,	9.26	2.34	2-2.5	7.04	2.56	2.30	11.90	11-13	9.60	9-12	1.84	1.84-2.50
317	Special Formula "A,"	12.06	3.11	3.30	4.60	2.82	2.04	9.46	10	7.42	7	7.14	7

II. ANALYSES OF COMMERCIAL FERTILIZERS COLLECTED DURING 1898, IN THE GENERAL MARKETS BY THE AGENT OF THE HATCH EXPERIMENT STATION OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

Laboratory No.	Name of Brand.	Name of Manufacturer.	Sampled at
	Compound Fertilizers.		
15	Lister's Celebrated Onion Fertilizer,	Lister's Agricultural Chemical Works, Newark, N. J.,	Sunderland.
59	Bone Fertilizer for Corn and Grain,	Lowell Fertilizer Co., Boston, Mass.,	Hudson.
84	Corn Manure,	Mapes Formula & Peruvian Guano Co., New York City,	Fitchburg.
164	Bone Fertilizer for Corn and Grain,	Lowell Fertilizer Co., Boston, Mass.,	Easthampton.
181	Corn Manure,	Mapes Formula & Peruvian Guano Co., New York City,	Northampton.
218	Potato Manure,	Crocker Fertilizer and Chemical Co., Buffalo, N. Y.,	Springfield.
222	Fish and Potash,	Clark's Cove Fertilizer Co., Boston, Mass.,	Springfield.
242	Vegetable Bone,	Crocker Fertilizer and Chemical Co., Buffalo, N. Y.,	Springfield.
257	Fish and Potash,	E. Frank Coe Co., New York City,	Westfield.
278	Fish and Potash,	E. Frank Coe Co., New York City,	Amherst.
286	Lister's Celebrated Onion Fertilizer,	Lister's Agricultural Chemical Works, Newark, N. J.,	Amherst.
318	Special Formula "C,"	L. B. Darling Fertilizer Co., Pawtucket, R. I.,	So. Amherst.
320	Special Formula "B,"	L. B. Darling Fertilizer Co., Pawtucket, R. I.,	So. Amherst.
330	Fish and Potash,	Clark's Cove Fertilizer Co., Boston, Mass.,	N. Amherst.
77	Special Potato Fertilizer,	Parmenter & Polsey Fertilizer Co., Peabody, Mass.,	Beverly.
89	Economical Potato Manure,	Mapes Formula & Peruvian Guano Co., New York, N.Y.	Fitchburg.
108	Prolific Crop Producer,	Williams & Clark Fertilizer Co., Boston, Mass.	Lowell.
114	Breck's Lawn and Garden Dressing,	Bradley Fertilizer Co., Boston, Mass.,	Boston.
128	Economical Potato Manure,	Mapes Formula & Peruvian Guano Co., New York, N.Y.	Taunton.
150	High Grade Special Potato Fertilizer,	E. Frank Coe Co., New York City,	Taunton.
163	Potato Manure,	M. E. Wheeler & Co., Rutland, Vt.,	Easthampton.
171	Economical Potato Manure,	Mapes Formula & Peruvian Guano Co., New York.	Northampton.
284	High Grade Potato Fertilizer,	E. Frank Coe Co., New York City,	New York City

Laboratory Number.	Name of Brand.	Moisture.	Nitrogen in 100 lbs.		Phosphoric Acid in 100 lbs.							Potassium Oxide in 100 lbs.	
								Total.		Available.			
			Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
	Compound Fertilizers.												
15-286	Lister's Celebrated Onion Fertilizer,	8 51	5.68	3 20-4.15	6.55	2.58	—	9.13	8.5-10	9 13	7.5-9	6.14	7-8
59-164	Bone Fertilizer for Corn and Grain,	10 51	1.86	1.65-2.5	4.22	4.92	1.15	10.29	9-12	9.14	8-10	2.34	3-4
84-181	Corn Manure,	10 61	2.91	2 47-2.88	3 07	8.44	.26	11.77	10 12	11.51	8-10	6.20	6-7
218	Potato Manure,	9 09	3.80	3.71-4.53	6.93	.08	2.05	9.06	9-12	7.01	8-10	5.90	5.4-6.4
222-230	Fish and Potash,	14.44	2.49	2.-2.80	1.20	3.81	3.20	8 21	7-10	5.04	6-8	2.12	2-3
242	Vegetable Bone,	6 87	4.78	5-6	5.17	2.41	.20	7 78	11 5 14.5	7.58	10 5-12 5	7.22	5.98-8.
257-278	Fish and Potash,	8 93	2.10	2 3	4 73	3 56	2.12	10 41	7-9	8.29	6-8	2.80	2-3
318	Special Formula "C,"	6 99	3.61	3.30-4.12	2.25	4.84	3.71	10.80	9-11	7.09	5 5-7	11.18	10-11
320	Special Formula "B,"	6.68	3.93	3.30	1 89	6.09	3.71	11.69	10.	7.98	7	7.27	7
77	Special Potato Fertilizer,	22.45	3 22	3.29-4 12	4.71	4.49	1 54	10.74	9-13	9.20	8-11	8 26	7-9
89-128-171	Economical Potato Manure,	8.41	3.49	3.29 4.12	1.79	2.25	2.18	6 22	6-8	4.04	4-5	8.67	8-9
108	Prolific Crop Producer,	14 59	1.09	.82-1.65	3.17	5.03	2.01	10.24	7-11	8.20	6 9	1.11	1-2
114	Breck's Lawn and Garden Dressing,	7 81	4.90	4.12-4.94	1 56	4.28	.56	6 10	—	5.84	5 6	5.91	5-6
150-284	High Grade Special Potato Fertilizer,	7.38	3.38	2.4-3	5 83	1.97	1.46	9 26	9-11	7.80	7-10	7 34	6-8
163	Potato Manure,	14.49	2.18	2.06-2.88	6.01	2.81	1.28	10 10	10-15	8 82	9-15	3.95	3.85-4

II. ANALYSES OF COMMERCIAL FERTILIZERS COLLECTED DURING 1898, IN THE GENERAL MARKETS BY THE AGENT OF THE HATCH EXPERIMENT STATION OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

Laboratory No.	Name of Brand.	Name of Manufacturer.	Sampled at
	Compound Fertilizers.		
34	Complete Potato and Onion Manure,	National Fertilizer Co., Bridgeport, Conn.,	Sunderland.
44	Gardener's Complete Manure,	Packers' Union Fertilizer Co., New York City,	Northboro.
49	High Grade Potato Manure,	Packers' Union Fertilizer Co., New York City,	Northboro.
68	Acid Phosphate,	Read Fertilizer Co., New York City,	Amesbury.
119	Plymouth Rock Brand,	Parmenter & Polsey Fertilizer Co., Peabody, Mass.,	Beverly.
130	Ammoniated Bone Phosphate,	National Fertilizer Co., Bridgeport, Conn.,	Dighton.
148	Plymouth Rock Brand,	Parmenter & Polsey Fertilizer Co., Peabody, Mass.,	Dighton.
156	Gardener's Complete Manure,	Packers' Union Fertilizer Co , New York City,	Easthampton.
157	High Grade Potato Manure,	Packers' Union Fertilizer Co., New York City,	Easthampton.
197	Potato Manure,	Quinnipiac Co., Boston, Mass.,	Fall River.
203	Standard Complete Manure,	Standard Fertilizer Co., Boston, Mass.,	Rehoboth.
231	Complete Manure for Top Dressing,	Prentiss, Brooks & Co., Holyoke, Mass.,	Holyoke.
239	Hubbard's Potato Phosphate,	Rogers & Hubbard Co., Middletown, Conn.,	Holyoke.
243	Superphosphate,	Prentiss, Brooks & Co., Holyoke, Mass.,	Holyoke.
259	Potato Manure,	Quinnipiac Co., Boston, Mass.,	Westfield.
266	Potato Manure,	Quinnipiac Co., Boston, Mass.,	Pittsfield.
270	Soluble Guano,	Pacific Guano Co., Boston, Mass.,	Pittsfield.
276	Market Garden Fertilizer,	Benjamin Randall, Boston, Mass.,	Amherst.
329	Special Potato Manure,	Pacific Guano Co., Boston, Mass.,	So. Amherst.

Laboratory Number.	Name of Brand.	Moisture.	Nitrogen in 100 lbs.		Phosphoric Acid in 100 lbs.							Potassium Oxide in 100 lbs.	
								Total.		Available.			
			Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
	Compound Fertilizers.												
34	Complete Potato and Onion Manure,	10.60	3.40	3.3-4.1	2.81	7.56	.84	11.21	10-12	10.37	8-10	6.60	6-8
44-156	Gardener's Complete Manure,	7.72	2.06	2.47-3.30	5.96	2.52	.58	9.06	10-15	8.48	8-12	12.86	10-12
49-157	High Grade Potato Manure,	12.43	2.15	2.06-2.88	5.76	3.76	1.36	10.88	9-14	9.52	8-12	6.10	6-8
68	Acid Phosphate,	13.42	—	—	11.82	2.36	1.68	15.86	—	14.18	—	—	—
119-148	Plymouth Rock Brand,	8.81	2.88	2.47-3.29	3.84	3.56	2.12	9.52	9-13	5.68	8-11	4.02	4-4.25
130	Ammoniated Bone Phosphate,	14.62	1.91	1.85-2.00	1.54	8.28	1.48	11.30	9-11	9.82	7-9	2.10	2-3
197-259-266	Potato Manure,	13.31	2.59	2.47-3.29	4.04	2.92	2.64	9.60	7-11	6.96	6-9	4.92	5-6
203	Standard Complete Manure,	12.07	3.37	3.30-4.12	2.68	6.28	2.94	11.90	9-13	8.96	8-11	7.07	7-8
231	Complete Manure for Top Dressing,	7.05	4.24	4.12-4.94	2.84	2.04	4.40	9.28	7-9	4.88	5-6	8.46	7-9
239	Hubbard's Potato Phosphate,	12.81	1.54	2.-2.5	8.72	1.84	2.48	13.04	10-12	10.56	9-10	5.33	5-6
243	Superphosphate,	10.56	1.98	2.06-2.47	5.12	4.22	6.52	15.86	10-12	9.34	8-10	2.42	2-3
270	Soluble Guano,	15.05	2.17	2.25-3.00	5.06	4.36	2.18	11.60	10.5-16	9.42	8.5-12	1.90	2-3.5
276	Market Garden Fertilizer,	19.88	6.02	3.25-4.00	2.56	4.90	1.36	8.82	11.45-13.74	7.46	8-10	5.68	4-5
329	Special Potato Manure,	11.47	2.68	2.47-3.30	3.24	3.28	3.08	9.60	7-10	6.52	5-7	4.60	5-6

II. ANALYSES OF COMMERCIAL FERTILIZERS COLLECTED DURING 1898, IN THE GENERAL MARKETS BY THE AGENT OF THE HATCH EXPERIMENT STATION OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

Laboratory No.	Nane of Brand.	Name of Manufacturer.	Sampled at
	Compound Fertilizers.		
167	Amimal Corn Fertilizer,	Packer's Union Fertihzer Co., New York.,	Easthampton.
177	Potato Phosphate,	Williams & Clark Fertilizer Co., Boston, Mass.,	Northampton.
188	Brightman's Superphosphate,	W. J. Brightman, Fall River, Mass.,	Fall River.
286	Special Tobacco Fertilizer,	Lister's Agricultural Chemical Works, Newark, N. J.,	Newark, N. J.
315	Fish and Potash,	Pacific Guano Co., Boston, Mass.,	So. Amherst.
	Bones.		
39	Ground Bone,	Thomas Hersom & Co., New Bedford, Mass.,	Amherst.
66	Fine Ground Bone,	F. H. Smith, Northboro, Mass.,	Amherst.
67	Pure Ground Bone,	Sanford Winter, Brockton, Mass.,	Amherst.
229	Steamed Bone,	McQuade Bros., Worcester, Mass.,	Worcester.
281	Bone Meal,	D. Whithed, Lowell, Mass.,	Amherst.
291	Ground Bone,	Thomas Stetson, Randolph, Mass.,	Amherst.

Laboratory Number.	Name of Brand.	Moisture.	Nitrogen in 100 lbs.		Phosphoric Acid in 100 lbs.							Potassium Oxide in 100 lbs.		Mechanical Analysis.			
								Total.		Available.							
			Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Fine.	Fine Med.	Med.	Course Med.
	Compound Fertilizers.																
167	Animal Corn Fertilizer,	13.88	2.51	5.47-3.29	6.17	2.53	2.18	10.88	9.15	8.70	8-12	2.12	2-4				
177	Potato Phosphate,	12.50	2.66	2.47-3.30	4.22	2.32	2.04	8.58	7-11	6.54	6-9	5.42	5-6				
188	Brightman's Superphosphate,	16.89	2.67	2.5-3.25	2.58	2.98	3.66	9.22	8-11	5.56	6-8	4.78	5-6				
287	Special Tobacco Fertilizer,	11.65	1.90	1.65-2.47	8.26	2.22	1.46	11.94	9.50-11	10.48	8.50-11.50	4.00	4.5				
315	Fish and Potash,	16.31	2.75	2.47-3.30	1.87	3.21	2.40	7.48	6-8	5.08	4-7	4.23	4-6				
	Bones.																
39	Ground Bone,	4.87	1.93	1.5-2.00	—	6.26	22.52	28.78	27-28.5	6.26	—			79.19	15.81	5.00	—
66	Fine Ground Bone,	3.67	3.96	3-4	—	3.48	18.42	22.90	23-24	3.48	—			61.14	33.67	5.19	—
67	Pure Ground Bone,	3.52	3.19	3-4	—	5.20	16 68	21.88	21-22	5.20	—			42.64	30.33	13.73	13.30
229	Steamed Bone,	6.18	3.24	2.78	—	4.56	17.52	22.08	24.52	4 56	—			47.08	22.79	23.34	6.79
281	Bone Meal,	3.12	1.47	1.29	—	7.48	22.14	30.76	32.55	8.62	—			69.57	23.67	6.75	—
291	Ground Bone,	6.96	3.95	4-4.5	—	4.86	16.00	20.86	21-22	4.86	—			19.10	31.51	37.44	11.95

TRADE VALUES OF FERTILIZING INGREDIENTS IN RAW MATERIALS AND CHEMICALS.

	1898. Cents per pounds.
Nitrogen in ammonia salts,	14.
" nitrates,	13.
Organic nitrogen in dry and fine ground fish, meat, blood, and in high-grade mixed fertilizers,	14.
" " " cottonseed meal,	12.
" " " fine bone and tankage,	13.5
" " " medium bone and tankage,	10.
Phosphoric acid soluble in water,	4.5
" " soluble in ammonium citrate,	4.
" " in fine ground fish, bone and tankage,	4.
" " in cottonseed meal, castor pomace and wood ashes,	4.
" " in coarse bone and tankage,	3.5
" " insoluble (in am. cit.) in mixed fertilizers,	2.
Potash as Sulphate, free from Chlorides,	5.
" " Muriate,	4.25

The market value of low priced materials used for manurial purposes, as salt, wood ashes, various kinds of lime, barnyard manure, factory refuse and waste materials of different description, quite frequently does not stand in a close relation to the current market value of the amount of essential articles of plant food they contain. Their cost varies in different localities. Local facilities for cheap transportation and more or less advantageous mechanical conditions for a speedy action, exert as a rule, a decided influence on their selling price.

The market value of fertilizing ingredients like other merchandise is liable to changes during the season. The above stated values are based on the condition of the fertilizer market in centers of distribution in New England, during the six months preceding March 1898.

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS

AGRICULTURAL COLLEGE.

BULLETIN NO. 55.

NOVEMBER, 1898.

The Bulletins of this Station will be sent free to all newspapers in the State and to such individuals interested in farming as may request the same.

AMHERST, MASS.:
PRESS OF CARPENTER & MOREHOUSE,
1898.

HATCH EXPERIMENT STATION

OF THE

Massachusetts Agricultural College,

AMHERST, MASS.

By act of the General Court, the Hatch Experiment Station and the State Experiment Station have been consolidated under the name of the Hatch Experiment Station of the Massachusetts Agricultural College. Several new divisions have been created and the scope of others has been enlarged. To the horticultural, has been added the duty of testing varieties of vegetables and seeds. The chemical has been divided, and a new division, "Foods and Feeding," has been established. The botanical, including plant physiology and disease, has been restored after temporary suspension.

The officers are :—

Henry H. Goodell, LL. D.,	*Director.*
William P. Brooks, Ph. D.,	*Agriculturist.*
George E. Stone, Ph. D.,	*Botanist.*
Charles A. Goessmann, Ph. D., LL. D.,	*Chemist* (Fertilizers).
Joseph B. Lindsey, Ph. D.,	*Chemist* (Foods and Feeding).
Charles H. Fernald, Ph. D.,	*Entomologist.*
Samuel T. Maynard, B. Sc.,	*Horticulturist.*
J. E. Ostrander, C. E.,	*Meteorologist.*
Henry M. Thomson, B. Sc.,	*Assistant Agriculturist.*
Ralph E. Smith, B. Sc.,	*Assistant Botanist.*
Henri D. Haskins, B. Sc.,	*Assistant Chemist* (Fertilizers).
Charles I. Goessmann B. Sc.,	*Assistant Chemist* (Fertilizers).
Samuel W. Wiley, B. Sc.,	*Assistant Chemist* (Fertilizers).
Edward B. Holland, M. Sc.,	*First Chemist* (Foods and Feeding).
Fred W. Mossman, B. Sc.,	*Ass't Chemist* (Foods and Feeding).
Benjamin K. Jones, B. Sc.,	*Ass't Chemist* (Foods and Feeding).
Philip H. Smith, B. Sc.,	*Assistant in Foods and Feeding.*
Robert A. Cooley, B. Sc.,	*Assistant Entomologist.*
George A. Drew, B. Sc.,	*Assistant Horticulturist.*
Herbert D. Hemenway, B. Sc.,	*Assistant Horticulturist.*
Arthur C. Monahan,	*Observer.*

The co-operation and assistance of farmers, fruit-growers, horticulturists, and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the

Hatch Experiment Station, Amherst, Mass.

SYNOPSIS.

Part I.

Part II.

ERRATUM.

On page 35, line 20 and in foot note, for *Vahne* read Vanha.

DIVISION OF BOTANY.

George E. Stone and Ralph E. Smith.

In the presentation of this bulletin by the Botanical department we ought first of all perhaps to explain why we have undertaken a work which is zoölogical rather than botanical in its nature. For five or six years many complaints of damages caused to plants by nematode worms have been addressed to the Station. Since the trouble was not brought about by any vegetable organism such as a fungus it did not strictly belong to our consideration. The only other department of the Station to which it could be referred was the entomological, and since worms are not insects it might be questionable whether investigations of this nature would belong to that department. What is true in our Station seems to have been the case in most other states. We find more or less mention of damages caused by nematodes in the reports and bulletins of the different experiment stations, but in hardly any case has the subject been investigated. This is not due to negligence on the part of station workers, but simply to the fact that few stations have any department to which this work would fall, inasmuch as the study of worms belongs to specialists in the domain of zoölogy. As a consequence very little has been done in investigating the pest in this country and nothing at all in this section, though the necessity for such investigation has been continually increasing. It should be stated, however, that such study as has been made upon this subject has been done almost entirely by botanists.

Realizing the impossibility of making definite recommendations to those seeking advice in the matter and feeling that the subject was one of great importance to the gardeners of Massachusetts, we finally undertook investigations, the results of which are contained in this bulletin.*

*We wish here to express our thanks to our colleague Prof. C. H. Fernald of the Entomological Division of the Station for many courtesies which he has shown us in this work.

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There are many points of interest connected with the study of the early life history of nematodes which would delight the embryologists, but it was not our purpose to enter into this matter as it has no important economic bearing and does not fall within the sphere of station work. Our innumerable cultures of nematodes have furnished us with rare and abundant material for such investigation, but we have preferred to leave it to those especially practiced along the lines of modern zoölogical technique.

Our endeavor has been to acquaint ourselves with the main zoölogical features connected with the subject as far as possible and necessary, by careful examination of the most important literature relating to the subject as well as by actual research. In stating our results and drawing conclusions we have endeavored to present nothing which is not well established on fact and in principle. We have made no attempt to present a technical treatise upon the subject, but have aimed to give simply a clear and concise description of the nature of nematode worms and their relation to greenhouse plants, together with what we have been able to learn concerning means and methods for their suppression.

This investigation has been carried on in connection with the regular botanical work during portions of 1894, 1895, 1896 and 1897. That portion of the work relating to the life history and development of the nematode has been done by Mr. Smith while the investigations of the remedies to be used have been carried on by Mr. Stone. We have worked in co-operation with each other, however, and hold ourselves individually responsible for the entire work.

Nematode Worms in the Greenhouse.

The practice of growing plants under glass has seen many and important changes since its introduction. Beginning no doubt with the growing of a few plants in the window for the sake of their beauty in the winter, a comparatively short time has seen the introduction and development of the modern greenhouse, with all its accessories, improved methods, and appliances for growing plants, not to mention the great development in the nature and variety of the plants themselves. Especially recent is the practice of growing vegetables under glass, now carried on so extensively in the vicinity of all large towns and cities. During the last decade the value of greenhouse products in Massachusetts has more than doubled. In

1885 it amounted to $688,813; in 1895 $1,749,070; an increase of 153%.* But with this development in the methods and extent of greenhouse work there has been a corresponding increase in those elements and factors conspiring to make the success of such work difficult and uncertain.

All plants growing in the greenhouse in winter are, and must be, in an environment which is in a general way the more or less successful result of an attempt to imitate the natural conditions which exist in an ideal summer, and the degree of healthy and vigorous growth which the plants attain, and indeed their very existence, depends upon the success of this imitation. To be sure the gardener has an advantage over Nature in his absolute control over the heat and water supply, which are the two principal factors upon which the "ideal" conditions depend, but this advantage may or may not be profitable to him according as he employs it properly or improperly.

Of the factors upon which plant growth depends the most important are heat, light, air and water, (both in soil and air), as well as the mechanical and chemical nature of the soil. It might seem then that the proper handling of these factors should result in perfect success in plant growing, but such is not always the case. There are other factors which may come in and render of no avail the greatest skill and knowledge, which reaches only to this point. Artificial heating, ventilation, watering, fertilizing, etc., may be carried to perfection and still there are certain troubles or diseases which may attack the plants and hinder or entirely prevent their growth. The overcoming of such troubles is one of the most difficult problems of the gardener's art. They may be due to insects. These in the limited area of the greenhouse can usually be easily detected and destroyed. Another and more serious source of trouble lies in the attacks of fungous diseases, blights, mildews, rots, etc., which cause so much injury to plants growing in all situations. The Fungi causing these diseases are plants of low order and microscopic size, living as parasites upon other plants and causing more or less injury to them. They are much more likely to attack sickly or unhealthy plants than those growing vigorously. Their occurrence, therefore, especially in the greenhouse, depends to a considerable extent upon the health of the plants. Aside from insects and fungi, injuries may

*Census of Mass. 1895, vol. VI., pt. 2, p. 327.

be caused to plants by other organisms of various kinds, among which the nematode worms are probably the most important.

What Nematodes Are.

The Nematodes or Nematode Worms form a class of animals grouped under the Vermes or true worms. They are much lower in the scale than the larvae or caterpillars of insects, which are popularly known as worms and often cause injuries to plants, and are lower also than the earthworm, which is one of the most highly developed of the Vermes. The nematodes vary greatly in size, shape, and manner of life and include many peculiar and remarkable forms. Most of them however have at some period of their existence an elongated worm-like form, whence the popular names eel worm, thread worm, etc. Some keep this form during their whole existence and live in water, earth, decaying matter, and other damp places. Most of them are entirely harmless to plants and animals. They are usually of very small size, scarcely or not at all visible to the naked eye. Many different species of this kind exist abundantly in Nature. The well known "vinegar eel" is an example. A great number of nematodes however live for all or part of their lives as parasites; many on animals and a few on plants. Such forms pass through many most remarkable changes in their development. The Trichina of pork and many other animal and human-infesting worms are nematodes, while the tape worm, liver fluke, and in fact almost all organisms of that nature are closely related. The so-called hair-snake is a nematode, much larger than most kinds. In relation to plants, we have to consider, in this locality only a few, and, as far as we know, but one species of nematode. We know of no other among the many indigenous to our soil capable of causing any considerable injury to plants. All such trouble is due primarily to the one species, Heterodera radicola, (Greef.) Müll. There is a more or less prevalent idea that all kinds of nematodes cause injuries to plants, but such is certainly not the case. The soil may swarm with nematodes but, if our observations are correct, unless there are among them this one species no injury will result.

Symptoms Of Nematode Injuries.

The only definite indication of the attacks of Heterodera radicola is found in the roots of affected plants. These are more or less covered with what we shall call galls, that is swellings or enlargements of the roots, more or less roundish, but very irregular in shape and varying in size. These galls are sometimes very prominent both in size and number, but at other times are small, few, and inconspicuous. Their number depends entirely upon the abundance of the worms. The size and shape of the galls depends also to some extent upon the abundance of the worms and their location in the root, but in different kinds of plants we find galls which are somewhat characteristic in appearance. This is very natural when we consider that the gall is a growth of the plant itself and has no organic connection with the worm. As different plants produce different shaped leaves, flowers, fruits, etc., under the common influence of nature, so they may produce galls of different shapes though the worm which causes them is the same.

The smallest galls with which we have met occur on the violet, none being larger than a small pea and most of them being inconspicuous swellings near the tips of the rootlets. They might easily be overlooked in this plant, even if very numerous. In the cyclamen also the galls are small, but larger than in the violet. In the rose they seem to vary somewhat in different varieties, but are mostly of small size, especially on the smaller roots. On the main root they become larger and one correspondent writes that he has seen them as large as a duck's egg. This is an unusual size on any plant and must have been the result of a growth of considerable time. In the cucumber and tomato the galls are quite large and very prominent. Besides the formation of root galls the nematode attacks are indicated by the effect upon the vitality of the plant, though this effect is not particularly definite or characteristic. In very badly affected soil plants may be killed or very much stunted before reaching any considerable size. The tomato and cucumber seedlings shown in plate VII., figs. 3 and 4, were grown in such soil and never reached any considerable size. Only in extreme cases, however, is the soil as full of worms as this was, and more frequently the plants grow normally at first, but after reaching a considerable size begin to appear sickly. The leaves die at the edges, the plant stops growing and gradually fades away or sometimes collapses quite suddenly. The cucumber is perhaps the most liable to be killed outright, while roses, violets, etc., often linger for a considerable time, although this depends largely upon how badly the soil is infested. If the worms are abundant when the plants are first started their attacks will become evident at once. If only few at first they will have but little effect until several generations have developed, but this does not require a very long time. We feel very sure that more damage is caused to greenhouse plants by Heterodera radicola than is generally supposed. Working as it does in the roots of the plant and frequently producing even there very slight indications of its presence, plants might, and doubtless often do, linger along and finally die while the cause of the trouble is vainly sought above ground or in the soil, without its real location being suspected. If the roots were examined the casual observer might fail to notice anything unusual in some kinds of plants, even though they were badly affected. In all cases, therefore, where greenhouse plants become unhealthy and sickly and appear to be gradually dying without apparent cause, an examination for nematode galls on the roots should be made.

Galls Due to Other Causes Than Nematodes.

It must not be understood that all galls or swellings on the roots of plants are due to nematodes. There are other agencies and organisms producing a somewhat similar effect as regards superficial appearance, among which two are the most important. These are two low vegetable organisms, the one (Plasmodiophora Brassicae, Wor.) causing the well known "club root" of cabbage and turnip, and the other, a bacterial organism producing galls or "tubercles" on the roots of plants of the order Leguminosae. Plasmodiophora Brassicae is one of the very lowest plant organisms, consisting simply of a homogeneous mass of protoplasm or plant substance and having no distinct parts, organs, or tissues. It lives as a parasite in the roots of the cabbage, turnip, kohl rabi, radish, shepherd's purse, and other plants of the order Cruciferae, and produces an effect sometimes very similar to that of the nematode. We have seen roots of tomato affected by nematodes and those of cabbage with "club root," which could not be told apart except by the odor of the cabbage or by microscopic examination. The two things, however, are quite distinct, having nothing in common except their general appearance. The club root organism enters the root in the form of minute spores and then increases in bulk so as to cause a distension of the cells and consequent enlargement of the root into "clubs." Its effect can usually be distinguished in this locality from nematode injuries by the plants which it affects. Any galls on the roots of cruciferous plants growing out of doors in summer may usually be considered as club root.

The other gall-producing organism affects clover, pea, bean, lupine, horse bean, cow pea, vetch, and all other *legumes* or plants of the order Leguminosae. It is a bacterial or microbe-like organism consisting of extremely minute single cells, each cell being a complete individual in itself. These little organisms enter the roots of leguminous plants from the soil and reproduce and multiply there, causing the root by their presence to swell up into little galls or *tubercles* as they are commonly called. These tubercles are quite similar in appearance to nematode galls. Instead of injuring the plant, however, they have, on the contrary, a very beneficial and remarkable effect. It has long been known that leguminous plants have the power which is not possessed by other plants of obtaining free nitrogen from the air. This is of course very beneficial to them. What gives them this power was for a long time unknown, but it is now well established that this peculiar advantage is in some way connected with and due to the bacteria in the roots, though just how it comes about is not yet satisfactorily determined. We do not recall any leguminous plants cultivated to any extent in greenhouses, except perhaps one or two flowering plants, so that no great confusion with nematode injuries need arise from this source.

Root galls may sometimes be traced to insects or other causes, but not to any extent in greenhouse plants and therefore are not liable to be confused with nematode galls. Galls are sometimes formed on the root of the raspberrry by an insect (Rhodites radicum) which are quite similar. We know of no perennial outdoor plant in our climate which is affected by nematodes.

Nature of the Galls Produced By *Heterodera radicola*, And the Harmful Results Occurring From Them.

By breaking open a gall from the roots of any affected plant and carefully examining the fragments there may be seen with the naked eye or more easily with a hand lens, little, white, glistening, pearl-like bodies about the size of a pin head, imbedded here and there in the tissue. These are the mature female worms and the cause of the formation of the galls and consequent injury to the plant. Their number varies with the size of the gall, or, more logically, the size of the gall depends upon their number. In some parts of the root will be found minute pimple-like excrescences, usually of a yellowish color, just large enough to contain a single worm. From these the galls and number of worms contained varies indefinitely.

In order to get an idea of these abnormal root growths, let us first briefly consider the normal structure of the root in a plant like the cucumber. If such a root be cut across with a sharp knife there can readily be distinguished on the cut ends two different tissues or parts. The central part of the section is occupied by a more or less star or cross shaped portion differing in color and appearance from the other tissue which surrounds it. This is called the *central cylinder*, and the other part the *cortex*. Both are composed of variously formed *cells*, as are all parts of the plant. The cortex, (Pl. VI., fig. 2, c.) consists of comparatively large, thin walled cells which make it a sort of spongy tissue, the principal function of which is to absorb water from the soil. In this water are dissolved the substances forming the food of the plant. The central cylinder, (Pl. VI., fig. 2, p.) consists of several tissues, each having its particular structure and function. Its elements are mostly composed of cells of a firmer, thicker structure than those of the cortex and thus it serves to give the root its strength and stability, just as the woody portions do in the stem. Among the elements of this central cylinder one of the most important is a tissue composed of large, long, thick-walled, tube like cells, connecting end to end longitudinally to form passages from the root up through the entire plant to the leaves. (pl. VI., fig. 2, d.). Through these vessels, which are called *ducts*, the crude sap, i. e. water containing nutritive substances in solution, coming in through the cortex from the earth is carried up to the stem and thence to the leaves where it is transformed under the influence of sunlight into plant substance. We may, in a very general way, considering only the function of taking water from the soil, liken such a root to a bundle of tubes composed of some material through which water can pass, enclosed in a covering of spongy material; the tubes of course representing the ducts of the central cylinder and the spongy material the cortex. Imagining such a contrivance to be placed in water, it can readily be seen how the water might soak through the outer layer into the tubes and thence be carried wherever an impelling force might direct it. Such a force is supplied in the plant by the so-called *root pressure*, the force which circulates the sap.

If now a section be made of a fair sized nematode gall, a considerable difference in the arrangement of the tissues will be seen. The central cylinder no longer has its regular outline and central position, but forms an irregular, misshapen area, extending nearly to the outside of the root in some places, while in others it is far from the surface. The cortex also has an irregular shape and thickness, but it is much thicker than in the normal root. Here and there on the surface of the section will usually be seen the female worms or their remains, some near the edge and others at various depths in the root. Examination with the microscope shows a great disarrangement of all the root tissues. (Pl. VI., fig. 5). The cells of the cortex are increased in number and size, being affected especially in the vicinity of the worms, which are located mostly at the inner edge of the cortex at its junction with the central cylinder. In the latter portion of the root serious changes have taken place, as a result of which the injury to the plant is mostly to be ascribed. The ducts and smaller vessels, instead of running directly through the root as in the normal specimen are greatly distorted and deviated so that many of them run directly at right angles to their natural course, i. e. across the root, and a cross section shows their sides, which are marked with lines and dots on their wall, instead of their open ends as in the section of the normal root. Where one of the worms is located near or in the cylinder the vessels grow in such a way as to form an irregular mass completely enclosing it, and even where the nematode is in the midst of the cortex they are greatly deviated from their natural course. The size and shape of the galls, as we have already pointed out, depends largely upon the number and location of the worms, and also upon the kind of plant, but not, as far as we know, upon the worm itself. That is to say, we cannot conclude that galls of a certain shape indicate a particular kind of worm, for while each of the affected plants has a gall more or less peculiar to itself, the worm is the same in all. Large galls are formed where several worms attack the root at the same place. If they be close together and distributed on all sides of the root the resulting gall will be of quite regular shape. Irregular galls are formed where several worms locate on one side of the root, or at short distances from one another so that several small galls grow into one. Most of the galls start when the roots are very young, or on the younger portion, near the tips of older roots. Here the tissues are in a formative stage and the central cylinder is just beginning to form. Plate VI., fig. 1 shows a section of a young and normal root at this stage. The cortical tissue forms the larger part of the structure while the central cylinder consists of a limited area of small cells in which a few ducts are just beginning to develop. When a nematode attacks this young rootlet it very soon begins to appear like those shown on the seedlings in plate VII. Plate VI., figs. 3 and 4, show sections of these young galls. In fig. 3 are seen three young worms which are just entering the root (as shown from the exterior in plate VII., fig. 1). There were others no doubt on the opposite side which did not come into view in this section. Comparing this with the normal rootlet in fig. 1, we notice first of all the increased size, due principally to the increase in number and size of the cortex cells. The central cylinder no longer forms a definite mass in the center, but has separated into several portions and occupies an irregular area. The few ducts which have been formed are already distorted in direction and run obliquely. Fig. 4 shows a similarly affected root at a somewhat later stage. We see here a worm farther developed than those in fig. 3, the broad, large celled cortex, and the central cylinder divided into two parts in each of which appear several ducts and vessels growing in an oblique direction. From this stage the abnormal growth continues and the tissues become more and more confused and distorted until the gall reaches a considerable size and has the complicated structure shown in fig. 5.

The effect upon the vital function of the plant produced by this malformation of the root can be readily imagined. It is brought about principally in two ways; first, by the general interruption of all the functions, and second and particularly by the interruption of the normal flow of sap from the roots, caused by the distortion of the ducts. Continuing the comparison of the root with the bundle of tubes, imagine the latter to have become twisted, "kinked," doubled up, and tied into knots. It is very plain then that the passage of water through them would be hindered. The parts of the plant above ground, absolutely dependent upon the roots for moisture and food, must necessarily suffer from such an abnormal growth in a measure proportionate to its extent. A few galls on the roots produce no apparent effect. Where they are quite abundant the plant becomes stunted and sickly, and where the roots become completely covered with galls, as they do in badly infested soil, the plant is killed outright, for its food and water supply is entirely cut off. These effects, therefore, are not brought about directly by the nematodes, but only indirectly. That is to say they are not due to the direct action of the worm in feeding upon the root as is the case with the attacks of insects and fungous diseases, where the plant dies or sustains injury from the loss of its vital substance. To be sure the worms obtain their food from the roots after entering them and must cause some damage in that way, but far more serious must be the result of the derangement of the vital functions caused by the abnormal growth of the plant, which in trying to overcome the injury in the roots produces greater injury to its other parts. It is evident from published writings, even in experiment station bulletins, that a very general impression exists that nematode worm injuries are brought about by a swarm of little worms feeding upon the roots, much as insect larvae feed, but this idea is altogether wrong. The amount of food which the worms consume is insignificant and entirely disproportionate to the amount of damage caused. The structure of the affected roots, on the other hand, shows plainly that therein lies the chief source of injury.

Secondary Effects.

In this connection it will be proper to consider what we may call the secondary effects of these nematode attacks. This would include the attacks of other injurious organisms which are favored by the weakened condition of nematode affected plants. Among the most common of these organisms are those fungi which produce diseases. It is a well known fact that the least vigorous plant is most easily affected by disease. While it is true that some of the most destructive plant diseases attack the strong and weak alike, in the case of many others like certain "mildews", "blights", "spots", etc., the disease only appears on plants which for some reason are not growing vigorously. We believe that the destructive effects of the well known "violet disease" (Cercospora Violae) are greatly increased as secondary results of nematode galls on the roots. That is the galls have weakened the plants and thus given the fungus a foothold. In the same way we have seen the cucumber powdery mildew appear on nematode ridden plants while others in the same house which had no nematodes were likewise free from mildew. The tomato blight might easily be induced in the same way. We do not mean that nematodes are always the agent which induces these diseases,—poor drainage or ventilation, improper temperature or fertilizers, and a hundred other things may serve to weaken the plants and stop their growth, thus leaving them an easy prey to disease,—but we do believe that nematodes are at the bottom of much more trouble with plants than is generally suspected.

Another secondary result of nematode attacks is worth considering. In examining roots which are badly infested we find not only the worms of this particular species but also other kinds of nematodes, other low animal organisms, fungi, and bacteria, forms which have no power to attack the healthy root but which come in after the plant has been weakened and its root partly destroyed, and no doubt aid considerably in hastening its death. Thus the injuries caused to plants by Heterodera radicola are of three kinds; first the small direct injury by the worm feeding on the substance of the plant; second, and most important, the indirect injury brought about by the interference with the vital functions of the plant on account of the abnormal growth; and third, secondary effects as described above.

Description of Free-Living Nematodes.

A typical nematode of the free-living, harmless class is shown in plates I. and II. This is a form found in decaying roots which had been killed by Heterodera. It is a species of Rhabdites. The animal originates from an egg, (Pl. I., fig. 1.) which is of a noval shape, about .07 mm. ($\frac{1}{350}$ of an inch) in length and half as wide, and consists of a membranous covering inclosing a mass of granular protoplasm and fat globules. After being impregnated the contents of the egg divide into two parts (fig. 2) and then by continual division and development as shown in figs. 1-12, develop gradually into an elongated structure which assumes the form of a young worm, doubled up several times in the egg membrane. When fully developed it bursts the membrane and is discharged into the water or earth or wherever the mother may be. In this particular species the young are born alive. In others the eggs are discharged as soon as mature or when the young worm is partly developed, completing their development outside the mother. The newly hatched worm (fig. 13) is a minute elongated organism about .3 mm. ($\frac{1}{90}$ of an inch) in length, tapering to a rounded end at the head and a pointed tail behind. Its structure is quite simple. The body wall is composed of muscular layers and incloses an internal cavity almost entirely filled with the *alimentary canal*, which forms the very simple digestive system. This begins at the head end, in the mouth opening (fig. 15, m.) and runs back for about one-third the length of the body in a narrow tube, the *oesophagus*, which has a thick wall and two bulb like enlargements, one near the middle and the other at the posterior end, (fig. 15, x and b.). These parts are rather indistinct in the very young worm, but become more prominent as it grows older. From the oesophagus the alimentary canal broadens out into the *intestine* or *stomach* (s) which occupies most of the remaining length of the body, terminating in a narrow portion, the *rectum*, which has its outlet at the *anus*, near the posterior end. The whole body is filled more or less with granular protoplasm and fat globules. The only other organ distinguishable at this stage is the sexual, which originates in both sexes in a little cluster of minute cells situated close to the intestine, near or just posterior to the middle of the body. This is shown more enlarged in fig. 14. As the worm approaches maturity it increases in length and proportionally in width, the alimentary canal becoming more distinct and the sexual organs developing. The sexes now become distinguishable. In the female the sexual organ becomes an *ovary*. The cells composing it increase rapidly in number, extending toward both ends of the body. At the same time an opening called the *vulva* (v) is formed through the body wall on one side, about one third the body length from the tail. The worm has now reached the stage shown at plate I., fig. 17, or the somewhat later stage at plate II., fig 1. The ovary extends almost the entire length of the intestine, forming a long tube full of small, roundish cells, the immature eggs, and connected with the vulva or opening in the side of the body. Or we may regard it as two tubes, one extending forward and the other backward from the opening.

In the male, meantime, the sexual organ has also developed into a long tube, which however has no special outlet of its own but opens directly into the rectum just in front of its opening at the anus. This male organ is the *testis*, and in it the small round *spermatozoa* are developed. In the extremity of the intestine, just above the anus, there develops in the male a two branched, curved, sharp pointed *spicule*, which can be protruded from the anus and serves as an aid to copulation. For the same purpose there is also formed in the male a hood like expansion of the tail called the *bursa*. Plate

II., fig. 5, shows the mature male in its relative size to the mature female, fig. 4. Fig. 6 shows the posterior end more enlarged with the spicule (q), anus (y), bursa (z), and the testis (t). At this stage copulation takes place, the male and female being about equal in size, having a length of .8mm. ($\frac{1}{30}$ of an inch) the male being mature, but the female not yet fully developed. The male clasps the body of the female (Pl. I., fig. 18) by means of the bursa so that the opening of the testis is directly in contact with that of the ovary, and discharges its spermatoza into the small cavity which is situated just under the opening. The male has now completed its life and dies, while the female goes on to develop eggs and young. The body continues to increase in length and still more in diameter, assuming a somewhat distended, cigar shaped form (Pl. II., fig. 1). The eggs in the ovary begin to mature, those nearest the opening first, and soon the worm reaches the stage shown at fig. 2. The intestine is no longer the most prominent organ of the body cavity. That is now almost filled by the ovary, a long wide tube extending from the oesophagus to the posterior end of the body, filled with eggs in all stages of development. Soon the young begin to hatch and move about in the ovary, whence they are forcibly discharged through the side opening. In adult worms which were killed during examination the eggs continued to hatch but the young worms seemed unable to reach the exterior. They squirmed vigorously about, travelling from end to end of the body cavity (which finally became nothing but a sack, full of a living mass of young worms) and occasionally one would chance upon the vulva and protrude its head, but they always drew back again before getting out completely and showed by their actions that the forcible discharge by the parent which was observed in living specimens was necessary for their release. Fig. 3 shows a living mature female, and fig. 4 one which was dead and somewhat disorganized.

Plate IX., figs. 4 and 5 shows the male and female of another species in which the eggs are discharged when partially developed. Fig. 1 is a small male of another related species. In this is shown at (*e*) a small opening through the body wall just opposite the oesophagal bulb, which is the orifice of an excretory organ, a long tube running down the body which occurs in most nematodes but is not easily distinguishable. Fig. 2 shows the posterior end of this male more enlarged, bursa (z), spicule (q), intestine (o), and testis (t).

Besides the digestive, sexual, and excretory systems, nematodes also have a sort of nervous system, consisting principally of a so called *nerve ring*, which surrounds the oesophagus just behind its median bulb. This, however, is usually very indistinct and not highly developed. A circulatory system is entirely wanting in nematodes.

Description of the Parasitic, Gall Forming Nematode, *Heterodera radicola.*

(a) EARLY LIFE.

Turning now from this typical species of a nematode in its simplest form, to the gall forming species which causes the injury to plants, we shall find some similarities in structure and development and also some striking differences. The egg (Pl. IV., figs. 1-16), as in the other species is an elliptical or rather bean shaped body .1mm. ($\frac{1}{250}$ of an inch) in length, composed of a chitinous membrane inclosing a mass of granular protoplasm and fat globules.

The covering, although very thin, is extremely tough and very resistant to heat, cold, chemical substances, etc., affording to the egg contents a protection which is well nigh absolute against the ordinary influences of nature. In its earliest stage the mature egg consists inside the membrane of a loose, undivided mass with a nucleus in the centre. After fertilization the nucleus divides and two cells are formed (Fig. 3). These divide again and again passing through various embryological changes and developing into a young worm as shown at fig. 16. The worm moves about freely in the shell and finally ruptures it and escapes. In its earliest life it resembles the free living species having a similar form and structure. It is a minute worm-shaped creature about .33mm. ($\frac{1}{75}$ of an inch) in length, quite invisible to the naked eye. Plate VII., figs. 5 and 6, are intended to give an idea of the size of the worm at this stage. Fig. 5 shows it among the particles of a fine loam soil, while Fig. 6 shows an enlarged portion of an angle worm with two black lines upon it near the centre, the shorter of which represents a young nematode in its proportionate size to the angle worm. The longer black line represents the length of the mature male nematode, at the greatest length it attains at any time or in any form. Imagining the angle worm reduced to its normal size, some idea will be obtained of the minuteness of the nematode when similarly reduced. It is in this young stage and in the egg that the worm exists in the soil. Its structure is simple, consisting of a body wall containing the alimentary canal (oesophagus, intestine and rectum) and the almost indistinguishable rudiments of the sexual organ. In these respects it is very similar to the free living species. In its anterior end, however, within the mouth opening, is seen a structure not found in the ordinary forms. This is a small spear like organ, (Pl. V., s, fig. 5,) which can be moved about to a certain extent and assists the worm in penetrating roots. Most of the young worms when hatched are in the interior of the galls on the roots. They are able to escape without difficulty since the gall becomes decayed and disorganized and since their small size makes it an easy matter to force their way through the tissue, between the cells. Arriving in the soil they at once proceed to attack new roots if any be present, or if not they are able, as our experiments have shown, to exist for a considerable time without change, awaiting an opportunity for further development. Plate VII., fig. 1, shows young worms entering the tip of a rootlet. In this they no doubt make use of the spear like arrangement in forcing their way in. Having once effected an opening they are able to force their way between the loose cortex cells without difficulty. Having penetrated the root so that the whole body is covered, the worm comes to rest and its remarkable course of development proceeds. It does not simply increase in size retaining the same general form, as do the ordinary nematodes, but it begins to increase in diameter in the middle of the body, and in the course of about a week has a sort of spindle shape, broad in the middle and tapering towards both ends, (Pl. IV., figs. 3 and 4). From now on the swelling occurs more rapidly at the tail end, giving the body a club shape, (fig. 5). Thus far the sexes are indistinguishable but now appears a remarkable difference in their mode of development. The female continues to enlarge, but the male undergoes a remarkable transformation and returns to the slender, worm like form.

(b) DEVELOPMENT OF THE MALE.

Up to this point the development of the male, like that of the female, has consisted of an enlargement and broadening of the body. It now, however, ceases to enlarge in this way and begins to draw in from the body wall and increase in length inside the wall, which keeps its original shape, though it is now simply a sac enclosing the worm with which it has no connection. The transformation which the male now undergoes is somewhat similar to the pupal or "cocoon" stage in insects. During its increase in length the worm is obliged to double over inside the old wall, first once, then twice and even three times. It now appears as shown in plate V., fig. 4, which stage it reaches in about four weeks after entering the root. The old skin still retains its tapering form at the head and sharp pointed tail. Within it is coiled the mature male worm which soon proceeds to break forth and seek its mate. The mature male is shown in plate V., fig. 5. It is a slender worm-shaped creature, having a length of about 1.5 mm., ($\frac{1}{17}$ of an inch), and a breadth of about .045 mm., ($\frac{1}{600}$ of an inch). The body tapers towards the head, at which end it is about half as wide as in the middle. Towards the posterior end the diameter is nearly uniform. The body wall is marked by quite prominent transverse striae. On the head end is a cap-like thickening of the wall with six grooved depressions radiating from the mouth opening in the centre. Strubell considers this as a boring appliance to assist the worm in forcing its way through the soil and roots. The spear is quite large and prominent, the three-lobed base and the enlargement at the centre being plainly visible. The oesophagal bulbs are rather indistinct. The excretory duct is seen at its opening near the beginning of the intestine and can be traced down through the body for some distance. The intestine, testis, and spicule appear much as in the free living nematodes. We are able to find no ground for Atkinson's* statement that the rare case of a two-branched testis occurs in this species. We have found the organ to consist of the usual single tube connecting with the intestine near the spicule. This connection, however, and the general structure at this point is very indistinct, the most prominent objects being the two walls of the intestine, which, to judge from his figure of the male, are what he has regarded as the two tubes of the testis. No bursa is found in this species, nor is one necessary, since the females are fixed in the roots during copulation. The male comes to maturity at a time when the female is still immature, and since its existence ceases very soon after it reaches the adult stage it is not always easy to find specimens. Working with old, mature galls as material we were puzzled for some time at finding plenty of mature females, but no males. In following through the development of the worm, how-

*Nematode Root Galls. Rep't Alabama Agr'l Expt. Station, 1889.

ever, by examining galls from affected plants at frequent intervals during their formation, it becomes evident that at the time when the females are mature the males have ceased to exist. but that they may be found without difficulty if looked for at the proper time.

C. DEVELOPMENT OF THE FEMALE.

The early stages of the female worm are similar to and indistinguishable from those of the male. It does not, however, return to the worm-like form after once entering the root and beginning to swell up, but continues in the same way until it comes to have the gourd-like shape shown in plate IV., fig. 6. This swelling affects the body wall and also the intestine, which enlarges correspondingly. The animal retains its pointed tail-like process up to the stage when the male can be distinguished, but soon after this disappears and the posterior end of the body assumes a roundish form. This change takes place by the "moulting" or casting of the skin, a process which takes place several times (four or five) during the development of the worm. This moulting is very similar to that of insect larvae, the skin lining the oesophagus being cast as well as that of the exterior of the body. Plate IV., fig. 4, shows the female at the time when the male is just becoming distinguishable (plate V., fig. 2,) and in plate IV., fig. 5, the female is represented about one week later, i. e. at the time when the male has completed its transformation and become mature. At this stage the intestine of the female has become very broad at the posterior end and contracts suddenly to a narrow portion or rectum leading to the anus. The ovary has been developing from the immature sexual organ and now consists of a two-branched tube, starting at the posterior end of the body, where the sexual opening is just appearing close by the anus. The simultaneous maturing of the male and development of the sexual opening of the female leave but little doubt that copulation now takes place, though we have not actually observed it as we did in the free living form. The return of the male to the worm-like form is evidently an adaptation to enable it to reach the female, which is entirely immovable after entering the root. It is not probable, however, that the male is obliged to travel a great distance in order to find its mate, as the worms show a sort of gregariousness in entering the root and usually several locate near one another. The European nematode which attacks the sugar beet does not form galls such as we meet with here, but the females locate so near the surface of the root that in their increase in size they rupture the epidermal tissues and their posterior portions project into the soil, whence, according to Strubell, they are fertilized by the males. In our form, however, while some of the females are located near enough the surface for this to be possible, most of them are completely imbedded in the tissue of the gall, through which the male must penetrate in order to reach them. After copulation the male perishes and the female continues to develop. It still increases somewhat in size and in about five or six weeks from the time it entered the root it reaches its mature form shown in plate IV., fig. 6. It is now about 1 mm. ($\frac{1}{25}$ of an inch) long and more than half as broad, being visible to the naked eye as a little white pearl-like speck or globule in the tissue of the gall. It still retains the spear and oesophagal bulb, but the intestine is disorganized and indistinguishable. The body cavity is filled with fat globules which render it semi-opaque. In the most transparent specimens the ovary can be somewhat distinguished, consisting of two long tubes coiled about in the body, filled with eggs in various stages of development and uniting at the sexual opening at the posterior end of the body. Plate IV., fig. 7, shows the ovary removed from the body by crushing it open. The extremities of the two tubes are filled with a transparent mass of small cells, the undifferentiated eggs. Below this the eggs become more and more mature, developing fat globules and a very prominent nucleus. Fertilization takes place in the ovary tube so that the eggs located toward the opening are partly developed. Life becomes extinct in the female at the time when the eggs mature and there remains simply a cavity in the gall filled with eggs, young worms, and the remains of the old one. The young worms gradually find their way out into the soil, seek new roots to attack, and a new generation begins.

Recapitulation of the Life History of Heterodera and the Formation of its Galls.

Let us now briefly review the course of development of this worm and the galls which it produces. Young worms coming into the soil from previously affected plants wander about until they find roots suitable for their attacks. Aided by a spear-like organ in the head they force their way into the younger portion of the root and imbed themselves in its tissue. This irritation of the tissues of the plant causes an abnormal development of the root, consisting in an increased production of cells and a derangement of the tissues from their natural arrangement. The worms increase in length and much more in diameter, assuming a spindle and then a club shape. The females continue this swelling process until they have the shape of a gourd and a size just visible to the eye. They are now mature, and having been fertilized by the male previous to their maturity they produce eggs which develop into the young worms of the next generation. The life period of the female is about six weeks. The male worms do not remain in the swollen form, but after about four weeks from entering the root they change again into a slender worm-like form which enables them to move about and seek the females, with which they copulate and then perish. While the worms are developing, the abnormal growth of the root continues and results in a gall-like swelling or enlargement and such a disarrangement of the tissues that the progress of the sap through the plant is hindered to an extent depending upon the number of galls on the roots. This injury, together with that caused by the worms drawing their food from the plant, checks its growth and often kills it outright or so weakens it that fungous diseases come in and hasten its destruction.

Historical Review.

It is difficult or impossible to say just when the injurious effects of nematode worms on plants were first recognized as such. It is probable, however, that the first record of such injuries is that of Hermann Schacht,[1] a German botanist, who, in 1859, in connection with studies on the sugar beet, discovered what he described as "little white specks of the size of a pin head," upon the roots, which he correctly determined to be nematodes. Three years later Schacht published again, giving a more complete description of the subject of his discovery. In 1871, Schmidt,[2] another German, made investigations upon the subject and gave to the worm discovered by Schacht the name Heterodera Schachtii. Schmidt's work was continued by several different investigators, and in 1888

1. Zeitschrift f. Rübenzuckerindustrie 1859, '61, '62.
2. Ibid 1871, 1872.

Strubell[3] published an elaborate treatise upon this nematode, which had become a most serious obstacle to sugar beet growing in Germany. In 1872 Greef[4] described a gall-forming nematode from Germany, giving it the name Anguillula radicola, which Müller[5] redescribed in 1883 under the name Heterodera radicola. This was a form closely allied to Heterodera Schachtii and was never satisfactorily determined as distinct from it. In 1889 Dr. J. C. Neal[6] published under the auspices of the Division of Entomology of the United States Department of Agriculture, a bulletin upon a gall-forming nematode which was and had been for a long time the cause of much damage to plants in Florida. This worm he described under the name Anguillula arenaria. Later in the same year Atkinson, (loc. cit.) of the Alabama Experiment Station, published a bulletin upon what was evidently the same species described by Dr. Neal but referred it to Heterodera radicola of Müller. In 1890 N. A. Cobb,[7] consulting Entomologist to the Department of Agriculture, New South Wales, published the results of an investigation on a root gall nematode occurring in that country, which he called Tylenchus arenarius and considered identical with Neal's species. This includes the most important general accounts of gall-forming nematodes from an economic standpoint which have been published, although the European literature of the subject is very extensive. Such work, it will be seen, has been very meagre in this country and confined to the southern portions. In addition to these more elaborate publications short notes upon nematodes have appeared in the bulletins of several Experiment Stations, and in various agricultural, horticultural, and floricultural publications, mostly within the last ten years. Many of these have contained errors and none have given any comprehensive account of the matter.

It is impossible to say just when the effects of nematode attacks began to be noticeable in greenhouses. The earliest reference which we have been able to find is in an article in the *American Florist*, April 15, 1888, by J. N. May, in which the writer states that

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3. Untersuchungen über d. Bau und d. Entwickelung d. Rübennematoden Heterodera Schachtii, Schmidt. Bibliotheca zoologica II., 1888.

4. Sitzungsber. d. Gesellsch. zur Beförder'g. d. Naturwiss. zu Marburg 5 Dez., 1872.

5. Neue Helminthocecidien und deren Erzeuger, Berlin, 1883.

6. The Root-Knot Disease in Florida. Bull 20 U.S. Dept. of Agr., Div. of Entomology, 1889.

7. Tylenchus and Root-Gall. Agr'l Gazette, N. S. Wales, Vol. I., p. 155. 1890.

he observed what he calls "club root" in violets in 1876. This without much doubt was the work of nematode worms. The trouble seems to have been common since about 1888, most articles on the subject having appeared since that time. It is now common everywhere and known to every gardener and florist.

Identity of our Species.

We have carefully examined the work of Strubell, Neal, Atkinson, and Cobb, and compared them with our own. Atkinson's excellent account of the Alabama species leaves no doubt that it is identical with ours. The only discrepancy of importance is in regard to the structure of the male reproductive organ, to which we have already referred in discussing the structure of the male. In all other respects his description applies perfectly to what we have found. That portion of Neal's work which relates to the structure and development of the worm is by no means complete and contains not a few obvious errors, but indicates nevertheless, without much doubt, that his species was identical with Atkinson's and that which we have investigated. Cobb, also, appears to have had the same species to deal with in Australia. It may therefore be assumed that the forms studied by Neal, Atkinson, Cobb, and ourselves, are all to be referred to the species which has been called Heterodera radicola, (Greef) Müll.

An examination of Strubell's very complete and accurate description of Heterodera Schachtii shows that our species, if not identical with that, is hardly more than a variety of it. The identity or distinctness of these species has always been unsettled. The only really distinctive character between the two of which we have been able to find any statement is that of Atkinson in regard to the male testis, and of which, as already stated, we doubt the validity. Aside from this we find nothing which could not be considered as individual variation or at most a difference of variety. We were able to examine a few mature females of H. Schachtii brought by Dr. Stone from the Experiment Station at Halle, and found them apparently identical in structure with our H. radicola, but we were not able to compare the two in all stages of development. It would seem remarkable that forms should exist agreeing so completely in general structure and in the details of so unique a course of development and yet be distinct species. Certain violet roots sent in for examination by a gardener in this state were found to be infested with a nematode agreeing in every way with the ordinary H. radicola which we were investigating, except that the eggs, one of which is shown in plate IX., fig. 6, were only three-fourths as large. The structure of the worm was the same in every particular, the embryological development was similar, yet every egg of the thousands in the lot had the unusually small size. Shall this be considered a distinct species? If not, then we can see no reason for considering Heterodera radicola as a distinct species from H. Schachtii, until actual comparison shall show them to be so, on characters not yet established.

NOTE.—Since the above was written there has appeared a bulletin on the cotton plant from the Office of Experiment Stations. U. S. Department of Agriculture, in which, under the heading of diseases of the cotton plant Professor Atkinson has briefly described the nematode root gall disease. In describing the structure of the male worm he speaks as follows: "Occasionally some males were found which showed but a single testis. Since Heterodera Schachtii possesses but a single testis, it might be well to inquire whether that species was also present and whether they are associated in the same roots in some cases or whether there is a variation in H. radicola in the possession of paired and single testes."

This statement has a very important bearing on the question as to the relations between H. Schachtii and H. radicola in that it casts a doubt upon the only distinctive feature between the species which has been presented. If the first hypothesis be true; namely that both species are present in this country as distinct species, then it would be natural to conclude that our species is H. Schachtii while that studied by Atkinson in Alabama in 1883 was H. radicola. The almost absolute agreement of our results in detail, however, leaves but little doubt that we had the same species to deal with. If the second hypothesis, that "there is a variation in H. radicola in the possession of paired and single testes," be correct, then the separation of the species on this character loses its value completely. We feel, therefore, all the more certain that Heterodera Schachtii and Heterodera radicola are one and the same species.

PART II.

Nature of the Problem in Controlling Nematodes.

The problem of nematode control is not the same in all latitudes or in all countries but is determined by the nature of the conditions which practical growers have to deal with. In the Southern States and in those countries in which the winters are mild nematodes can exist in the soil during the whole winter without any detriment, whereas in the latitude of New England where the winters are cold and prolonged the parasitic form Heterodera cannot survive. As a result of this the parasitic species, the Heterodera, finds its proper habitat in the greenhouses where the soil is kept from freezing and it also survives the winter to a large extent in unfrozen manure heaps. This statement does not hold, however, with the non-parasitic species of nematode, inasmuch as these forms or at least their eggs are capable of standing an exceedingly low temperature and we have never failed to find them in all kinds of garden soil, or, in fact, in any soil which contains abundant decomposing organic matter. These non-parasitic forms are frequently found in decaying vegetables of all sorts and we have many times observed them in the laboratory on decaying matter which had evidently been subjected to no source of contamination except ordinary water from the faucet. The fact that Heterodera cannot stand our New England climate greatly simplifies the problem of controlling nematodes, for here we have the problem confined to our greenhouses and manure heaps and not to hundreds of acres of soil as is the case in the milder climate of Europe and that of the Southern States. Heterodera, however, does occur occasionally in some of our outdoor plants but such cases are always where the plants with their contaminating soil have been removed from the greenhouses as in the case of violets, etc., or else where nematode infested manure has been applied to the soil. It must be evident, therefore, that any rational treatment pertaining to nematodes must take these facts into consideration and must especially bear in mind the sources of contamination. Then again we must pay some attention to the life history of nematodes in order to be successful in controlling them. We have already shown that nematodes propagate by eggs and any method which fails to destroy these is of little account. Could we succeed in ridding badly infested soil of adult nematodes it would only be a matter of one or two weeks before the soil would be swarming again with nematodes ready to attack their proper host. Our experiments both in the greenhouse and laboratory have repeatedly demonstrated this, and this fact is interesting as showing how badly infested soil may become with nematode eggs. It is very clear that any remedy which is to be applied to the soil for the purpose of completely ridding it of nematodes must be one which will not only kill all of the worms but their eggs as well. It is, in fact, the eggs of the nematode which constitute the most difficult factor in their control as they are surrounded by a more or less impenetrable membrane and we have not as yet discovered any solution capable of destroying them in the soil which can be employed cheaply and effectively without injury to the crop.

Plants which are Subject to Nematodes.

The plants which are subject to nematode ravages are quite numerous and they represent a great many different families. Prof. Kühn[1] in 1881 gave a list of 180 European plants belonging to 35 different families which nematodes attack and this list has undoubtedly been enlarged since that time. The most susceptible families according to Kühn's list are the Gramineae (Grasses) in which there are recorded 46 species of plants subject to nematodes, while the Leguminosae (Clovers, etc.) is represented by 33 species, the Compositae (Aster, etc.) by 16 species and the Cruciferae (Mustards, etc.) by 14 species. Neal in his work entitled "The Root-Knot Disease of Plants" has enumerated over 60 species of plants in Florida susceptible to the attacks of nematodes, and Atkinson (l. c.) has listed 36 different plants observed by him in Alabama.

In our Northern States the number of plants attacked by nematodes is very much smaller and is almost entirely confined to greenhouse species. In the North the greenhouse cucumber, tomato, violet, rose, and cyclamen constitute the most important host plants, although they are not infrequently found causing considerable dam-

1. Die Ergebnisse d. Versuche z. Ermittelung d. Ursache d. Rübenmüdigkeit u. z. Erforschung d. Natur d. Nematoden. p. 120, 1881.

age to other well known greenhouse plants such as coleus, spinach, heliotrope, fern, moon flower, begonia,[2] and clematis.[3]

Halsted[4] has also called attention to the occurrence of nematodes in the leaves of coleus, chrysanthemum, lantana, bouvardia, begonia, pelargonium, salvia, zinnia and ficus comosa, where they give rise to decomposed spots in the leaves which finally result in their falling off, and giving the plant a generally unhealthy appearance. Halsted has also observed them in the oat in New Jersey, and Sturgis[5] has found them doing considerable harm on the roots of outdoor asters. From the large list of plants attacked by nematodes belonging to numerous and widely separated families it would seem that almost every family under peculiar circumstances might be subject to them. Nematodes normally have a choice in their host, but when this is not present they will attack other plants which apparently seem uncongenial to them. Instances have come under our observation where a crop of lettuce which had been preceded by a crop of nematode infested cucumbers was profusely covered with nematode galls. This, however, in our experience is exceedingly unusual although we are aware of the fact that Kühn gives the lettuce in Germany as one of their host plants. We have, however, grown many crops of lettuce in infested soil without ever finding a gall upon their roots.

Amount of Damage Caused by Nematodes.

When we take into consideration the large number of host plants subject to nematode attack and the economic value of these plants, the losses caused by them must be enormous. The losses, however, are much more severe in those countries where the winter is mild than in colder climates where the nematodes are practically confined to greenhouses. In Europe the greatest loss occurs to sugar beets and in our Southern States the damage done to all kinds of fruit trees and garden truck amounts to considerable. In regard to the extent of the losses caused by nematodes to our economic plants we can do no better than quote Dr. N. A. Cobb, (l. c., p. 179) Patholo-

2. Selby, Ohio Agr'l Exp. Station, Bull. 73, p. 228.
3. Comstock. Garden and Forest, Vol. III., p. 59.
4. N. J. Agr'l Exp. Station, Fifth Annual Rept., 1892. p. 385. See also Garden and Forest, Vol. III. and IV.
5. Conn. Agr'l Exp. Station Report. 1892, p. 45.

gist to the Australian Government, who has made an extensive study of this whole group of worms from various parts of the world. He states "The extent of the damage done by gall-forming worms is difficult to estimate. Much land in Europe has become so badly infested that certain crops—for example, sugar beets—have to be abandoned altogether. Not a beet root will mature. The plants break the ground, languish a few weeks and then die. Were it possible to sum up in pounds, shillings and pence the damage done (by nematodes) the total would probably amount to a fortune for a nation."

In Massachusetts the greatest loss is experienced in the raising of greenhouse cucumbers. The comparatively soft, tender tissues of the cucumber offer little resistance to their attacks, and while the plant is not always killed outright the vines are weakened to such an extent that the crop is greatly diminished. The amount of damage done to tomatoes is not so severe according to our experience as that done to cucumbers, as tomatoes possess a firmer tissue than the cucumber plant and for this reason appear to suffer much less from nematode attacks. The roots of roses, however, are frequently nematode ridden and the result is always disastrous as is evidenced by their generally weak condition and lack of foliage. Violets are also commonly affected with nematodes, and they are undoubtedly the direct cause of many of the difficulties with which violet growers have to contend. One of our correspondents, an intelligent and experienced gardener, writes as follows upon this subject: "After quite a little deliberation I have come to the conclusion that one-half of the trouble in violets is due to nematode worms either in a direct or indirect manner, viz., leaf curl in violets may be direct, by the paralysis of the roots due to the action of the worm, and violet spot is indirectly caused by insufficiency of nutriment to the leaf, causing it to be weak there and immature, thus making it an easy prey to fungous diseases." Nematodes are found less often upon cyclamens and other greenhouse plants, although when they are abundant they give rise to unhealthy conditions in the plant which are not easily overcome and which greatly affect the beauty and value of it.

A Review of the Various Remedies which have been Applied for Nematode Repression.

a. TREATMENT BY CHEMICALS.

In considering the effects of the application of chemical substances to the soil it must be borne in mind that we have to deal with quite a different matter from that of applying fungicides or insecticides to the surface of a branch or leaf. In the case of a leaf or branch we have organs which are more or less protected with a cuticle, thus rendering them to a large extent impervious to solutions which in the case of roots where absorption of nutrients is one of the principal functions the effects are much more injurious. It is well known to physiologists that the roots of a plant constitute one of the most sensitive and irritable organs with which we have to deal, and it does not require a very strong solution of any substance in the soil to produce abnormal conditions in the plant. The nutritive solutions contained in the soil which the plant utilizes for its food are always exceedingly dilute and even when slightly concentrated by excessive manuring, or by the use of an improperly proportioned and too concentrated fertilizer they greatly injure the plant. Indeed those pathologists who have an extensive opportunity to observe sickly plants not infrequently have to deal with disorders due entirely in the first place to improper feeding, although the gardener may surmise that the trouble is brought about by some insect or fungous pest which may be associated with his plants merely in a secondary manner. What applies to the excessive use of normally nutrient substances would apply with greater force to substances which do not constitute the food of plants and some of which are known to be quite poisonous to them. Chemical solutions for the killing of nematodes in the soil would have to be applied in a very concentrated form and in considerable quantities in order to be effectual, although some experimenters have advocated the homeopathic method of applying remedies. Various chemical remedies, however, have been recommended, many of which have been tried with reported success. These have been applied both in solutions and in a solid form, either upon the soil before planting, or after the plants were set out. Some of those employed by various experimenters are as follows:—Potassium permanganate, Sulfate of Manganese, Tobacco dust, Tobacco decoction, Unslaked lime, Carbon bisulfide, Kainit, Ammoniacal liquor from gas works, Ammonium sulfate, Potassium chloride, cyanide, sulfate, and sulfide, Nitrate of Soda, Sulfate of Zinc, Lye, Hyposulfite of Soda, Carnallit, Potassium sulfocarbonate and xanthogenate, Sulfate of Iron, Unleached Ashes, Carbolic Acid, Gasoline, Naptholine, Kerosene Emulsion, Arsenates, Muriate of Potash, Sodium chloride, Sodium sulfocarbonate and xanthogenate, Sulfur, and Calcium sulfate. Neal, (l. c.) who employed a large number of chemicals, obtained negative results with almost everything. He found, however, that the alkaline solutions gave more encouraging results than any other and tobacco dust mixed with Kainit also worked well.

Professor Kühn who has worked upon the problem of nematode control for many years has experimented with a great variety of chemicals of different strengths. He found no chemicals, however, that would control nematodes, although the use of some has shown partial benefits.

Ammoniacal liquor from gas works was recommended by Villet[1] who claimed that it destroyed nematodes and acted as a fertilizer at the same time.

Lye was recommended by Comstock[2] as a wash for greenhouse benches before renewing the soil.

Watering rose plants affected with galls with a solution of lime water or soda was advocated by May[3], although he subsequently found that even when Nitrate of Soda was applied as strong as 1 oz. to 4 gals. of water (1-500) it failed to kill nematodes.

Bailey[4] tried concentrated commercial lye, common salt, lime and Carbon bisulfide on pots of infested soil in which tomatoes were planted. These experiments were upon a small scale and while he obtained galls on all of the plants except the one which was treated with salt at the rate of 2 lbs. to a pail of water he does not consider them conclusive.

Halsted[5] calls attention to the use of lime either by sprinkling it upon the soil or by plowing it in.

Selby (l. c.) experimented with potash salts such as Muriate of Potash and Kainit and also Manganese sulfate, Potassium perman-

1. Rev. Scient. ser. 4, 1895. No. 1, p. 27.
2. Garden and Florist, Vol. III., p. 59.
3. American Florist, 1896, p. 649, also 1897, pp. 770-771.
4. Bulletin 43. Cornell University, Agr'l Exp. Station, 1892.
5. New Jersey Agr'l Exp. Station Report, 1892, p. 384.

ganate, lime water and air-slaked lime, but with the exception of a slightly accelerated growth produced by the use of some of the above named solutions he obtained entirely negative results.

Hollrung reports some experiments with potash salts such as Kainit, Carnallit, and Potassium chloride. The results obtained were rather inconclusive but seem to show that potash salts while having a palliative effect must not be considered as specifics for nematode repression.

Many European investigators have tried potash salts of various kinds upon soil for the repression of nematodes. The literature giving the results of their experiments seems to agree that more beneficial effects have been obtained from their use than any other. On the other hand Dr. Max Hollrung[1] who has experimented extensively for a number of years on the beet nematode and who has had opportunity to try a great variety of methods and chemicals, claims that potash salts in amounts in which they can be used as fertilizers are not capable of destroying nematodes in the soil, and that the beneficial effects of potash salts in such soils are due to other chemical and physical causes. Some sugar beet experimenters have advocated the use of good fertilizing together with the practice of planting early. They claim that by this method sugar beets can be started at a time when they are likely to be less attacked by nematodes, as the plants can thrive even when it is too cold for the nematode to be active and consequently less loss will be experienced by their ravages. In regard to the efficiency of chemicals it must be borne in mind that there are probably no instances where soil has been completely rid of nematodes by this means, although in many instances better crops have been produced after their application.

Various methods of treating nematodes have been practiced for a great many years in Europe, and a considerable amount of literature has already made its appearance relating to this subject. Many methods have been recommended and tried only to find that they were not in every instance sure and practical, and these in turn have been followed by others which have promised better results.

One thing, however, appears to be certain, that many of these remedies have only been given a superficial trial. Had the case been otherwise, many of the remedies advocated would have become

1. Zeitsch. landw. Cent. Ver. Sachr., 1892. No. 12.

obsolete long before this. Instances have occurred where experiments have been carried on by the use of similar remedies which have given exactly opposite results. It must be borne in mind that it is impossible to draw reliable deductions from experiments which have been tried only once or twice upon a small scale. Especially is this true in regard to nematodes, as they normally manifest different periods of activity. We have observed instances where nematodes have disappeared from soil where no treatment has been applied and under circumstances which rendered their disappearance not easy of explanation. Upon this point it should be remembered that we do not as yet fully understand all of the environmental conditions which play a role in their life history, and for this reason we are more likely to fall into errors in interpreting results from experiments. Our own experiments which were very extensive have convinced us that the application of chemical substances to the soil is of little practical value in ridding it of nematodes.

(b).—THE DESICCATION METHOD.

It is well known that drying is very destructive to nematodes and we have repeatedly seen the effects of this in our laboratory and greenhouse. Vahne* who has advocated this method of treatment takes advantage of a long dry spell of weather, either in the fall or spring, and by working the soil repeatedly with plows and cultivators, thus giving it a chance to become as dry as possible, claims to have succeeded in making it an uncongenial habitat for the worm. After the drying process is partially completed he applies unslacked lime at the rate of 2-4 tons to the acre which assists further in the desiccation of the soil and destruction of the worm. He has tried this method with reported success upon fields where sugar beets were planted, and he further maintains that it is efficient as a remedy for certain parasitic fungi such as the damping fungus (Pythiun de Baryanum) Leaf spot of beet, (Phoma Betae) etc. This method is undoubtedly a very cheap one of controlling nematodes provided it works satisfactorily, although it must be difficult out of doors in a variable climate to always find the right season for its application. We have frequently found that drying small masses of soil in the greenhouse for a number of weeks completely rids the soil of

*J. Vahne, Zur Frage d. Vetilgung v. Nematoden aus schadlichen Pilzen im Boden, Wiener landw. Ztg. 1897, p. 732.

nematodes but we have no data in regard to this method when carried on upon a large scale. We have, on the basis of our own experiments, frequently advised cucumber growers who were troubled with nematodes, to try this method on a more extensive scale than we could. But as yet we have received no reports. Most of our cucumber houses lie idle long enough during the summer to give this method a more thorough trial than is possible out of doors, inasmuch as greenhouse soil is not subject to occasional drenchings from rain and consequently the drying can be carried on to a much greater extent. This treatment is so simple that it is hoped reliable data may be furnished ere long.

(c).—THE HALLE OR CATCH CROP METHOD OF DESTROYING NEMATODES.

The method of treating nematodes other than by chemicals was originated and employed some years ago by Dr. Julius Kühn of the University of Halle, Germany, and it has since been extensively tested by Dr. Kühn and his colleague Dr. Hollrung, both of whom have spent some years in investigating the nematode pest in connection with the sugar beet industry. In 1896 we visited Halle and examined the work done at this institute, and we wish here to express to Dr. Max Hollrung our appreciation of the many courtesies shown us while there.

The parasitic nematode (Heterodera) is widely distributed and very injurious to the sugar beet in Europe and any method which endeavors to control it must be one which can be applied cheaply, on account of the large area which it is necessary to treat. The method employed is based upon the knowledge gained from a study of the life history of the organism. It has been shown by Strubell that the worm on entering the beet develops its young in the course of six weeks, and Kühn taking advantage of these facts reasoned that, if the infested host plants could be dug up and destroyed before the worms laid their eggs, the soil could be rid of a large number of worms. His method, therefore, consists in trapping the worm and is popularly known as "The Catch-crop Method", and for the succesful carrying out of this idea in treatment he made use of a host plant especially susceptible to Heterodera, generally a species of mustard (Brassica Rapa rapifera, Metzg.) which he sows on the soil in the spring. The nematode attacks the mustard, gains entrance to the root, and locally stimulates the plants to produce galls. About the time the roots of the mustard become well covered with galls, which is an indication that the worms are confined within the tissues of the host, and before they have laid their eggs, the roots of the mustard are plowed up and are either exposed to the drying rays of the sun or are raked up and burned. In this way the catch-crop method not only destroys a great many nematodes contained in the infested soil, but also hundreds of eggs, which if left would in a short time give rise to innumerable adult worms. Dr. N. A. Cobb (l. c. p. 170.) states that the female nematodes lay from 300-400 eggs, and when we consider that some galls are one inch or more in diameter and contain numerous females the crop of young must be enormous. We have frequently obtained hundreds of them when only two or three females were introduced. By continual planting catch crops in the soil the nematodes can be reduced to a considerable extent, as the experiments of Kühn and Hollrung seem to show, but it is impossible to completely rid the soil of the worms. Such a method might be of some value in our Southern States where the nematodes are very abundant and attack a large variety of cultivated plants, but in the north, where the Heterodera cannot stand our winter climate and where they attack almost entirely greenhouse plants, more effective remedies must be sought.

The Effect of Chemicals upon Nematodes.

Our first experiments relating to the control of nematodes were largely along the line of many of those we have just described, that is to say we endeavored to find some chemical method of control. The problem confronting us was to be sure somewhat different from that confronting those having large areas of infested soil out of doors with which to deal. Granting that the chemical method of treatment might be more or less successful out of doors, we ought nevertheless to require some more absolute method in greenhouses, because there is much less area of soil there to be treated and it is under conditions which can be more readily controlled. Nevertheless we made many hundreds of experiments with chemicals in order to give them a thorough trial and to see if such a method of treatment was practical. We carried on our experiments simultaneously in the laboratory and in the greenhouse which were connected with each other. Parts of the greenhouse had been devoted to nematode work for over three years and the space devoted to the purpose was large enough to pursue our experiments to advantage. In general, however, the solutions were tried in the laboratory first to see what effect they would have upon the adult worm. For this purpose numerous cultures of nematodes were kept on hand. In order to test the various solutions upon them we employed hollow glass slides placing the worm directly in the solution, and where volatile solutions were used we utilized what is known as the Van Tieghem drop culture chamber which consists of a glass cylinder about $\frac{3}{4}$ in. in diameter, having a capacity of about 3cc., fastened to an ordinary slide. This gave us a tight moist chamber in which the nematodes were suspended in a drop of water on the under side of the cover slip, the volatile solution being placed in the bottom of the chamber. The number of nematodes selected for treatment varied anywhere from 5 to 100. The experiments were confined entirely to the adult worm* and not to the eggs of the nematode which were, however, sometimes present. In some instances the solutions were made up from pure chemicals, in other instances commercial chemicals were used. The following table shows the various experiments made in the laboratory with chemical solutions of different strength.

*Note. In these experiments various free living species of nematodes were used.

TABLE SHOWING THE EFFECTS OF VARIOUS STRENGTHS OF CHEMICAL SOLUTIONS UPON ADULT NEMATODE WORMS.

Solution.	Strength of solution.	Time of observation.	Results.
Manganese sulfate,	1-250	9 days	alive.
	1-100	18 hrs.	alive.
Common salt,	1-250	2 days	alive.
	1-100	52 hrs.	alive.
Potassium nitrate, c. p.,	1-250	52 hrs.	alive.
	1-100	52 hrs.	alive.
Magnesium sulfate, c. p.,	1-100	6 days	alive.
Calcium sulfate, c. p.,	sat. sol.	24 hrs.	alive.
Kainit,	1-250	5 hrs.	alive.
	1-100	52 hrs.	alive.
		10 days	alive.
Sodium nitrate, c. p.,	1-100	52 hrs.	alive.
Potassium sulfid,	1-100	3 hrs.	alive.
	1-50	1-2 hr.	alive.
Hydronapthol,	1-2000	96 hrs.	alive.
Tobacco decoction,		18 hrs.	alive.
Ammonia sulfid,	1-100	3 hrs.	alive.
Potassium permanganate,	1-100	3 min.	most all movement ceased.
		10 min.	all dead but two.
		35 min.	all dead.
	1-200	3 hrs.	dead.
	1-250	4 hrs.	dead.
	1-400	1 hr.	slight movement.
		4 hrs.	apparently dead.
	1-500	18 hrs.	dead.
	1-800	5 hrs.	some living.
		24 hrs.	all dead.
	1-1000	24 hrs.	dead.
Lime water (slacked),	sat. sol.	24 hrs.	alive.
Lime water (air slacked),	sat. sol.	24 hrs.	alive.
Lime and sugar equal parts, (saccharate of lime),	1-100	30 min.	dead.
	1-40	30 min.	dead.
	1-20	30 min.	dead.
	1-10	3 min.	dead.
Caustic potash (crude),	1-100	18 hrs.	alive.
Ammonia, c. p. (vapor),	1-100		killed instantaneously.
Benzole (vapor),	full str.	1 min.	all succumb.
Ammonia, com'cial (vapor),	full str.	2 hrs.	slightly quicker than benzole.
	1-100		dead.*
Ammonia water (vapor), (from gas works),	full str.	1 min.	all succumb.
	1-5	5 min.	all succumb.
Potassium sulfid,	1-100	1 1-2 hrs	alive.
Formalin (commercial),	full str	7 min.	dead.
Carbon bisulfid,	full str.		died instantaneously.

*The exact time was not observed at which they all succumbed.

From these experiments it will be readily seen that there are many solutions that will kill the isolated nematode instantly, and there are many other solutions that have apparently no effect upon them when left in the solution for a number of days. Those solutions that are volatile and which give off a penetrating vapor are the most effective as nematode destroyers, such for example as Carbon bisulfid, Benzole, Ammonia, Formalin, and Ammonia water from gas works, the latter solution besides containing Ammonia, possesses many of the coal tar products and has some value as a fertilizer when used in dilutions. The most effective solutions applied were Potassium permanganate, Lime and Sugar, (Saccharate of lime), and Potassium sulfid. The first named solution 1-200 killed all nematodes in three hours and this strength of solution can be applied to the plants without injury to them. The lime and sugar was made as follows: 5 grms. of lime were slacked in water and to it was added 5 grms. of sugar to which was added 100 cc. of water, thus making practically a 10% solution or 10-100. For more accurate purposes the degree of alkilinity could be employed as a basis for the solutions. This was reduced to various proportions. In a saturated solution of slacked lime water the worms were alive and apparently well after 24 hours. This experiment was not continued as it was thought to be useless. In a solution of 1-250 Manganese sulfate they thrived 9 days and similar results were obtained with common salt, Potassium nitrate, Magnesium sulfate, Kainit and Sodium nitrate. Hollrung also experimented with solutions of Kainit, Carnallit, Chlorid of Potassium and Sulfate of Potash in a similar way. He employed different strengths of solutions which were as follows 0.1%, 0.5%, 1.0%, 2.5% and 5.0%, or 1-1000, 1-200, 1-100, 1-40, and 1-20, and examinations were made at different periods ranging from 5 minutes to 96 hours. He concluded that these solutions were not capable of being used as a remedy for nematodes.

Most of the solutions enumerated in the preceding table were also tried upon cucumber plants in the greenhouse which were planted in nematode infested soil. As a rule the pots employed were 10 inch ones and numerous seeds were sown in each. The roots of the seedlings were examined from time to time with the naked eye and also with the microscope to ascertain whether nematodes were present and the amount of infection to which they were subject. The following table shows the results in a condensed form of only a few of the experiments made along these lines. The name of each solution tried is given in the first column, and the strength of the solution, the amount applied, and the size and number of pots are also given.

The strengths of the solutions are given in proportion as in the previous table, for example, 1-200, which indicates that one part of the solution was used to 200 parts of water or practically a 0.5% solution.

While the experiments with chemicals given in this table constitute only a few of the many which we have made, they are nevertheless representative as far as reaching any positive results are concerned. In fact the solutions given in the table are those which in our laboratory experiments appeared to give the most promising results and as we have already pointed out some of them have been recommended by other experimenters. From the many hundreds of microscopic examinations of the young cucumber roots and previously infested soil in which they were growing there can be no doubt but that some of these solutions when applied quite strong and in considerable quantities are capable of killing many of the adult worms in the soil. We have repeatedly found many dead nematodes in the soil after applying large amounts of Potassium permanganate of the strength of 1-200 or 1-300, or of Potassium sulfid at the rate of 1-250, etc., and all of the experiments with Carbon bisulfid, commercial Ammonia, and most of those with Ammonia water from gas works showed the same thing. The remaining solutions appeared to have no effect upon the adult worms at the strengths at which we used them and even where we covered the surface of the soil with lime to a depth of $\frac{1}{8}$ inch and watered the same with a saturated solution every few days, nematodes were abundant in the soil. Evidently the most effective solutions for the worms were Carbon bisulfid and the two Ammonia solutions. The killing of a few adult worms in the soil, however, is of absolutely no consequence. As long as the nematode eggs are present a new crop of large proportions can be expected within a few days. The solutions appear to have no effect upon the eggs because they are protected by an almost impervious coating. Dr. N. A. Cobb states that the young embryo is well protected in the shell and can withstand very strong poisons.

TABLE SHOWING THE EFFECTS OF SOLUTIONS UPON NEMATODE-INFESTED EARTH IN WHICH CUCUMBERS WERE GROWING.

Solutions.	Strength of solution.	Amount applied to each pot.	No. of pots employed.	Results.
Potassium permanganate.	1-200	700 cc.	6 10-in.	Negative.
	1-250	800 "	6 "	
	1-500	800 "	6 "	
	1-750	800 "	6 "	
	1-1000	800 "	6 "	
	1-300	800 "	8 "	
	1-250	2500 "	1 "	
Kainit.	1-200	800 "	6 "	Negative.
	1-200	800 "	6 "	
Manganese sulfate.	1-200	800 "	6 "	Negative.
	1-200	800 "	6 "	
Potassium sulfid.	1-250	250 "	4 7-in.	Negative. 1-100 injured the plants.
	1-200	250 "	2 "	
	1-100	250 "	2 "	
Slacked lime water.	saturated sol.	applied freely.	4 "	Negative.
Nitrate of soda	1-150	500 cc.	4 "	Negative.
Ammonia, (commercial).	1-100	250 "	2 10-in.	Negative.
	full strength.	10 "	2 "	Negative. Solution applied before planting.
	" "	15 "	2 "	
	" "	25 "	3 "	
Carbon bisulfid.	" "	5 "	6 "	Negative. Solution applied before planting.
	" "	10 "	6 "	
	" "	15 "	6 "	
	" "	20 "	6 "	
	" "	30 "	2 "	
Ammonia water, (gas works).	" "	10 "	6 "	Negative. Solution applied before planting.
	" "	20 "	6 "	
	" "	25 "	8 "	
	" "	40 "	6 "	
	1-4	800 "	12 "	Negative. Solution applied after planting. 1-3 and 1-4 injured the plants.
	1-5	800 "	9 "	
	1-6	900 "	6 "	
	1-8	800 "	6 "	
	1-3	150 "	1 "	

Plate X. illustrates the result of one experiment which bears upon this point. The photograph was taken in our experiment house and shows six pots with dead immature cucumber plants in them which were set out at the same time as the other robust uninfected plants shown at their right and left. In this experiment two of the pots received before planting 30 cc. of Carbon bisulfid each; two also received 30 cc. of Ammonia water from gas works; and two pots were treated with 2100 cc. of Potassium permanganate at the rate of 1-300. The Potassium permanganate pots were again treated twice some days afterwards with the same amount and strength of solution except that the last treatment was at the rate of 1-250. Microscopic examinations of the soil after treatment showed many dead worms, but ten days afterwards when the young cucumbers had already appeared, an examination of the soil showed abundant nematodes, and galls had commenced to form profusely upon the roots. The cucumbers in each of the six pots were in badly infested earth and none of them ever lived to be more than 15 inches in height, and notwithstanding the fact that each pair of pots received different treatments of a severe nature there was no choice between the plants a few weeks later. Such results as these demonstrate the futility of attempting to treat nematodes by chemicals, for here we had them confined to pots, or in other words to narrow limits and under the most favorable conditions for exterminating them. Even should this treatment have proved successful the amount of solution which would have to be applied to open soil on a large scale would be costly. Almost all solutions when applied to the soil in considerable quantities are harmful to the plants. Potassium permanganate appears not to injure plants as much as one would suppose. We have applied at a single time 2500 cc. (over two quarts) of this solution at the rate of 1-250 to a 10 inch pot of earth containing cucumbers, without the slightest ill effect. Ammonia water from gas works as we obtained it is injurious when applied even at the rate of 1-6; that is one part of Ammonia water and six parts of ordinary water. Potassium sulfid is more injurious to plants than Potassium permanganate and a mixture of Sugar and Lime even when considerably reduced is quite injurious; although Lime itself causes no harm to cucumber plants and is sometimes used by practical growers to improve their soil. Carbon bisulfid was applied to the soil usually before the plants were set out. This was done as follows: a hole was made with a stick in the soil reaching nearly to the bottom of the bed, or pot if such happened to be used, into this was inserted a funnel to catch the liquid and convey it to the bottom of the hole, after which the funnel was removed and the top of the hole was stopped up with earth. The fumes from the very volatile liquid soon permeate the soil and in this way many worms are killed. It was not possible, however, to apply much of this solution to pots containing cucumber plants, as we found that they were invariably injured even when as small a quantity as 15 drops were used, although in the open soil it can be employed with much less injury to the plants. Commercial Ammonia and Ammonia water from gas works were usually applied in the same way as was the Carbon bisulfid, although neither of them at the concentration used caused any injuries to cucumber plants.

From the experiments with solutions we may draw the following deductions:—

There are many solutions capable of killing a certain percentage of adult worms that can be applied to the soil either before or after planting without injuring the plant. The strength and the amount of the solution necessary to kill the adult worm in the soil is considerably greater than that necessary to apply when the worm is isolated. This is due to the difficulty in getting the solution to come in contact with each particle of matter in and around which the nematodes thrive. None of the solutions named above are capable of killing the eggs of the nematode in the soil, and unless this is accomplished the treatment is of no account.

Sterilizing or Heating the Soil the most Effectual and Practical Method of Exterminating Nematodes in the Greenhouse.

Our experiments in heating the soil by means of steam for the control of nematodes have been carried on for three years. At the outset we did not happen to know of any practical method of heating soil with steam—neither did we consider it wise to experiment too extensively along this line until we had obtained more knowledge of the efficiency of chemicals upon nematodes. Subsequently, however, we learned of some investigations being made by B. T. Galloway[1] of the U. S. Dept. of Vegetable Pathology on the effects of heating soil by steam for the purpose of ridding it of violet

1 For description see American Gardening Vol. XVIII, 1897 p. 127.

nematodes, and this led us to make more extensive trials of the steam heating method. While our experiments upon sterilizing[1] the soil were well under way there appeared Bulletin No. 73 of the Ohio Station[2] which gave some account of sterilizing the soil for the nematodes on cucumbers. It appears from this bulletin that Mr. Lodder, a practical cucumber grower in Ohio, who had experienced severe losses from nematodes reported favorable results from the use of steam. In looking up the matter further we also found that a Mr. W. N. Rudd[3] had earlier employed a method similar to that described above with favorable results. More recently Mr. J. N. May[4], a large rose grower, has described a method which he has used extensively for sterilizing his soils to rid them of nematode worms. Mr. May's heating is done on a large scale and it would appear to be a practical method of treating nematodes even when carried on in connection with a large range of houses. Our own experiments along this line have demonstrated that as far as greenhouse culture is concerned the method of sterilizing the soil by means of steam for the purpose of ridding it of nematodes is at the present time the most practical method which can be employed, although it is not at all improbable that some other cheaper method may yet be found.

Amount of Heat Necessary to Kill Nematodes and Their Eggs.

From the account given by Mr. May it would appear that considerable heat is required to kill nematodes in the soil. He states that "by the best authorities it is proven that nothing short of 225° F. will kill them (nematodes) when protected in the soil, but to make sure work 235° F. of heat is necessary". In regard to this statement we shall have to take some exceptions and will subsequently show that such temperatures are unnecessary to kill nematodes except under exceptional conditions.

It is well known that a temperature of 212° F. will kill any organism in a short time and in fact the great majority of organisms are killed at much lower temperatures. Again the resistance of animals

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1 Note. While the term sterilizing has been employed by all writers who have described their experiments upon steaming soil, it must be borne in mind that probably in every instance complete sterilization has not been accomplished. We made cultures of soil which had been heated up to 204 F. and in every instance bacteria were abundant.

2 Ohio Agricultural Experiment Station, Bulletin No. 73, p. 227, 1896. By A. D. Selby.

3 American Florist, Vol. IX, p. 171, 1894.

4 American Florist, Vol. XIII, Feb., 1898.

to heat is not so great as the spores of bacteria and fungi. In the case of nematodes we have not only to kill the adult worm which is not remarkably protected against heat and desiccation, but also its eggs which are able to offer considerable more resistance to the various elements, inasmuch as they are provided with a more protective membrane. Nevertheless there is nothing about the structure of a nematode egg which would render it so impervious to heat as some of the smaller spores which every bacteriologist has to deal with in sterilizing his culture media. If a large mass of soil is heated and the circulation of the steam is irregular through it then it may be necessary to use high temperatures in order to thoroughly impregnate every particle of the soil with steam and thus bring every particle to the same temperature. From a letter which we received from Mr. May we inferred that this was the principal reason for his using high temperatures. Our own experiments upon this point were numerous and they were made with earth containing abundance of nematodes of various species in all stages of development. For the sake of convenience we will designate these experiments as a, b, c, etc. In all of these experiments we employed cucumbers in pots of various sizes, (from 4 in. to 10 in.), and the plants were left until they were sufficiently large to show root galls upon them if nematodes were present in the soil. In every case except "a" the pots containing the infested earth were sterilized in an Arnold steam sterilizer and when moderate heating was required they remained in the sterilizer only a few minutes. The earth in experiment "a" was part of a large lot which was sterilized in a box by means of steam from a boiler. (See fig. II., 1, 2, 3). In every instance numerous microscopic examinations were made of the soil and roots of the plant in order to determine whether nematodes were present. The non-parasitic species are generally present in almost every soil and their presence can very often be suspected by the coloration of the root. They are generally found on the older parts of the root near the surface of the soil as indicated by the dirty brown color of the epidermal tissue. The experiments are as follows:

Exp. a. Six 4-in. pots were filled with infested earth which had been heated at 212° F. The pots were also sterilized and the cucumber seed after soaking 12 hours in water was placed for 10 minutes in a saturated solution of corrosive sublimate and before using was rinsed with sterilized water. During germination and the growth of the plants they were always watered with filtered water. Hence all source of contamination was eliminated. Result, no nematodes.

Exp. b. Six plants treated as above. Result, no nematodes.

Exp. c. Twelve pots of cucumbers, the seeds of which were treated as in Exp. "a" and the plants watered with sterilized water. Instead of the soil in the pots all being heated to 212° F. they received the following various degrees of heat before planting:

No. of pot,	1	2	3	4	5	6	7	8	9	10	11	12
Temperature,	114°	118°	127°	140°	147°	150°	159°	161°	163°	163°	170°	176° F.

Result. Nos. 1, 2, and 3 all damped[1] off. The remainder were perfectly free from the damping fungus and nematodes.

Exp. d. Sixteen pots of cucumbers treated the same as "c."

No. of pot,	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Temperature,	147°	149°	154°	159°	163°	167°	168°	172°	176°	183°	185°	186°	192°	194°	196°	19[illegible]°F.

Result, no nematodes.

From these experiments which only represent about one-half of what was done it appears that a very high temperature is not necessary in order to free infested soil of nematodes. The number of degrees of heat necessary is about 140° F., but as a matter of safety the temperature should go above this inasmuch as in large areas of soil the distribution of heat is always unequal, and while one portion may be heated as high as 190° F. another portion may not exceed 110° F. The conclusion then that the soil must be heated under pressure to a temperature of 225° or 235° F. in order to kill all nematode life is therefore not valid in all cases. These experiments were made with sufficient care and were repeated often enough with the same results to consider them trustworthy. The practice of soaking the seed in a strong solution of corrosive sublimate before planting them was perhaps an unnecessary precaution inasmuch as we have never been able in repeated examinations to find any evidence of nematode infection from this source, but the watering of the pots with filtered water[2] or water which had been previously boiled was quite necessary where we were making observations upon non parasitic species. We have observed many instances of sterilized soil becoming infested with the non parasitic nematodes from

1. The damping fungus in this case was the Pythium De Baryanum, Hesse, which is frequently troublesome to cucumber seedlings.

2. We used for this purpose an ordinary sand filter which we attached to the faucet.

the water supply, although we have never detected a case where the parasitic species originated from this source. It is quite likely that the infection comes more often through the nematode eggs contained in the water and less often through the adult worm. The non parasitic nematodes are in general associated with all kinds of decay, and all of our public water supplies which contain decomposing vegetation furnish no doubt an environment for certain species of nematodes. It is not improbable that the high temperatures recommended by some for the control of nematodes were based upon experiments in which care was not taken to prevent contamination, but it is more likely that the large mass of soil employed was not heated evenly and perhaps some portions fell below the requisite degree of temperature. This is more likely to occur where defective methods of piping are employed and also where the soil is piled up to a considerable depth, in which case a thermometer thrust into the top layers of the soil would not always indicate the temperature of some portions underneath.

Methods of Sterilizing the Soil.

Descriptions of methods of sterilizing the soil have not been very numerous up to the present time.

In 1892 Sturgis[1] recommended a method of heating soil for Aster culture. In this case the plants were grown out of doors and the roots became covered with galls probably through the introduction of unfrozen soil or manure which was infested with the worm. It can easily be seen that there are many difficulties in heating soil out of doors to kill nematodes and when attempted on a large scale it would not be practicable nor in this climate necessary, providing proper precautions are taken. Should such a measure become necessary, however, the method advocated by Dr. Sturgis might be employed on a small scale. He recommends the application of a device commonly used for drying earth in the preparation of asphalt pavements. It consists of a large piece of sheet iron 6 or 8 feet square, raised from the ground. A wood fire is built under this and the earth is thrown on and allowed to heat for 10 or 15 minutes. When this is completed the earth is removed and another supply is placed upon it and heated for the same length of time. A considerable quantity of earth can be heated in this way in

1. Conn. Agr. Expt. Station Report, 1892, p. 48.

a single day, but as we have previously stated we question whether for nematodes there is ever any necessity for treating out of door earth, provided careless inoculation of the soil is guarded against. This method of heating would, of course, produce different conditions in the soil from that of steaming. We have never found the dry heating method as satisfactory as the steam method, inasmuch as the former leaves the soil dry and disturbs the mechanical conditions, while the latter method leaves it moist and porous and more suitable for plant growth. The first notice of the application of steam for sterilizing upon a large scale which we have observed is that used by Mr. W. N. Rudd[1] of Mt. Greenwood, Ill. The steam method has probably been used by other growers even before this but we have taken no particular pains to look up this point. Mr. Rudd employed a box 20 ft. long, 6 ft. wide, and $4\frac{1}{2}$ ft. deep, over the top of which he placed some hot bed sash and in the bottom of the box he ran three lengths of $1\frac{1}{4}$ in. steam pipes which were bored every 18 in. with $\frac{3}{16}$ in. holes, thus allowing the steam when forced in to penetrate through the soil. He does not state the pressure of steam used or the temperature to which the soil reached, but says that when a potato which he usually put in the soil is cooked the earth is ready to be used and that two hours steaming is sufficient for this purpose.

Mr. Lodder[2] later describes a method similar to that used by Mr. Rudd but with some variation in the details of constructing the box and utilizing the steam. He used a box 20 ft. long, 6 ft. wide, and 5 ft. deep, which sat upon the ground and was provided with a solid bottom and a cover for the top. The floor of this box upon which the soil was placed was raised 1 ft. from the bottom, thus forming a superstructure,and consisted of $1\frac{1}{4}$ in. steam pipes laid close together which were open at each end presumably for the free circulation of the steam. The main steam pipe passed lengthwise through the box just under the superimposed pipe floor and was $1\frac{1}{4}$ in. in diameter with $\frac{1}{4}$ in. openings every foot. The pipes constituting the floor were covered with a layer of straw to prevent the earth which covered them from sifting through. The steam which is let into the pipes soon completely fills the space below the soil and when under pressure passes upwards between the pipes and through the straw,

1. American Florist, Vol. IX., p. 171, 1896.
2. Ohio Agr. Expt. Station, Bulletin No. 73. p. 231, 1896.

permeating the soil. Mr. Lodder claimed to sterilize the earth in this box, which contained 480 cu. ft., in four hours when a pressure of steam equal to 40 lbs. was maintained, and in three hours when the pressure was equal to 60 lbs.

Mr. Galloway[1] of the Dept. of Vegetable Pathology, Washington, D. C. has given a brief account of a method employed by him for sterilizing soil infested with rose and violet nematodes. He made use of an ordinary porous 2 in. drain tile instead of steam pipes punctured with holes. The drain tiles are placed in the bottom of a box of any convenient size and connected with a steam pipe leading from a boiler having a high pressure. The box used in his experiment was 12 ft. long, 12 in. deep and 6 ft. wide, filled with soil, and through this three lengths of tile were placed. This was covered with hot bed sash in order to inclose the steam. Such a box will hold 72 cu. ft. of earth and he claims that this amount of soil can be heated in two hours. From the results of our own experiments along this line we feel quite certain that with six lengths of tile in a box of this size instead of three this soil could have been heated in one hour.

Mr. J. N. May,[2] an extensive rose grower, has recently described a method of sterilizing soil which he employs on a large scale. He makes use of two bins, each of which is 12 in. deep, 3½ ft. wide, and 16 ft. long, and which hold together 112 cu. ft. of soil. These bins are provided with covers rendering them as air tight as possible. They are constructed upon the ground which is slightly graded so as to slope in one direction for the purpose of taking care of the condensation in the pipes. At the bottom of the bins are placed a number of steam pipes 1 in. in diameter which are provided with manifolds at each end and which virtually make a coil. Every third pipe is bored upon the side with holes about 15 in. apart. When the soil is put in and the steam is turned on, part of it escapes through the holes in the pipes and penetrates the soil above. The condensation is conducted by the manifolds back to the boiler. When one bed is sterilized it is uncovered and taken away while the other bed, which in the meantime has been prepared, is steamed. By this method Mr. May empties five or six bins in a day, but to

1. American Gardening, Vol. XVIII, p. 127, 1897.
2. Sterilizing Soil for Destroying Eel Worms. American Florist, Feb. 5, 1898.

accomplish this he states that it is necessary to have a boiler of some 25-horse power carrying at least 50 lbs. pressure of steam continually. These are the only methods for sterilizing soil, so far as we are aware, that have been described, and all of these methods have been described within two or three years.

In our experiments[1] relating to soil sterilization we have tried many methods and found the tile system as used by Galloway cheap, and satisfactory for many purposes, especially when we wish to sterilize the soil in the bed in which the crop is to be grown. Another advantage which it possesses is that it can be used for subirrigating purposes. To ascertain the best method of using tile we arranged them in beds of equal size containing the same amount of similarly prepared earth. The beds were 18 ft. long, 30 in. wide and 1 ft. deep and each contained 45 cu. ft. of soil suitable for growing cucumbers. Part of the soil had been used previously for cucumbers and tomatoes and was well infested with nematodes, and previous to sterilization it was mixed with fresh horse manure. The beds contained a different number of feet of pipe which were laid in various ways and in each case they were placed about 2 in. from the bottom. For details concerning the manner of piping see fig. I., a, b, c, d, e. Bed (a) was piped with two lengths of tile without any end connection. Bed (b) was piped with three lengths of tile with end connections, thus forming a continuous circuit. Bed (c) was piped with two lengths of tile with end connections and cross tile every two feet. Bed (d) was piped with three lengths of tile as in (b). Bed (e) was not piped at all. Each bed was treated separately from a 4-horse power portable boiler having a pressure of steam varying from 40 to 80 lbs. The steam was conducted from the boiler through a half-inch pipe provided with a valve, and this led into a 1 in. pipe, (fig. I., 1), which had a four way connection, the ends of which were inserted into the free open ends of the tile. The connections were easily made with the boiler and when one bed was sterilized it was disconnected and the pipe attached to another bed. The steam was confined by means of boards placed over the top, although straw mats or blankets would have served the purpose better. The valve regulating the amount of steam from the boiler was never turned on more than half way, this being found sufficient to supply

1. See Nematode Worm and Root Gall on Cucumbers and Tomatoes, New England Farmer, Feb. 26, 1898.

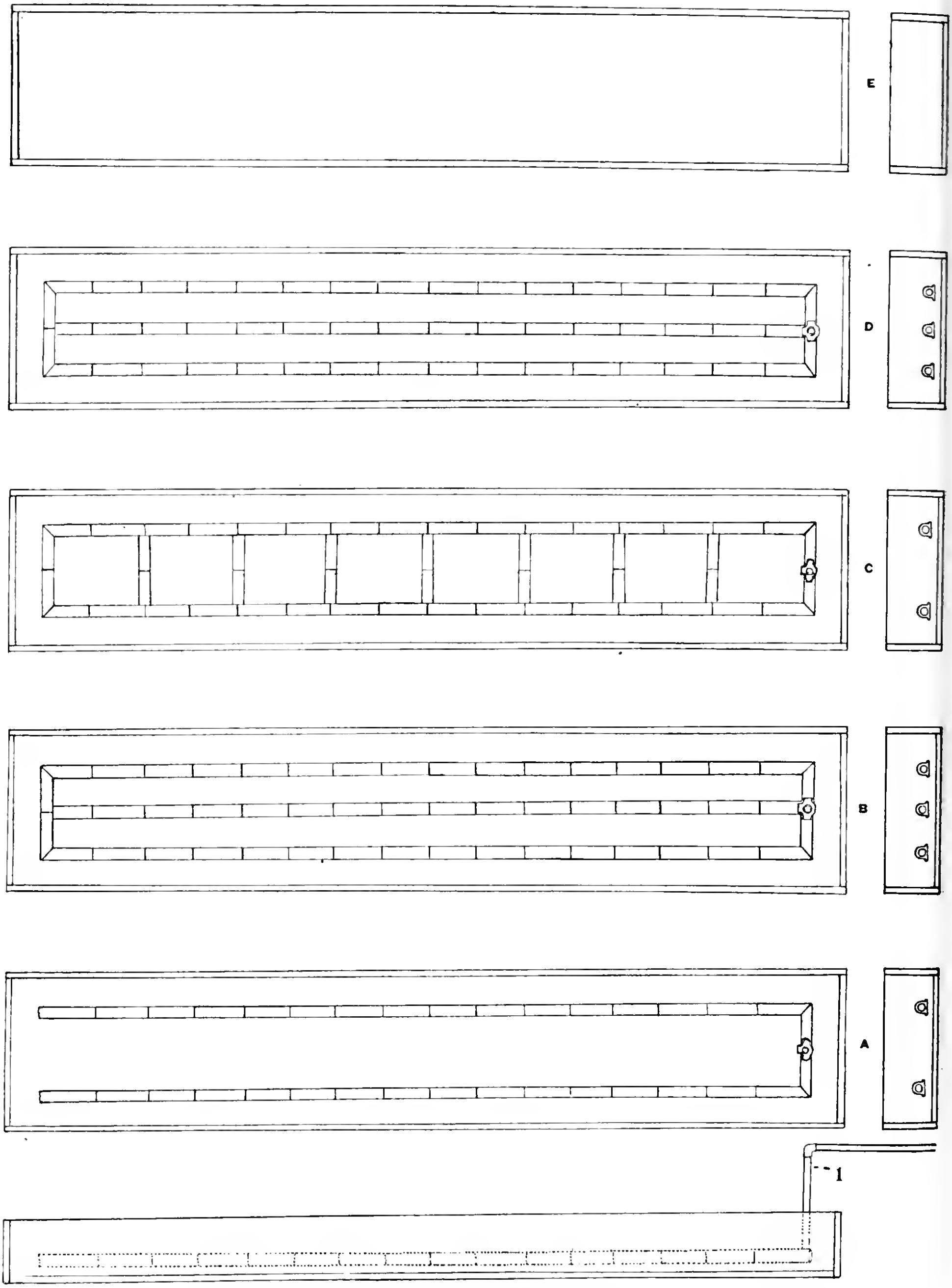

Fig. I Showing the arrangement of piping beds with 2 in. tile. The beds are 18 ft. long, $2\frac{1}{2}$ ft. wide and 1 ft. deep. The tile are placed about 2 in. from the bottom and the various methods of arranging them are shown in cross and vertical section.

all the steam required, and it was, moreover, necessary in using so small a boiler in order to keep the pressure of steam high.

The results of these experiments are as follows:

Bed (a) was heated to 204° F. in 1.15 hrs.
Bed (b) " " " " " " 45 min.
Bed (c) " " " " " " 1.00 hr.
Bed (d) practically the same as (b).

These experiments show that bed (b) which was piped with three lengths of tile gave the best results, with bed (c) following, and the most unsatisfactory results were given by bed (a). Bed (d) gave practically the same relative results as (b). Bed (b) contained a few more feet of pipe than (c), and more than $\frac{1}{3}$ more than (a), and for this reason alone it might be expected that the heating of the soil in the bed (b) would be more effective. There is another more important difference, however, and that is in the method in which the steam circulated. The cross tiles in (c) were not nearly as effective as the middle lengths in (b), neither would they have been even if they had contained the same linear feet. Bed (a) would have heated more effectually if there had been a continuous loop. Had the four beds been piped the same and all connected at once with a large boiler maintaining a high pressure of steam they could have been heated in two hours time. The tile which were employed for sterilizing were left in the soil, but in these experiments they were not used for sub-irrigation purposes. Should the soil, however, be removed and replaced by other soil it would be desirable to remove the tile, which can, however, be easily put back. We have tried many different methods of piping with variations in the pressure of steam and we will state that in order to get the cheapest and best results it is necessary to pay attention to two points, namely, that the higher the pressure of steam maintained, the quicker and more effectual are the results, and the greater tile area in which the steam has to circulate the quicker it will find its way through the soil and accomplish the sterilization of the same. It is not only necessary that there should be a number of feet of pipe in the soil in order to sucessfully heat it, but the area of cross sections is equally important.

In regard to the cross section area of the pipe we will relate the results of one of our experiments in trying to sterilize a box of soil with $\frac{1}{2}$ in. lead pipe made up into a coil of four lengths. This coil had holes in it 2 in. apart and was placed in a box containing

16 cu. ft. of earth which was easily heated in one hour's time when three lengths of 2-in. tile were used and a pressure of 4 or 5 lbs. of steam. With the small lead pipe it was found that it was impossible to heat the soil after running it for a number of hours. The method just described is especially adapted to sterilizing soil in the bed where it is subsequently to be used in growing some greenhouse crop subject to nematodes. It should be stated, however, that certain beds are more suitable for this purpose than others. Soil can be more effectually heated in a narrow bed than in a wide one. Many of our cucumber growers raise their plants in a bed 15 or 18 in. wide, 8 to 12 in. deep, and 50 to 100 ft. or more in length. Beds approximating these dimentions could be easily heated in a short time at little expense, and in a cucumber house it would be most desirable to construct them after this manner. Not unfrequently, however, cucumber houses are not provided with benches but the vines are grown directly in the ground soil. In this case should sterilizing become necessary, the earth in which the plants are growing can be separated from the remaining soil by means of 12 in. boards or plank and this lot of earth can be tiled and then treated. The boards or plank arranged in this manner restrict the amount of soil to be treated and prevent contamination from the untreated. In case pots are used as frequently happens in tomato culture the earth can be sterilized in a special bed or the pots containing the earth can be placed in a tight box and sterilized, although this latter method is not so practical as pots take up more room than soil placed in a bed. For sterilizing small quantities of earth we make use of an ordinary small house boiler which heats our laboratory and seldom indicates more than 3 or 4 lbs. pressure of steam. This is connected with a box, (see fig. II., 1, 2, and 3), containing 15 cu. ft. of earth, in the bottom of which is buried three lengths of tile supplied with steam from the boiler. With a pressure of 3 or 4 lbs. of steam the box can be easily heated to 212° F. in one hour's time and this amount of earth will fill about fifty 10 in. pots. A small bed of this description would be exceedingly convenient for florists in sterilizing earth for such pot plants as cyclamens etc. Another convenient arrangement for sterilizing which we use for a variety of purposes is shown in fig. II., 4, which represents a cross section of a box, but it is not adapted for sterilizing earth except when in trays or pots. This is simply an ordinary zinc lined box. It is provided

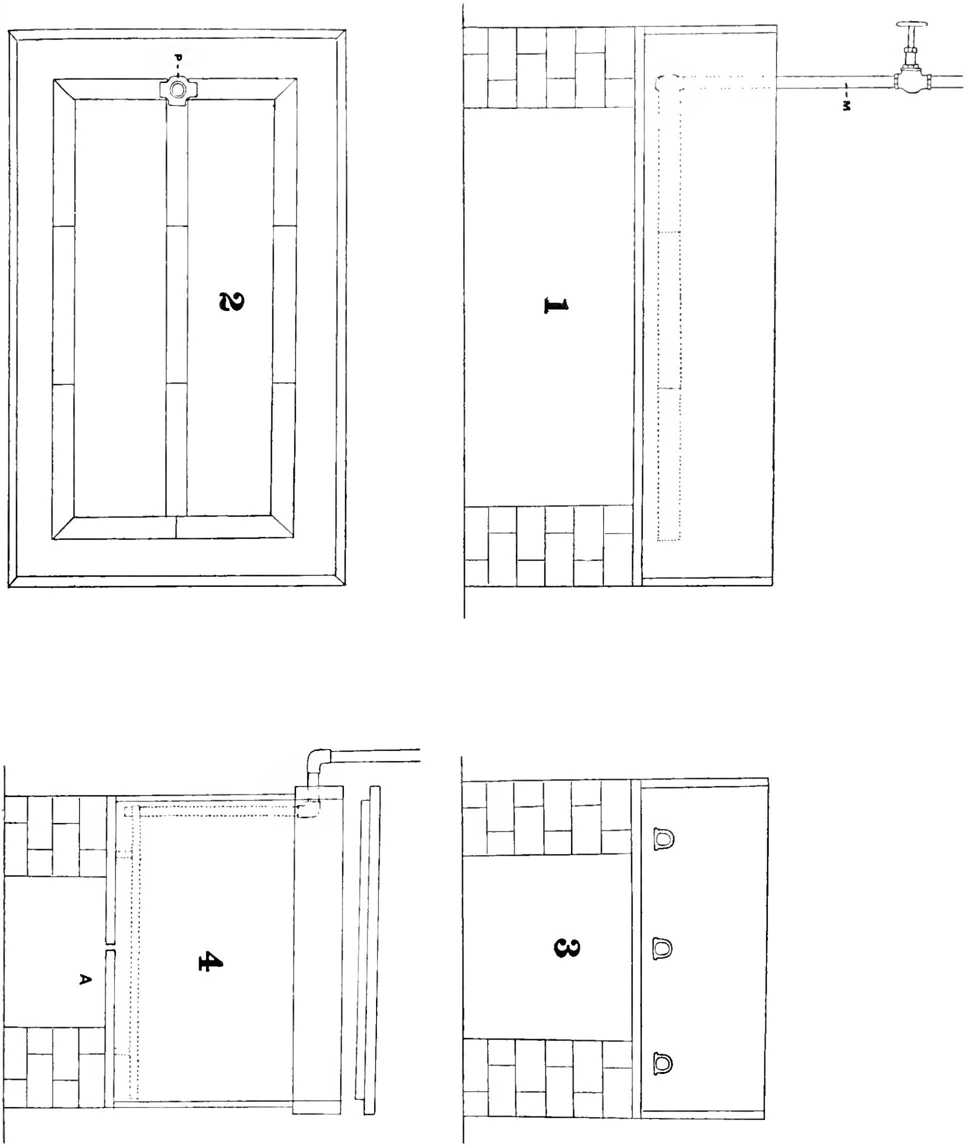

Fig. II Showing the details of a small sterilizing apparatus. 1, 2, and 3 represent various sections of a box furnished with tile and capable of holding 15 cu. ft. of earth. (m) steam pipe from boiler. (p) four way connection which enters the tile. 4 represents a cross section of a zinc lined box and cover for sterilizing pots and small boxes of soil. (a) valve or hole for drawing off the condensed steam.

with a wooden cover of double thickness which with the use of an old blanket makes it fairly tight. The steam pipe enters in one side near the top and passes down the inside to within an inch of the bottom. A wooden support made up of slats keeps the object to be sterilized from touching the bottom, and a valve (a), or much simpler, a hole plugged with a cork, allows for the drawing off of the condensed steam which gathers in the bottom of the box. This manner of sterilizing[1] is very convenient for steaming small boxes of earth, pots, etc., as it can be done in a very short time, and at very little expense. An old zinc lined refrigerator, however, could be substituted for the box to good advantage. The method of ridding the soil of nematodes where such plants as cucumbers, tomatoes, etc., are sown and where the crop is obtained from the seed offers fewer obstacles than such plants as violets where transplanting is accomplished by separation, as the latter process necessarily includes taking some of the old soil with the plant. If the violet plants are affected with nematodes it must be clear that the separating and transplanting of the plant into new soil would infest it whether sterilized or not, and result in a crop of sickly plants covered with leaf spots and few flowers. The only method which can be employed at present to control this trouble would be to start cuttings of the violet in sterilized earth, and when the cuttings were ready to transplant to place them either out of doors in some newly turned up land, or land which had not been contaminated with nematode infected manure, or else into earth in the greenhouses which has previously been sterilized. Experiments with violets are now under way and we shall report them at some other time. The manner in which roses are propagated also gives rise to similar obstacles in regard to nematode infection. If the same care is taken in regard to contamination as in violets the nematode problem is one which need give no alarm. Some rose growers in Massachusetts have never been troubled with nematodes. Mr. Montgomery who possesses considerable skill, knowledge, and experience in rose growing and who has charge of the extensive Waban conservatory at Natick, informs us that they have never been troubled with nematodes upon

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1. Since the above was written Prof. Britton has described a similar box in the Annual Report of the Conn. Expt. Station p. 310, 1897. He uses wooden trays which just fit the box, the bottoms of which are covered with galvanized iron netting which makes it more desirable for sterilizing earth.

their roses. They make a practice of using soil composted with cow manure which is allowed to remain out over winter. There is no doubt that owing to this method of preparing the soil they are able to keep nematodes in check.

Cost of Sterilization.

The expense of sterilizing the soil will largely depend upon one's equipment and the conditions under which it has to be done. If one has a large steam boiler which he uses for heating his houses, then the necessary expenses involved would not be very great. The expense of purchasing tile, or steam pipe if one happens to use such, which in the latter instance would have to be drilled and connected, would be the heaviest to bear. We prefer tile to steam pipe and think they are fully as effective, and then again they can be used for subirrigation purposes, a practice which according to those who have experimented with it gives beneficial results. On the other hand if one had to purchase a steam boiler together with the tile the first expense might be of some account. The 2 in. tile, however, cost about one cent each, or purchased in quantities somewhat less, and are slightly over one foot in length, and a second hand steam boiler* of 6 or 8 horse power giving a pressure of steam equal to 40 or 80 lbs. can be purchased for about $50 or $60, and would answer the purpose for most greenhouse growers. Larger boilers would be better as they carry more water, a necessary feature in this kind of work, inasmuch as there is considerable water used up in heating owing to the condensation of the steam. The soil in a bench 12 in. deep, 15 in. wide, and 80 ft. long, or in other words 100 cu. ft. of soil, in which were placed two lengths of tile 2 or 3 in. from the bottom, could be easily heated in one and one-half to two hours time. The tile in such a bed we will say costs $1.75 and the extra expense for coal would be unimportant. Some further idea of the expense of heating the soil can be obtained from the amount of soil employed and the time required to heat it to 212° F. as ascertained by Galloway and others. According to Galloway he succeeded in heating about 72 cu. ft. of earth in two hours time. Lodder's beds evidently contained 480 cu. ft. of soil which he heated in three hours, while Rudd's beds contained 600 cu. ft. which he

*In purchasing a second-hand boiler of high pressure it would be well to obtain the State Inspector's certificate.

heated in two hours, and according to Mr. May he heats 112 cu. ft. in one and one-half hours.

Effects of Heating the Soil on the Growth of the Crop.

In the numerous crops of cucumbers, tomatoes, and lettuce which we have grown in sterilized earth we have never noticed any thing of a detrimental nature, but on the other hand a decidedly beneficial effect as the result of sterilization. Not only is this shown in the difference in color which the plants take on, but in an appreciable acceleration of their growth. We have repeatedly run parallel cultures of sterilized and unsterilized soil and have invariably noticed these effects on cucumbers and lettuce. Mr. W. N. Rudd whom we have already quoted as having tried the sterilizing method says as follows[1]:—"One would imagine that the cooking would make the soil soggy, but it has no such effect, and indeed the soil seems in better condition afterwards than before the steam was applied, and the fine condition of the plants growing in soil which has been treated proves that the soil has not been injured in the least." It has long been known among practical gardeners that heating the soil produces beneficial results. Every greenhouse soil contains humus or vegetable mold and it is recognized by vegetable physiologists that the presence of humus in the soil plays an important part in assimilation and plant growth, but its efficiency depends partly upon the stage of decomposition at which it has arrived. It has been shown by experiments in which plants are treated in one case with humus in the raw condition, and in the other with humus which had been subjected to the action of steam for several hours at a temperature of 212° F., that there is considerable difference in the yield of the crop. It has been found that the same quantity of soil, after the action of heat, yields a crop many times in excess of the former or untreated soil. In other words by heating we convert the humus compounds in the soil into a more available form for the utilization of the plant. That the heating of the soil gives rise to some changes is shown by its darker color and more porous condition, and it is undoubtedly due to these changes which have taken place in the humus compounds which account for the accelerated and vigorous growth of the plants. Another feature which is characteristic of sterilized soils is the unusual occurrence of humus loving plants, or

1 American Florist, Vol. IX, p. 171-197.

saprophytes, that grow upon it, which is a good indication that the organic matter contained in the soil has undergone changes through the action of the heat. We have ourselves observed more than once certain species of saprophytic fungi growing upon our steamed beds which have never shown any tendency to grow on unheated soil, although with the exception of being steamed the soil was exactly the same as that upon which they never appeared.

Effects of Heating the Soil Upon Other Greenhouse Pests.

Besides the destruction of nematode worms, and the gaining of robust and vigorous plants which steaming the soil gives rise to, there are other beneficial effects worthy of being taken into consideration. Many of the fungous and insect pests to which our greenhouse plants are subject find their normal habitat in the soil. In our experiments upon heating the soil in the beds we killed thousands of red spiders, and we presume that we did the same with the cucumber aphis, or with the eggs, as we were remarkably free from them, although the soil had previously been used for cucumber crops which were badly contaminated with aphis. This latter statement, however, in regard to killing the aphis, is nothing more than a conjecture, as Entomologists tell us that they do not know where the aphis breeds,but they surmise that it breeds upon particles of organic matter in the soil or upon the old cucumber vines thrown out upon the compost heap. The soil undoubtedly harbors many of the spores of the mildews which are common to cucumbers, tomatoes and lettuce.

One of the most common and troublesome diseases to young cucumbers is the so-called "damping fungus," Pythium De Baryanum, which attacks the young plants at the surface of the ground and causes them to wilt and collapse. We have repeatedly found as a result of heating that this did not make its appearance when they were subjected to a temperature which was over 140° or 150° F.; when, however, the temperature went below these points the fungus appeared to be accelerated in its growth and development and damping was more likely to show itself than in normal pots. This fungus must be distinguished from the ordinary "damping fungus" (Botrytis) which attacks begonia cuttings, etc., in the propagating pit. Sterilizing the soil for this fungus would be of no account as the spores (conidia) of this species are everywhere and only await a favorable opportunity to germinate and develop themselves, whereas with the Pythium the conditions of dissemination are much more restricted. What is true in regard to the Botrytis is probably true in regard to some of the mildews, as there is no reason to doubt that the spores can thrive in the house for some time without coming in contact with the host, although sterilizing the soil would undoubtedly kill many of them. The so-called "drop" in the lettuce which is caused by a facultative parasite, a species of Botrytis, is also completely controlled by sterilization. This fungus causes no end of trouble to some lettuce growers and is confined entirely to the soil where it propagates only by means of its mycelium, but it frequently becomes disseminated from one part of the house to the other by means of the gardener's tools. Sterilizing the soil has also an effect upon the weed and grass seeds which constitute more or less of a nuisance in a house. The difference between a heated bed and one that is not heated is very marked indeed in this respect. In the beds which were heated at 204° F. there were no weeds or grass seeds to trouble us and the only things appearing were one or two clover plants. The seeds of the clover appear to be more resistant than other seeds and their presence can be accounted for probably by the fact that the temperature at certain points did not quite reach 204° F. In the beds that were not heated we hoed under a number of crops of weeds as the horse manure which was mixed with our soil was largely contaminated with seeds.

Relation of Nematodes to their Environment.

A knowledge of the relationship of the environment to an organism is of considerable importance in all experiment work where we have to deal with some pest which causes injury to our economic plants. Indeed some of the methods of controlling nematodes are based upon a knowledge of the influence of the common external factors or agencies which go to make up the environment and to which all organisms strive to adapt themselves. Such for example is the desiccation method which forms an important factor in the treatment recommended by Vanha.

The external factors playing an important part in the life history of an organism are heat, light, moisture, etc., and it is the variation of these ever changing factors with which the organism has to contend, and which gives rise to characteristic manifestations in its activities.

Every organism, however, is limited in its power to withstand the effects of these external forces. The range of susceptibility is represented by what is known as a minimum, optimum, and maximum condition. Whenever this range is disregarded, or in other words whenever the minimum or maximum conditions of the organism are passed, death results, but what constitutes the minimum, optimum, or maximum condition for one organism does not necessarily constitute the same for another and hence arise specific forms of susceptibility or powers of response in organisms.

EFFECTS OF HEAT.

We have already shown the effects of heat upon nematodes. A temperature of about 140° F. kills them and destroy the eggs, but they appear to thrive at those temperatures of the greenhouse soil which may vary anywhere from 45° F. to 75° F. The optimum temperature for Heterodera is probably not far from 60° to 70° F.

EFFECTS OF COLD.

Undoubtedly most, if not all, of the non parasitic forms of nematodes found here are indigenous to our northern climate, as their eggs will stand our severest winter temperatures. The adult worms, however, are easily killed by freezing as we have frequently seen in our experiments. That the eggs of these species can stand low temperatures is shown by an observation on old squashes which we have examined after they had lain upon the ground most of the winter and been subjected to alternate thawing and freezing even at a temperature equal to 20° F. below zero. When the squashes were brought into the laboratory no nematodes could be found, but when moistened with sterilized water and examined again after having remained in a warm room a week or ten days they were swarming with nematodes. We have observed the same thing in cultures of nematodes which we purposely allowed to freeze. This, however, does not apply to the parasitic species such as Heterodera which attacks cucumbers, tomatoes, violets, etc., inasmuch as this species is not native and freezing always kills the adult worms and their eggs. We have repeatedly shown this to be the case by allowing badly infested nematode soil to become frozen and on making thorough examinations of the soil afterwards have never found nematodes.

EFFECTS OF MOISTURE AND LIGHT.

A certain degree of moisture is evidently essential to nematodes and they do not appear to suffer much from an excess of it, as we have kept them in watery solutions for days at a time with no detrimental results. While nematodes naturally prefer the dark, as does their relative the earth worm, their exposure to light, as far as we have observed, causes no appreciable harm and they appear to multiply and thrive as well in it as they do in darkness.

EFFECTS OF ELECTRICITY.

Some experiments were made with nematode infested earth with alternating electric currents of varying strengths. The infested earth was placed in a glass tube $\frac{3}{4}$ in. in diameter and the various samples were subjected to different strengths of an alternating current for a period of one minute each. It is sufficient to say that the experiments proved of very little value, but they indicated that the amount of current necessary to rid the soil of nematodes would have to be large enough to produce considerable heat in the soil and at the present time there is no indication that this method of treatment would be practicable. We have demonstrated by experiments in our laboratory that the amount of alternating current which seeds can stand without being destroyed is largely determined by the amount of heat they are capable of enduring and in all probability the same would hold true of nematodes. There is reason to believe, however, that this statement would not hold good for direct currents. A current sufficiently strong to produce electrolysis in an organism would probably cause disintegration and death to nematodes.

EFFECTS OF DESICCATION.

Neither nematodes nor their eggs can stand desiccation. Jars containing innumerable nematodes were allowed to dry at the temperature of the laboratory and when examined one year afterwards, after having previously been moistened with sterilized water for some weeks, showed no evidence of nematodes. The same results have been obtained when we allowed nematode infested earth and other infested material to become dry. It is hoped that some practical use can be made of this fact in treating nematodes in greenhouses.

NATURE OF THE SOIL AS EFFECTING NEMATODES.

Some observers[1] have maintained that when artificial soils such as coal ashes mixed with peat were used, nematode galls were not formed except in the small ball of earth clinging to the plants when transplanted. It might be supposed that a soil of the nature of coal ashes would not constitute a favorable medium for nematodes and we have never observed any galls on plants in this medium, although we have obtained them abundantly on roots cultivated in peat soil and also to a certain extent in sawdust cultures. A single experiment made with a 10 in. pot of peat containing cucumbers will suffice to show that nematodes will thrive in a strong acid soil such as peat. About a thimblefull of nematode infested earth was inserted 1 in. beneath the soil close to the plant. Six weeks later the plant was taken up and examined and there were more than one hundred galls upon the roots. Cucumbers were again planted in the pot and their roots likewise became covered with galls. Nematodes in all probability can thrive to a limited extent in every soil in which their host plant is capable of flourishing, although there are certain soils such as coal ashes which do not appear to be especially adapted to their development and growth.

INFLUENCE OF CARBON-DIOXID AND OXYGEN.

All animals require Oxygen although not in the same degree. The fact that nematodes live in the soil which is richer in Carbon-dioxid than the air would indicate that they are normally adapted to a larger percentage of this gas than ordinary animals, and since they thrive in decomposing manure heaps they must be subject to a great variety of gases and chemical solutions of a strong nature. We observed, however, that when nematodes were placed in an atmosphere containing 85% of Carbon-dioxid their movements largely ceased in a very few minutes, but as soon as air was supplied, they resumed their movements.

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1. See experiments of E. H. Jenkins and W. E. Britton in Conn. Agrl. Expt. Station Report, 1895, p. 92.

Resumé.

Nematodes are small, mostly microscopic worms allied to the earth worm; many are entirely harmless, some are parasitic in animals, and a few in plants. Of the many species occurring in this section only one is known to damage plants. This is called Heterodera radicola and is the cause of the so-called "root-knot" disease of many plants. The species is very similar to and perhaps identical with the European H. Schachtii which causes so much damage to the sugar beet.

The amount of damage caused by nematodes to economic plants throughout the world is quite large.

The number of families and species of plants subject to nematodes are numerous. They not only attack the roots but frequently other parts of plants as well.

Certain species of nematodes, Tylenchus, etc., are indigenous to our climate and by means of their resistant eggs they are capable of surviving our winters, but the parasitic species Heterodera cannot.

The greatest amount of injury done to plants in the Northern U. S. is largely confined to greenhouses and occurs to such plants as the cucumber, tomato, violet, rose, cyclamen, etc. which are affected in their roots. Not infrequently, however, outdoor plants are subject to nematodes by being brought in contact with infested earth or manure.

Plants affected by Heterodera usually appear sickly and gradually fade away and die. The roots of such plants are found to be more or less covered with various sized galls or swellings. These galls are the result of an abnormal growth of the root due to the young worms forcing their way into it, and there remaining to complete their development. The damage to the plant is not due to the feeding of the worms upon the roots, but rather to the fact that the flow of sap from the root is cut off by the abnormal development of the tissues.

The nature of the problem of nematode control is one which must be based upon a knowledge of the life history and environmental conditions affecting the organism.

It has been found that the use of chemicals is of no practical value. None of the chemicals which we have used are capable of killing the eggs of nematodes when confined in the soil, and unless this is accomplished the treatment is of no account.

There are many solutions capable of killing a certain percentage of adult worms and that can be applied to the soil before or after planting, but the strength and the amount of the solution necessary to kill nematodes in the soil is considerably greater than that necessary when the worms are isolated. This is due to the difficulty of bringing the solution into contact with each particle of matter in and around which the nematode thrives.

The most effectual, complete, and practical method at the present time of exterminating nematodes in greenhouses is by heating the soil by means of steam. This can be accomplished without much expense providing proper attention is paid to the methods of applying the steam.

A pressure of steam exceeding 50 lbs. is not only cheaper, but more effective than a pressure which falls below this, and the amount and cross section area of the tile is important. See p.53.

The cost of heating soil depends upon the equipment employed and cost of labor, etc. Probably not far from 100 cu. ft. of soil under the most favorable conditions can be heated in one hour's time to a temperature of over 200° F.

The minimum amount of heat necessary to kill nematodes and their eggs while confined to the soil is about 140° F., but for all practical purposes it is desirable to make use of a higher temperature, at least from 180°-212° F.

The benefit of steaming or sterilizing the soil is not alone confined to the destruction of nematodes. Many other greenhouse pests are killed. The mechanical conditions of the soil are moreover greatly improved; the humus compounds are rendered more available for plant food, which results in giving plants grown in sterilized soil a considerable acceleration in their rate of growth.

The changes of the environment which appear to affect Heterodera the most are freezing and desiccation. Either of these agencies might be employed in certain cases to kill nematodes. The latter gives promise of becoming a cheap and efficient method.

Explanation of Plates.

Plates I. and II. Development of a free.living nematode, Rhabditis sp. Pl. I. Figs. 1-12, development of embryo in the egg. × 350. Fig. 13, young worm just hatched; m, mouth; o, oesophagus; x & b, oesophagal bulbs; s, stomach or intestine; r, rectum; a, anus; p, location of sexual organ, shown more enlarged in fig. 14. Figs. 15, 16, 17, further development of the female, showing ovary at o, and vulva at v, fig. 17. Fig. 18, male and female in copulation. Figs. 13, 15. 16, 17, 18, × 135. Plate II. Figs. 1-4, further development and maturity of female. Fig. 3, mature female; 1, lips; o, oesophagus, with x and b bulbs; s, stomach; r, rectum; a, anus; v, vulva; e, eggs in various stages; w, young worms. Fig. 4. dead mature female filled with young. Fig. 5, mature male. Fig. 6, posterior end more enlarged; z, bursa; q, spicule; y, anus; u, spermatozoa. Figs. 1, 2, 3, 4, 5, × 135.

Plate III. Figs. 1-16, eggs of Heterodera radicola, showing development of the embryo. × 325.

Plate IV. Development of the female Heterodera. Fig. 1, young worm just hatched. Figs. 2, 3, and 4, stages of development in the swelling up process of the female. Fig. 5, stage at which copulation takes place; h, spear; k, bulb; g, vulva; e, anus; c, ovary; w, stomach or intestine; d, rectum. Fig. 6, mature female with ovary tubes partly visible. All × 100. Fig. 7, ovary, more enlarged.

Plate V. Development of male Heterodera. Fig. 1, just hatched, indistinguishable from the female. Fig. 2, beginning of male metamorphosis, showing the body drawing in from the wall, and at t, the rudimentary testis. Fig. 3, same in later stage. Fig. 4. mature male, about to emerge from old body covering. Fig. 5, mature male; c, cap-like thickening on head; s, spear; e, excretory canal; t, testis; x, spermatozoa; i, intestine. Figs. 1, 2, 3, × 175. Fig. 4, x 90. Fig. 5, × 500.

Plate VI. Sections of normal and nematode-attacked cucumber roots, at various ages. Fig. 1, very young, normal root. Fig. 2, mature, normal root; c, cortex; p, central cylinder; d, ducts. Fig. 3, young root same age as fig. 1, attacked by nematodes. Fig. 4, same, one week later. Fig. 5, section of mature gall, showing distortion of tissues. All × 20.

Plate VII. Fig. 1, tip of cucumber root with young nematodes just entering, enlarged. Figs. 2, 3, and 4, seedlings of rape, cucumber, and tomato, from badly infested soil. Fig. 5, young Heterodera among the particles of a fine loam soil, $\times$ 175. Fig. 6, portion of an angle worm contrasted in size with Heterodera, represented by the two black lines near the center,the longer representing the length of the mature male, the shorter that of the young worm. $\times$ 10.

Plate VIII. Species of free living nematode.

Plate IX. Various forms of nematodes; figs. 1, 3, 4, 8, 5, free living species.

Plate X. Photograph showing the effect of nematodes on cucumbers grown in pots. The plants in the two middle pots have died. The plants on each side are uninfected ones and of the same age as the infected plants.

Plate XI. Cucumber root showing galls.

Plate XII. Tomato root showing galls.

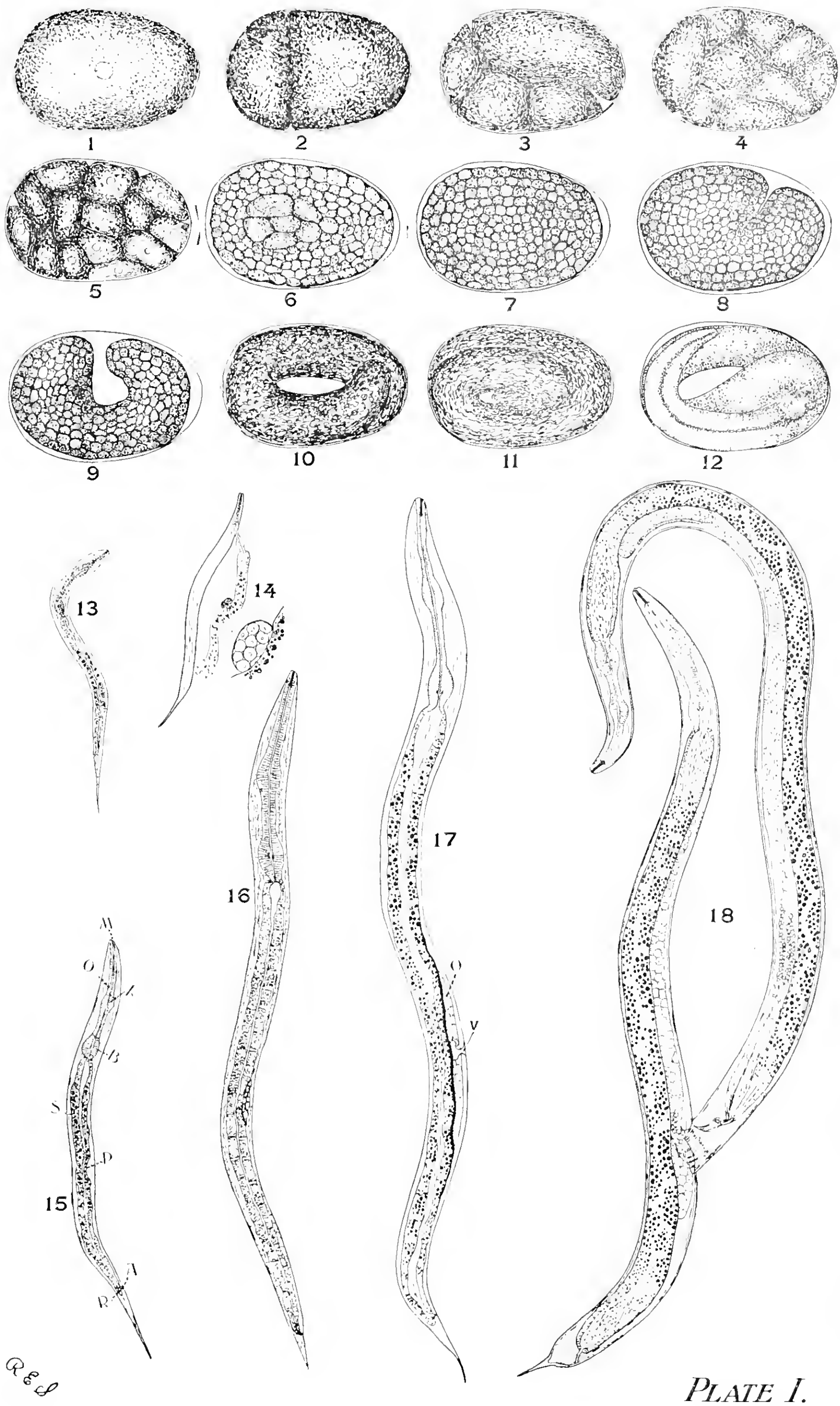


PLATE I.

PLATE II.

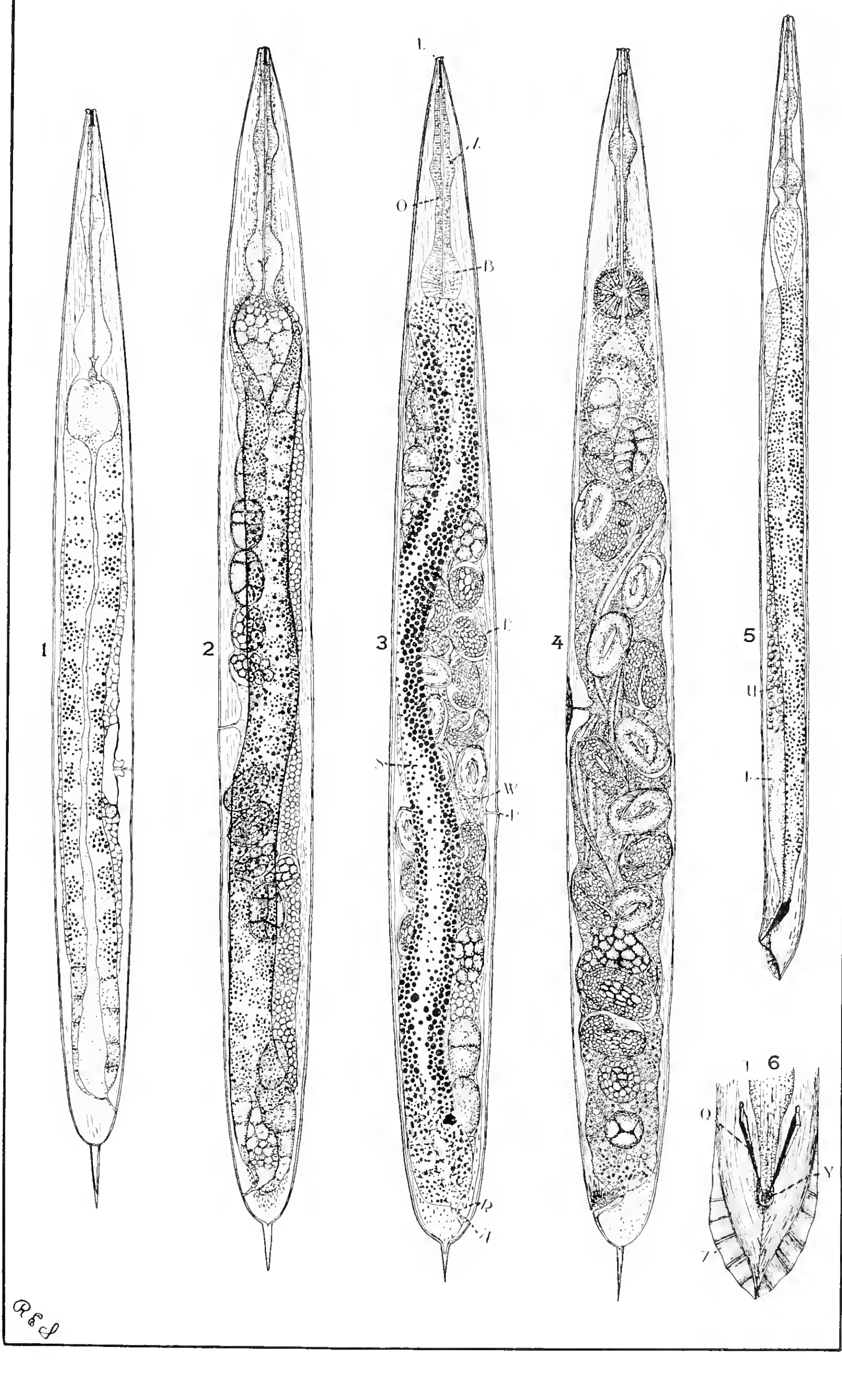
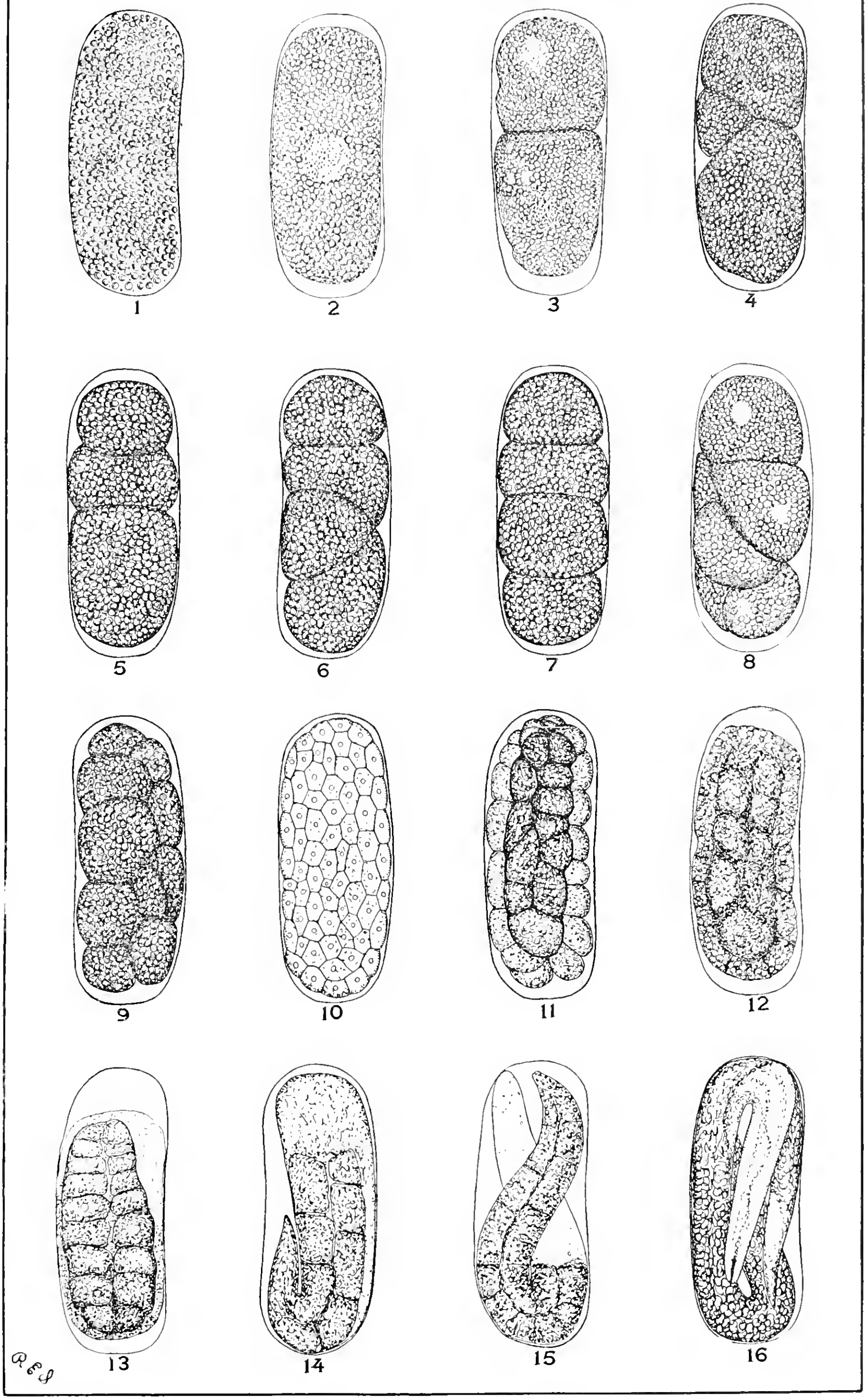


PLATE III.



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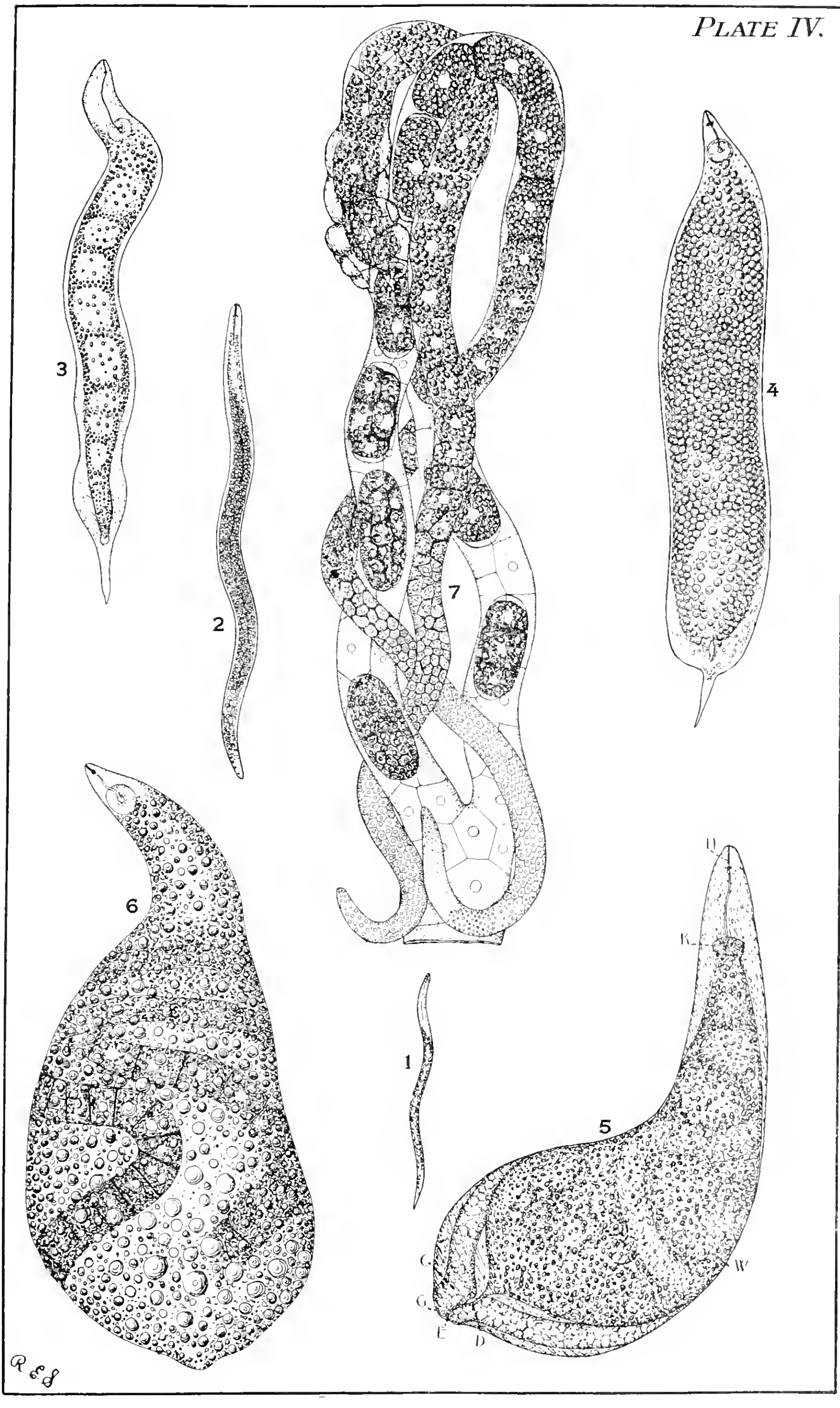
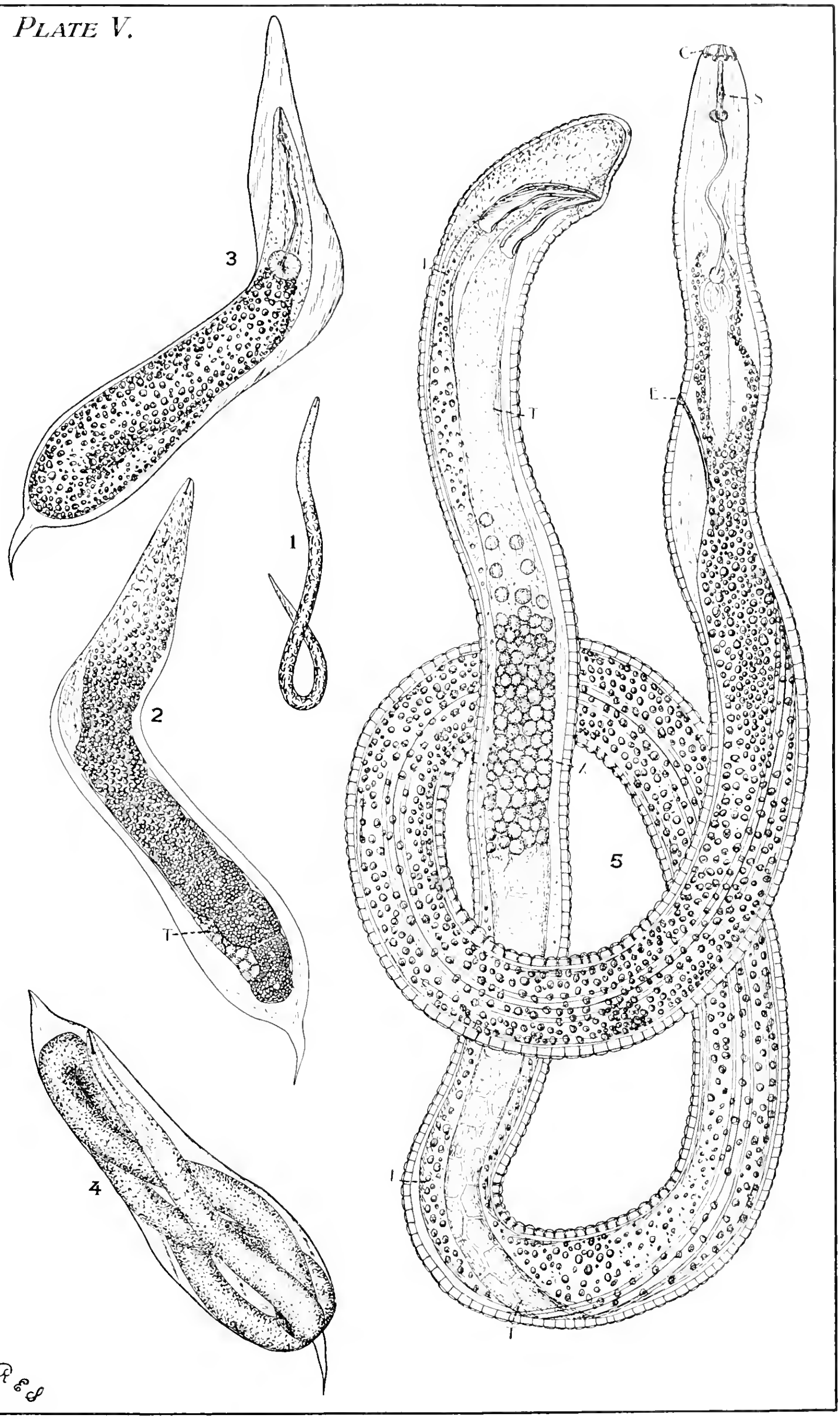


PLATE V.



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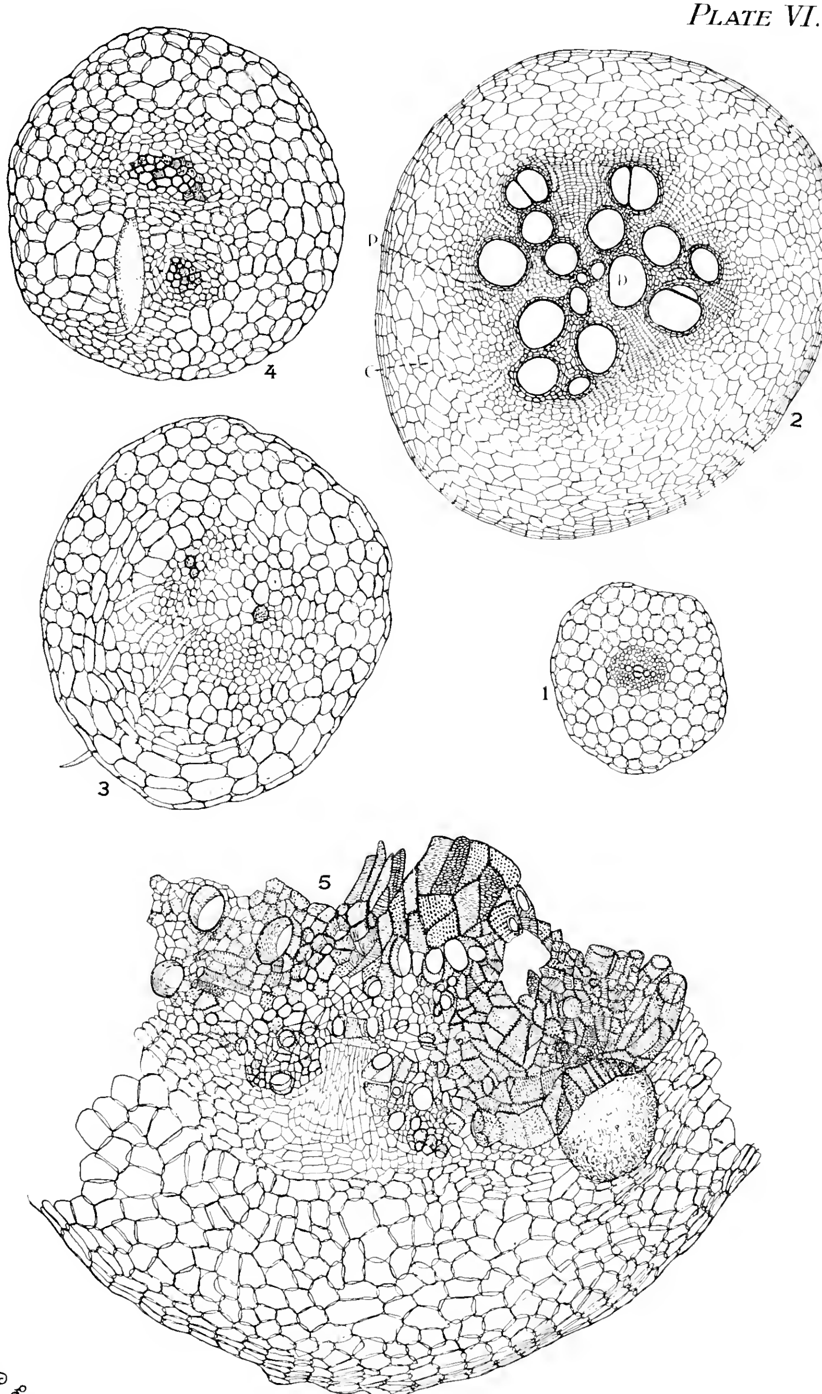
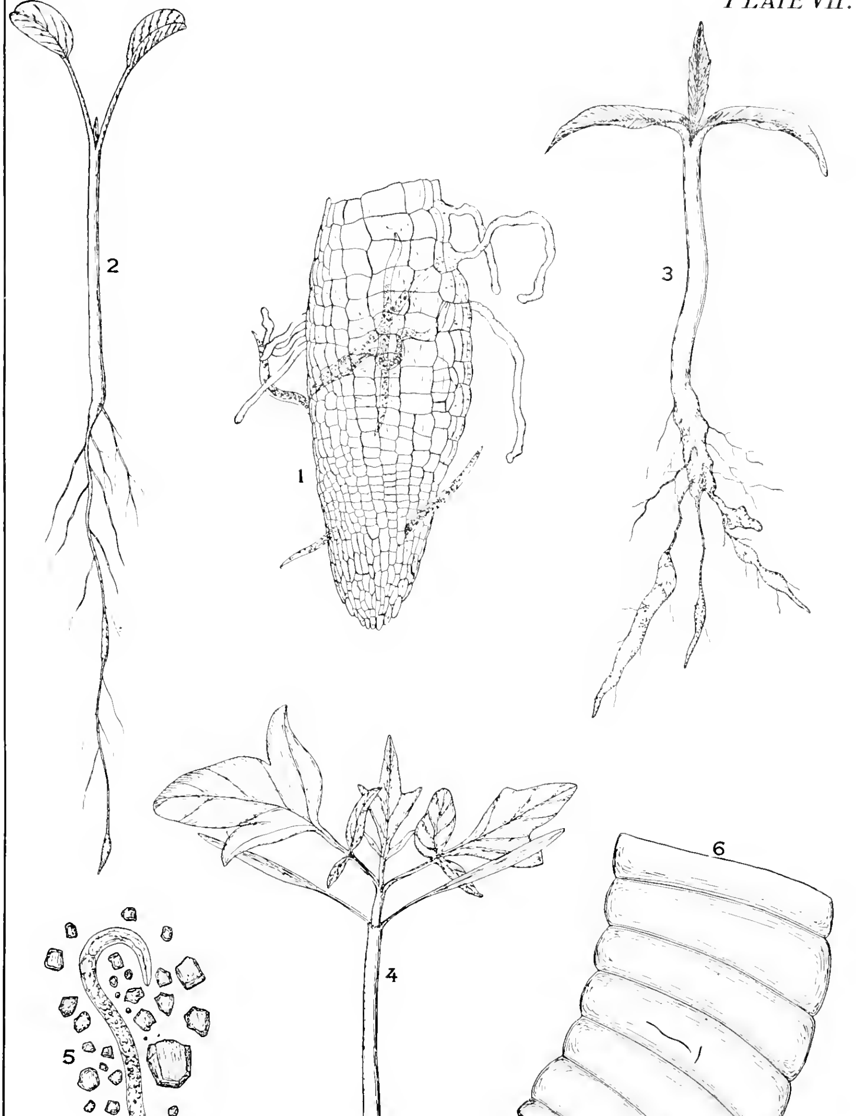


PLATE VII.



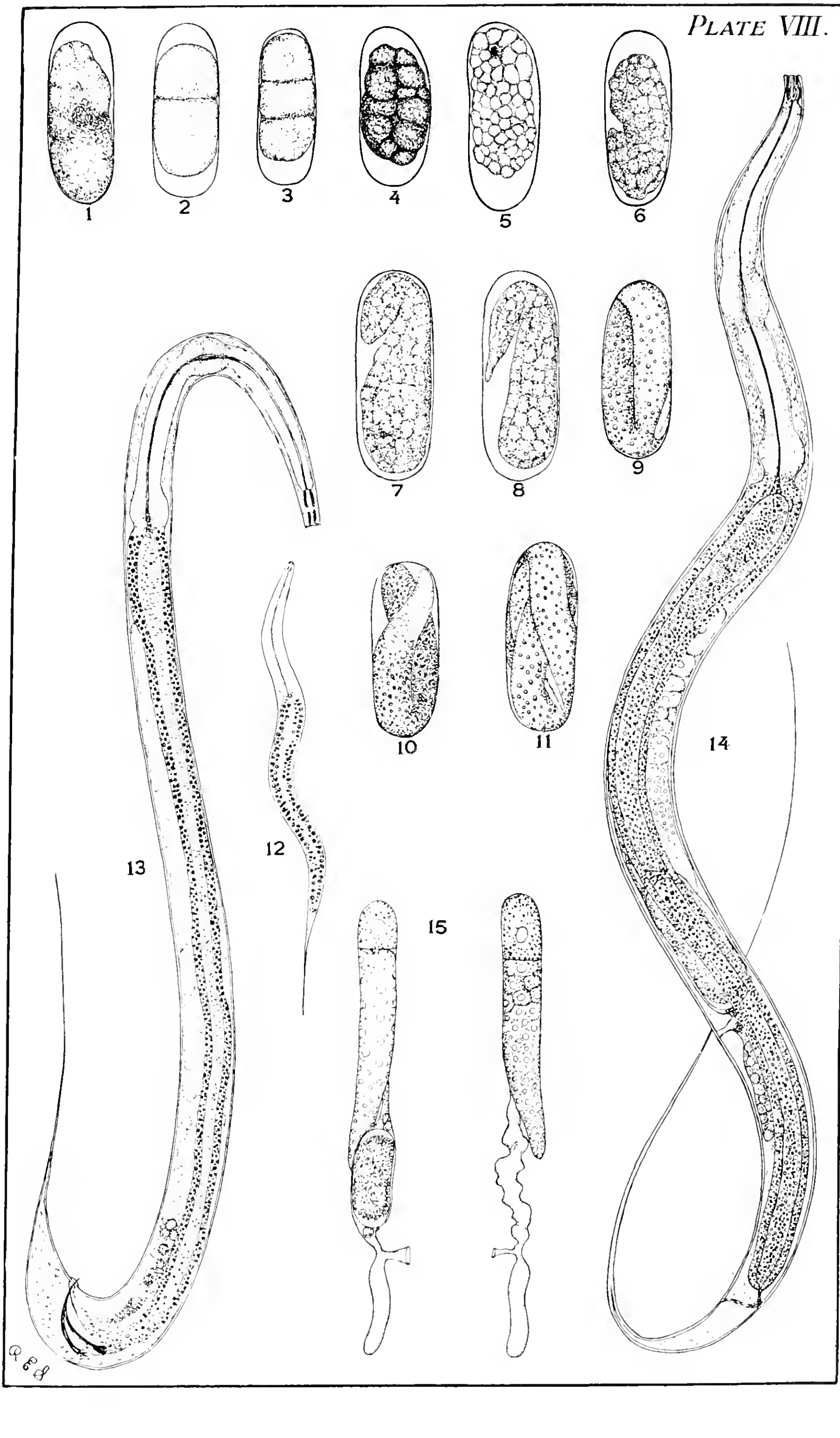


PLATE VIII.
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PLATE IX.

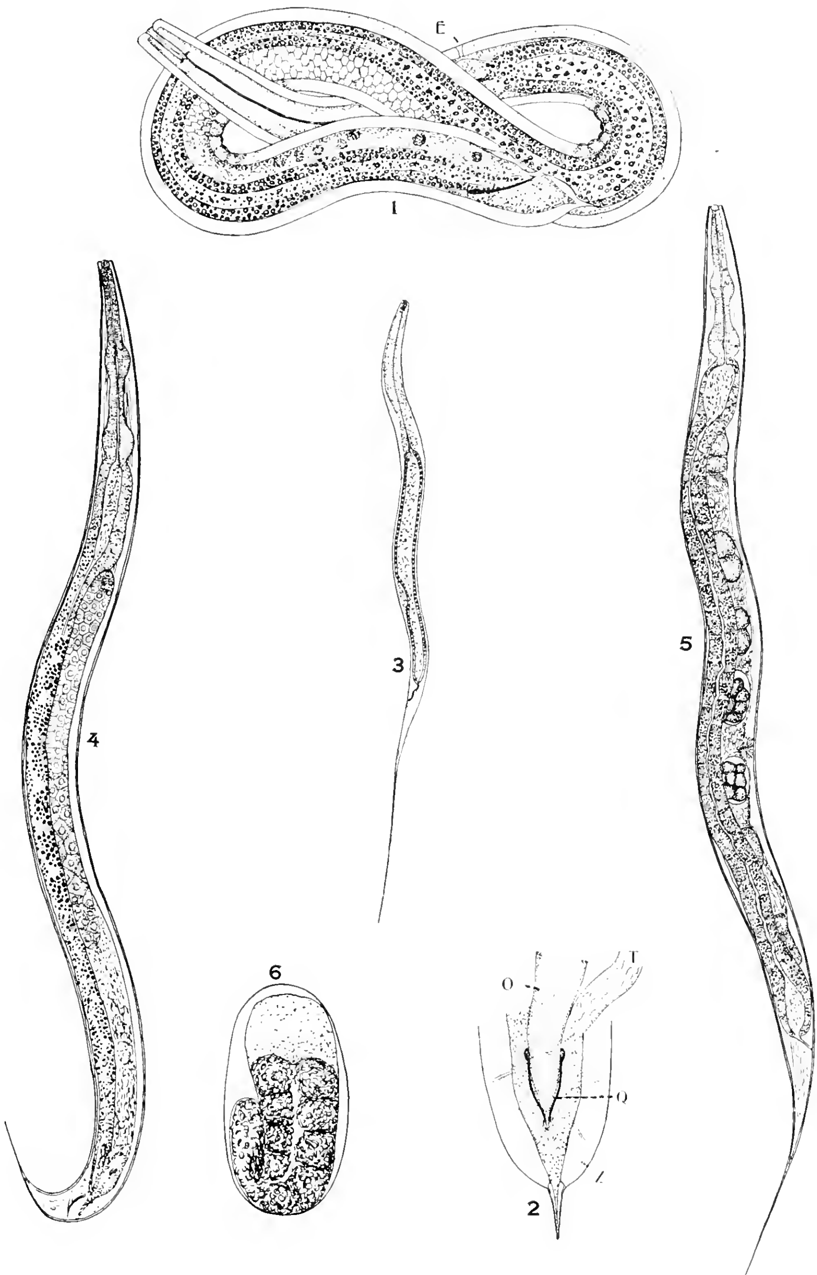
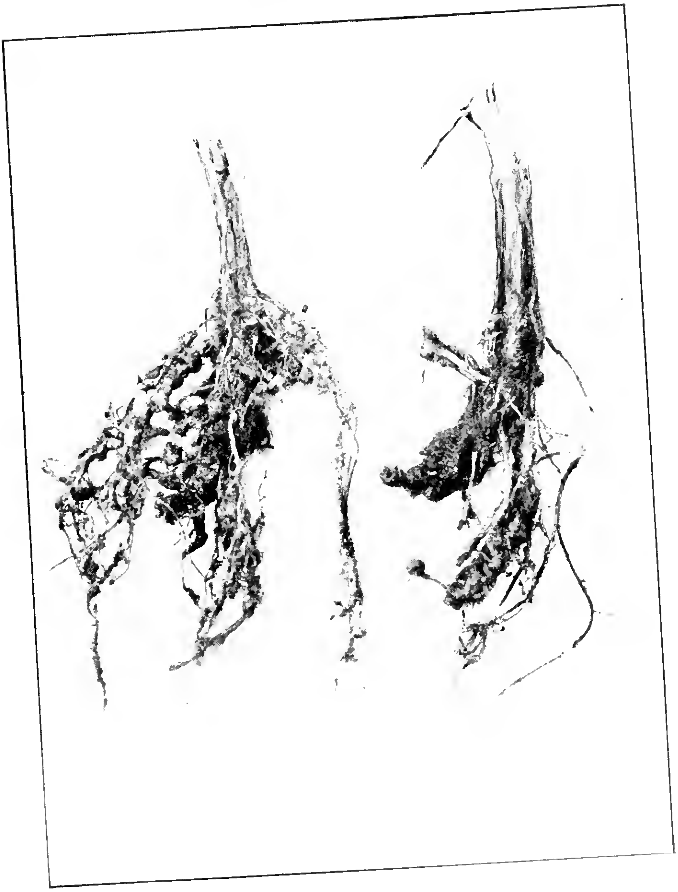
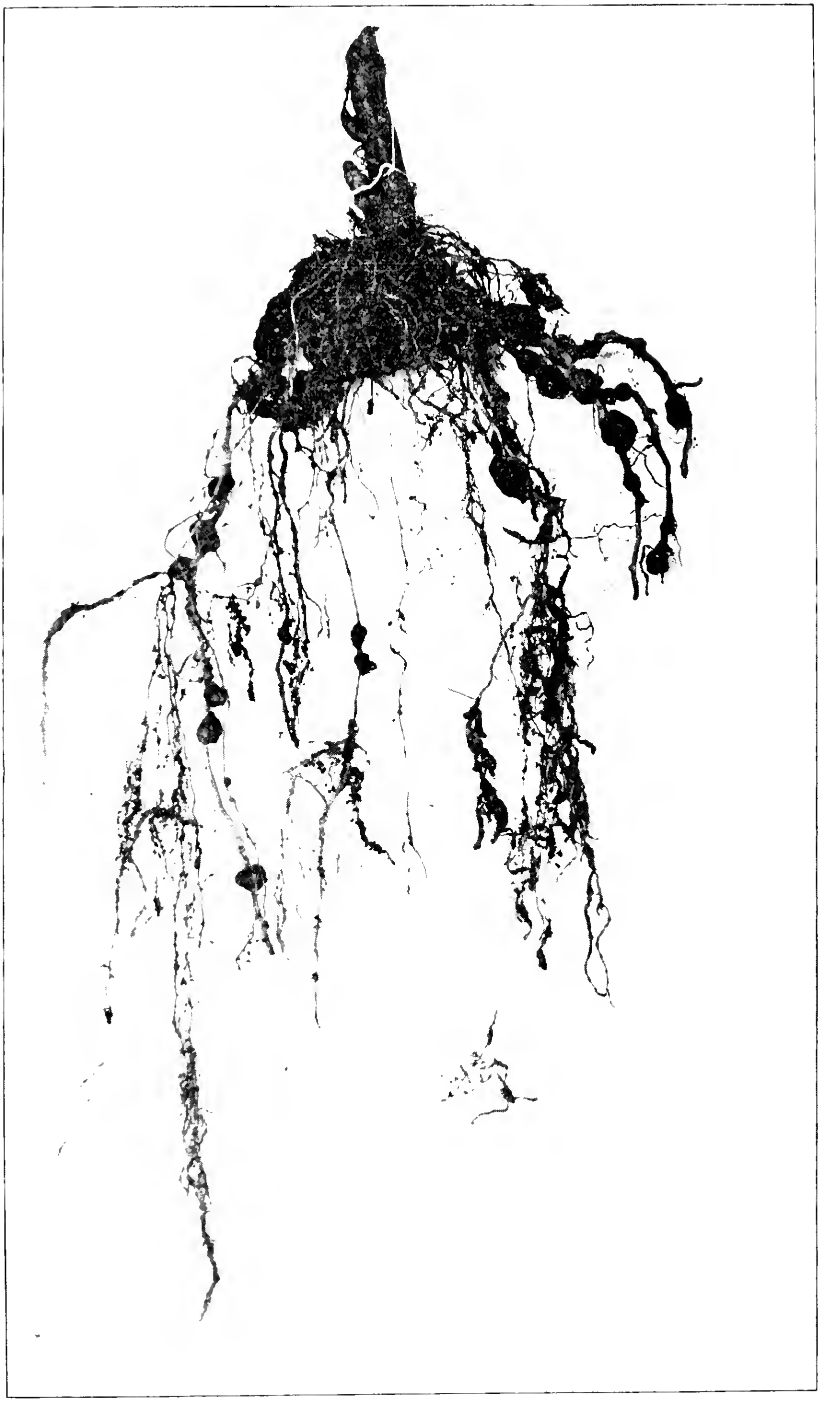


PLATE X.

PLATE XI.





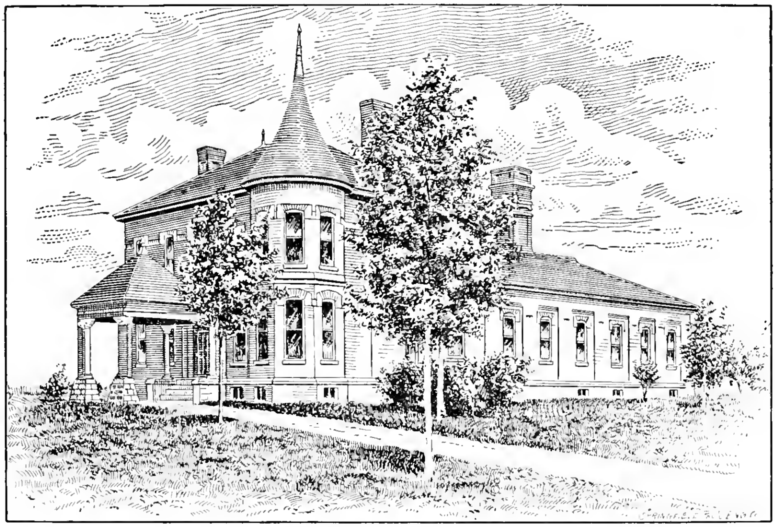
HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

BULLETIN NO. 56.

CONCENTRATED FEED STUFFS.



CHEMICAL LABORATORY.

NOVEMBER, 1898.

The Bulletins of this Station will be sent free to all newspapers in the State and to such individuals interested in farming as may request the same.

AMHERST, MASS.:
PRESS OF CARPENTER & MOREHOUSE,
1898.

HATCH EXPERIMENT STATION

OF THE

Massachusetts Agricultural College,

AMHERST, MASS.

By act of the General Court, the Hatch Experiment Station and the State Experiment Station have been consolidated under the name of the Hatch Experiment Station of the Massachusetts Agricultural College. Several new divisions have been created and the scope of others has been enlarged. To the horticultural, has been added the duty of testing varieties of vegetables and seeds. The chemical has been divided, and a new division, "Foods and Feeding," has been established. The botanical, including plant physiology and disease, has been restored after temporary suspension.

The officers are :—

Henry H. Goodell, LL. D.,	*Director.*
William P. Brooks, Ph. D.,	*Agriculturist.*
George E. Stone, Ph. D.,	*Botanist.*
Charles A. Goessmann, Ph. D., LL. D.,	*Chemist* (Fertilizers).
Joseph B. Lindsey, Ph. D.,	*Chemist* (Foods and Feeding).
Charles H. Fernald, Ph. D.,	*Entomologist.*
Samuel T. Maynard, B. Sc.,	*Horticulturist.*
J. E. Ostrander, C. E.,	*Meteorologist.*
Henry M. Thomson, B. Sc.,	*Assistant Agriculturist.*
Ralph E. Smith, B. Sc.,	*Assistant Botanist.*
Henri D. Haskins, B. Sc.,	*Assistant Chemist* (Fertilizers).
Charles I. Goessmann B. Sc.,	*Assistant Chemist* (Fertilizers).
Samuel W. Wiley, B. Sc.,	*Assistant Chemist* (Fertilizers).
Edward B. Holland, M. Sc.,	*First Chemist*(Foods and Feeding).
Fred W. Mossman, B. Sc.,	*Ass't Chemist*(Foods and Feeding).
Benjamin K. Jones, B. Sc.,	*Ass't Chemist*(Foods and Feeding).
Philip H. Smith, B. Sc.,	*Assistant in Foods and Feeding.*
Robert A. Cooley, B. Sc.,	*Assistant Entomologist.*
George A. Drew, B. Sc.,	*Assistant Horticulturist.*
Herbert D. Hemenway, B. Sc.,	*Assistant Horticulturist.*
Arthur C. Monahan,	*Observer.*

The co-operation and assistance of farmers, fruit-growers, horticulturists, and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the

Hatch Experiment Station, Amherst, Mass.

DIVISION OF FOODS AND FEEDING.

Joseph B. Lindsey.*

RESULTS AND SUGGESTIONS.

I. Farmers are especially cautioned against *adulterated cottonseed meal.* Samples of this substance were found in a large number of towns, especially in northeastern Massachusetts, during the spring months. *Sea Island Cottonseed*, so called, is also very much inferior to the genuine material. A prime cottonseed meal should have a bright yellow color, and contain at least 6.75 per cent of nitrogen, equivalent to 42 per cent of protein. The adulterated meal contains about 3.75 per cent nitrogen equal to 23.4 per cent protein. *It is therefore only one-half as valuable as the prime article.* It is evidently prepared by grinding the black hulls quite fine, and mixing them with the yellow meal. The resulting product is as a rule of a darker yellow than the pure meal. Samples of adulterated meal have also been found that were bright yellow. This meal had either been artificially colored or mixed with some inferior substance other than hulls. *We urge purchasers to buy only the guaranteed article, and to absolutely refuse the unbranded meal.* Pure cottonseed meal is one of the very cheapest concentrated feed stuffs.

II. Linseed meals, branded gluten meals, and gluten feeds, show no adulterations.

III. Wheat bran, middlings, and, with a few exceptions, mixed feeds, have not been found to contain any foreign admixtures.

Heilman's mixed feed was found to be of very poor quality. It contained a large amount of woody material, of very little feeding value. Several unmarked mixed feeds were similarly adulterated. The Lexington mixed feed showed several per cent less protein than the average.

IV. Many unbranded oat feeds have been found to contain as high as 65 per cent of hulls, and only from 5 to 7 per cent of pro-

*Assisted by E. B. Holland, B. K. Jones and F. W. Mossman.

tein. Such foods prove very costly at prices asked for them. See more extended remarks under analyses of these feeds.

V. †Protein Standards of unadulterated Feed Stuffs are as follows:

	Feed Stuffs.	*Protein Standard.*
Starchy (carbohydrate) *Feeds.*	*Corn meal,*	9 per cent.
	Hominy meal or chop,	10-11 "
	Chop feed,	8-9 "
	Oat feeds,	9-10 "
	Corn and Oat feeds,	9 "
	H. O. horse feed,	11 "
Protein Feeds.	*Wheat bran,*	16 "
	Wheat middlings,	18-20 "
	Mixed feed,	17 "
	Dried brewers' grains,	22* "
	Malt sprouts,	24 "
	H. O. Dairy feed,	19 "
	H. O. Poultry feed,	17 "
	American Poultry feed,	14 "
	Buffalo and Golden gluten feeds,	28 "
	Other gluten feeds,	22-24 "
	*Gluten meals,***	36 "
	Cleveland flax meal,	39 "
	O. P. linseed meal,	36 "
	Cottonseed meal,	42 "

*Minimum.

**King gluten meal should have 33 per cent protein and 15 per cent fat.

†By "protein standard" is meant the per cent of protein an unadulterated feed should contain.

CONCENTRATED FEED-STUFFS.

A. Classification.
B. Guaranteed Feed Stuffs.
C. Results of Inspection.
D. Cheapest Feeds at Present Prices.
E. Grain Mixtures, etc.
F. Key to Comparative Commercial Values.

This Bulletin is issued in accordance with Chapter 117 of the Acts and Resolves of Massachusetts for 1897. The law will be found in Bulletin 53 issued by the Station in April, 1898.

A. CLASSIFICATION OF CONCENTRATED FEEDS.

The term "concentrated feed," taken in its broadest sense, is meant to include the grains and other seeds of agricultural plants, as well as their manifold by-products left behind in the process of oil extraction and in the preparation of human foods. As here used it is applied more particularly to the various by-products.

The following classification is made on the basis of the amount of *protein* contained in the several feed stuffs, those in Class I. showing the largest amount, and those in Class IV. the smallest quantity.

Division I. Protein Feeds.			Division II. Carbohydrate or starchy feeds.
Class I. *30 to 45% protein.* 50 to 60% *carbohyd's. 75 to 90% digestible.	Class II. *20 to 30% protein.* 60 to 70% *carbohyd's. 80 to 85% digestible.	Class III. *14 to 20% protein.* 70 to 75% *carbohyd's. 60 to 75% digestible.	Class IV. *8 to 14% protein.* 75to85%*carbohyd's 75 to 90% digestible.
Cottonseed meal. Linseed meals. Chicago, Cream, King, Hammond and Star gluten meals.	Buffalo, Golden, Diamond, Davenport, Climax, Joliet, and Standard gluten feeds made from corn, Atlas meal, dried brewers' grain, and malt sprouts.	Wheat brans and middlings, "mixed feeds" and H. O. dairy feed.	Wheat, barley, rye, oats, corn, cerealine, hominy, and oat feeds, corn and oat chop, corn germ feed, and chop feed.

*Including fat reduced to carbohydrates.

B. GUARANTEED FEED STUFFS.

Although the law does not require that concentrated feed-stuffs be accompanied with a guaranteed analysis, it would most assuredly be a source of satisfaction to the consumer, and greatly to the interest of all reliable manufacturers, if the package containing the article be marked with the name under which the feed stuff is known in the trade, the net weight of the package, the name and address of the manufacturer, and the percentage of protein and fat it contains. *Feed stuffs thus marked and guaranteed, ought to be given the preference by all intelligent purchasers.*

The following firms now guarantee their products:

American Cotton Oil Co.,	**Cottonseed meal.**
J. E. Soper & Co.,	**" "**
Dyersburg Oil & Fertilizer Co.,	**" "**
Southern Cotton Oil Co.,	**" "**
Glucose Sugar Refining Co.,	**Chicago gluten meal.**
" " " "	**Buffalo gluten feed.**
" " " "	**Diamond gluten feed.**
Chas. Pope Glucose Co.,	**Cream gluten meal.**
Cleveland Linseed & Oil Co.,	**Cleveland flaxmeal.**

C. RESULTS OF INSPECTION.

I. Protein Feeds.

Cottonseed Meal.

Manufactured by:	Collected at:	*Guaranteed.* Protein.	Fat.	Water.	*Found.* Protein.	Fat.
American Cotton Oil Co.,	Greenfield,	43%	9%	6.40	45.03	10.12
" " " "	Uxbridge,	43	9	5.61	47.47	10.54
" " " "	Wilbraham,	43	9	5.24	46.29	11.37
" " " "	Spencer,	43	9	6.12	42.34	11.95
" " " "	Shelburne Falls,	43	9	7.60	47.25	9.54
" " " "	Fall River,	43	9	6.46	44.84	11.47
Average,				**6.24**	**45.54**	**10.82**

Cottonseed Meal (continued).

Manufactured by:	Collected at:	Guaranteed. Protein.	Fat.	Water.	Found. Protein.	Fat.
J. E. Soper & Co.,	Holyoke,	43	9	7.35	46.13	15.04
" " "	Gardner,	43	9	6.46	44.88	11.96
" " "	Marlboro,	43	9	8.87	45.19	9.50
" " "	Lawrence,	43	9	7.49	45.29	10.42
" " "	Brockton,	43	9	7.27	41.51	12.57
Average,				**7.49**	**44.60**	**11.90**
Dyersburg Oil & Fert.Co.,	Milford,	43	9	8.77	46.11	11.11
" " "	Lynn,	43	9	8.62	45.20	9.74
Average,				**8.70**	**45.66**	**10.43**
Southern Cotton Oil Co.,	Westminster,	None,		6.46	46.65	12.89
" " " "	Attleboro,	43	9-10	6.82	44.23	11.20
"Owl Brand,"	Athol,	43	9	8.14	45.65	9.70
" "	Marlboro,	43	9	8.35	45.13	9.28
" "	No. Wilbraham,	43	9	8.86	45.06	9.06
Average,				**7.72**	**45.34**	**10.42**

Particular attention is called to the fact that the above firms place a guaranty upon their goods.

Without name or guaranty.

Manufactured by:	Collected at:	Water.	Protein.	Fat.
Unknown,	Dalton,	5.76	43.08	13.32
"	Worcester,	6.33	48.74	8.36
"	So. Amherst,	7.66	47.23	8.97
"	Wakefield,	6.35	46.59	9.21
"	Lowell,	6.31	45.82	11.89
"	Ware,	6.50	47.00	10.98
"	Lowell,	8.14	45.60	9.21
"	Lexington,	8.47	44.38	8.60
"	Waltham,	8.53	46.50	10.18
"	Middleboro,	6.21	42.71	18.54
"	Franklin,	6.11	42.13	14.01
"	Ayer,	8.58	41.97	9.67
"	Plymouth,	8.23	43.22	10.79
"	Hudson,	7.83	46.34	9.46
Highest,			**48.74**	**18.54**
Lowest,			**41.97**	**8.36**
Average,		**7.22**	**45.10**	**10.94**

Adulterated Cottonseed Meal.

Manufactured by or for:	Collected at:	Water.	Protein.	Fat.
S. S. Sprague & Co.,	Franklin,	8.20	25.31	6.12
Unknown.	So. Framingham,	7.56	23.33	5.47
"	Gardner,	8.82	26.08	7.52
"	Baldwinsville,	7.47	19.16	8.03
"	Ayer,	7.34	19.66	7.04
"	Clinton,	7.47	21.50	8.71
"	Fitchburg,	7.22	25.25	6.16
"	Leominster,	7.64	23.67	5.75
"	Pepperell,	7.22	24.96	5.92
"	Cambridge,	7.19	20.35	8.20
"	Salem,	7.49	34.56	7.78
"	Lynn,	7.34	34.96	7.91
Made at Memphis, Tenn.,	So. Acton,	8.32	26.07	6.28
Unknown,	Williamstown,	10.28	24.47	5.13
	Highest,		**34.96**	**8.71**
	Lowest,		**19.16**	**5.13**
	Average,	**7.83**	**24.95**	**6.86**

Sea Island Cottonseed Meal.

Guaranty: None.

Butler, Breed & Co.,	Lawrence,	8.34	25.43	6.35
Unknown,	Newburyport,	8.04	36.10	8.22
Sea Isl. C. S. Meal Co.,	Middleboro,	9.25	22.63	6.38
Butler, Breed & Co.,	Brockton,	8.19	34.66	8.00
	Highest,		**36.10**	**8.22**
	Lowest,		**22.63**	**6.34**
	Average,	**8.46**	**29.71**	**7.24**

Both the adulterated and Sea Island meals are very inferior and most of them are worth only one-half that of a prime article. *See remarks under "Results and Suggestions" on page 3.*

Cleveland Flax Meal.

Guaranty: **Protein 38 to 40 per cent.**

Manufactured by:	Collected at:	Water.	Protein.	Fat.
Cleveland Linseed Oil Co.,	No. Adams,	8.94	37.22	2.61
" " "	Greenfield,			
" " "	Williamstown,			
" " "	Hudson,			
" " "	E. Brookfield,			
" " "	Needham,			

Old Process Linseed Meal.

Guaranty: None.

Manufactured by:	Collected at:	Water.	Protein.	Fat.
National Linseed Oil Co.,	No. Adams,	8.73	37.33	5.93
" " "	Hubbardston,	8.29	36.75	7.30
" " "	So. Amherst,	8.76	36.57	5.84
" " "	Lowell,	8.69	36.60	6.47
" " "	Attleboro,	10.08	36.11	2.67
" " "	Pittsfield,	9.30	37.38	6.90
	Average,	**8.98**	**36.79**	**5.85**
Douglas & Co.,	Mittineague,	9.07	38.79	2.75
" "	Concord,	7.29	25.84	7.52

Without name or guaranty.

Unknown—Old process,	Pittsfield,	8.99	35.77	6.96
" " "	Concord,	9.30	33.19	7.92
" New "	Worcester,	8.18	36.23	2.35
" " "	So. Amherst,	9.07	36.32	3.19
" " "	Athol,	9.50	38.59	3.35
" " "	Gardner,	9.85	38.16	3.11
" " "	Baldwinsville,	10.55	39.93	2.95
	Average,	**9.35**	**36.88**	**4.26**

The linseed meals, with one exception—that of a sample manufactured by Douglas & Co. and collected at Concord—appear to be free from adulteration, and to run quite even in composition.

Chicago Gluten Meal.

Guaranty: **Protein 37.50 per cent. Fat 9 per cent.**

Glucose Sugar Ref. Co.,	Huntington,	9.78	40.03	1.81
" " " "	Williamstown,	9.21	37.29	2.06
" " " "	Springfield,	9.87	37.35	2.72
" " " "	No. Adams,	8.72	39.59	2.05
" " " "	Dalton,	9.34	35.26	2.65
" " " "	Uxbridge,	9.40	37.00	3.14
" " " "	Hubbardston,	10.35	36.77	2.34
" " " "	Fall River,	10.38	39.81	1.91
" " " "	Northbridge,	9.40	37.00	3.14
" " " "	Uxbridge, E. Brookfield, Pittsfield, Medford, Lowell, Westfield,	9.89	38.16	1.74
	Highest,		**40.03**	**3.14**
	Lowest,		**35.26**	**1.74**
	Average,	**9.72**	**37.94**	**2.15**

Cream Gluten Meal.

Guaranty: **Protein 37.12 per cent. Fat 3.20 per cent.**

Manufactured by:	Collected at:	Water.	Protein.	Fat.
Chas. Pope Glucose Co.,	Chester,	8.99	34.88	1.58
" " " "	Northampton,	9.88	41.23	6.11
" " " "	Milford,	10.54	37.50	2.11
" " " "	Spencer,	9.92	36.73	2.16
" " " "	Attleboro,	9.04	32.50	3.05
" " " "	Baldwinsville,	11.25	34.97	2.79
" " " "	Lowell,	6.55	36.41	1.73
" " " "	North Adams, Uxbridge, Attleboro, Winchendon, Orange,	9.19	33.66	2.30
	Highest,		**41.23**	**6.11**
	Lowest,		**32.50**	**1.58**
	Average,	**9.34**	**35.21**	**2.59**

King Gluten Meal.

Guaranty: None.

Nat'l Starch M'f'g Co.,	Springfield,	7.74	33.84	15.02
" " " "	North Adams,	7.82	33.57	14.05
" " " "	Westboro,	5.31	34.03	15.50
" " " "	New Bedford,	6.53	33.08	5.03
" " " "	" "	6.49	36.14	19.77
" " " "	North Wilbraham,	8.16	33.47	11.71
	Average,	**7.01**	**34.02**	**13.51**

Hammond Gluten Meal.

Guaranty: None.

Stein, Hirsh & Co.,	Uxbridge,	8.06	40.01	3.42

Star Gluten Meal.

Guaranty: None.

Narragansett Milling Co.,	Bridgewater,	7.31	36.15	5.03
" " "	Plymouth,	7.21	33.55	4.81
" " "	Winchendon,	6.85	36.47	6.50
	Average,	**7.12**	**35.39**	**5.45**

The gluten meals here reported are all free from adulteration and resemble each other quite closely in chemical composition. Neither the King nor Star gluten meals are guaranteed. The King meal contains a large amount of oil, and should be fed with caution. The Star brand is comparatively new in the market. The Cream meal still occasionally shows some wide variations in composition, which it is hoped the manufacturers will endeavor to correct.

Buffalo Gluten Feed.

Guaranty: **Protein 28.9 per cent. Fat 3.38 per cent.**

Manufactured by:	Collected at:	Water.	Protein.	Fat.
Chicago Sugar-Ref. Co.,*	Chester,	8.79	26.69	4.14
" " "	Springfield,	8.16	26.86	4.27
" " "	Natick,	8.63	28.36	2.15
" " "	South Framingham,	7.74	28.99	2.41
" " "	Haverhill,	8.29	26.92	2.72
" " "	Waltham,	8.50	27.20	2.52
" " "	Beverly,	8.28	26.89	2.89
" " "	New Bedford,	7.81	26.17	2.44
" " "	Waltham,	8.69	27.57	2.51
" " "	Fall River,	7.51	26.30	2.72
" " "	Concord,	7.72	26.96	2.99
" " "	Needham,	8.31	26.77	2.64
" " "	Salem,			
" " "	North Brookfield,			
" " "	Great Barrington,	†8.85	25.34	2.80
" " "	Walpole,			
" " "	Haverhill,			
	Highest,		**28.99**	**4.27**
	Lowest,		**25.34**	**2.51**
	Average,	**8.40**	**26.60**	**2.85**

*Peoria Factory.
†Guaranty: Protein 25 per cent. Fat 4 per cent.

Golden Gluten Feed.‡

Guaranty: *None.*

Glucose Sugar-Ref. Co.,§	Natick,	7.97	26.66	3.70
" " "	Milford,	8.72	29.51	3.98
" " "	Plymouth,	8.02	27.74	3.63
" " "	Concord,	9.43	27.85	2.86
" " "	Waltham,	9.58	23.63	3.22
" " "	Brockton,	9.86	23.81	2.58
" " "	Lowell,	9.52	23.93	2.14
" " "	Lawrence,	8.34	27.05	3.97
" " "	Lowell,	9.50	27.44	2.35
	Highest,		**29.51**	**3.98**
	Lowest,		**23.63**	**2.14**
	Average,	**8.99**	**26.40**	**3.16**

The Buffalo and Golden gluten feeds resemble each other in composition and have about the same feeding value.

‡Called gluten meal by manufacturers.
§Marshalltown, Ia., Factory.

Diamond Gluten Feed.

Guaranty: **Protein 24.2 per cent. Fat 3.7 per cent.**

Manufactured by:	Collected at:	Water.	Protein.	Fat.
Glucose Sugar-Ref. Co.*	South Deerfield,	8.08	27.01	3.07
" " "	Marlboro,	8.66	26.95	3.34
" " "	Ashburnham,	8.81	21.65	*9.81
" " "	Lowell,	7.24	22.20	2.77
" " "	South Acton,	7.25	24.52	3.04
" " "	Franklin, Lowell, Pittsfield, North Wilbraham, Worcester,	8.72	23.69	3.15
	Highest,		**27.01**	**9.81**
	Lowest,		**21.65**	**2.77**
	Average,	**8.36**	**24.08**	**3.78**

Without Name or Guaranty.

Unknown,	Pittsfield,	7.10	18.23	2.65
"	Holyoke,	8.72	17.29	2.90
" Joliet,"	South Amherst,	7.44	27.78	2.64
	Average,	**7.75**	**21.10**	**2.73**

Diamond, Davenport, etc., have generally contained several per cent less protein than the Buffalo, and could be purchased for about a dollar less per ton. The tendency now is to make all of the standard gluten feeds of similar composition. Those without manufacturer's name or brand almost always are of inferior quality. Notice the two above, without name or guaranty.

Wheat Brans.

Pillsbury,	C. A. Pillsbury,	Mittineague,	9.56	16.22	4.57
"	" "	So. Deerfield,	11.18	15.88	4.70
Winter,	Kehlor Bros.,	Springfield,	5.59	16.34	4.41
Kehlors,	" "	Lowell,	9.77	16.54	4.47
None,	M. & M. M Co.,	Becket,	10.97	16.05	5.35
"	Washburn,Crosby & Co.,	So. Deerfield,	9.82	16.30	4.62
"A,"	N. W. Cons. Milling Co.,	New Bedford,	10.17	16.16	5 01
None,	" " " "	So. Deerfield,	10.50	15.83	4.56
Spring wheat,	" " " "	Westminster,	10.34	16.72	5.06
" "	Unknown,	Winchendon,	10.41	17.52	5.06
" "	"	Norwood,	9.78	16.37	4.37

*Old process feed.

Wheat Brans (continued).

Brand.	Manufactured by:	Collected at:	Water.	Protein.	Fat.
Winter,	Unknown,	Winchendon,	10.14	15.63	4.41
Spring,	"	Baldwinsville,	9.65	17.45	4.91
"	K. B.,	Needham,	10.38	16.32	4.82
None,	Victoria Mills,	Clinton,	11.32	15.58	4.80
Harders,	Isaac Harder & Co.,	Lawrence,	11.74	14.26	4.31
B. Bran,	F. W. Stock,	Salem,	9.84	14.75	4.16
"	" "	Athol,	8.42	15.47	4.45
Meyers,	J. T. Meyer & Co.,	Lawrence,	9.44	15.84	4.69
Winter Bran,	H. C. Cole Milling Co.,	North Adams,	9.97	17.25	4.60
Cow Bran,	Freeman Milling Co.,	Newburyport,	8.65	16.69	5.15
None,	Holly Milling Co.,	Fitchburg,	8.47	16.13	3.53
Minkota,	Minkota Milling Co.,	Northboro,	9.42	17.34	4.96
Star.	Star&CrescentMillingCo.	Concord,	9.15	16.16	4.92
None,	Hunter Bros.,	Ware,	9.46	16.00	4.14
Spring wheat,	Unknown,	North Adams,	8.89	15.91	4.73
Winter wheat,	"	Middleboro,	9.36	15.50	4.31
	Highest,....................................			**17.52**	**5.35**
	Lowest,.....................................			**14.26**	**3.53**
	Average,....................................		**9.72**	**16.15**	**4.63**

The wheat brans as a whole show an even composition, and appear to be free from adulteration.

Wheat Middlings.

Brand.	Manufactured by:	Collected at:	Water.	Protein.	Fat.
Snow's,	E. S. Woodworth & Co.,	S. Deerfield,	10.64	20.00	3.72
Snow's,	" " "	S. Amherst,	11.64	18.79	3.37
None,	N. W. Cons. Milling Co.,	S. Amherst,	10.48	17.28	4.61
None,	" " " "	Becket,	10.04	17.92	5.56
Comet,	" " " "	So. Acton,	9.43	20.59	3.76
None, None,	" " " " " " " "	Winchendon Taunton,	9.99	17.59	5.67
Comet X X,	" " " "	Haverhill,	8.97	22.23	5.71
Daisy X X,	C. A. Pillsbury,	Athol,	9.77	19.20	5.36
Daisy B.,	" "	Baldwinsville,	10.61	18.41	4.68
"	" "	Haverhill,	10.80	18.94	3.82
None,	" "	Ware,	9.92	20.68	4.94
"B," " " " " "	" " " " " " " " " " " "	Orange, Palmer, E. Brookfi'd Cheshire, Greenfield, Plymouth,	10.06	16.85	5.20

Wheat Middlings (continued).

Brand.	Manufactured by:	Collected at:	Water.	Protein.	Fat.
"A."	C. A. Pillsbury.	G.Barrington,	10.90	19.23	4 92
None,	" "	Greenfield,	10.50	19.33	5.15
Daisy,	" "	Newburyport,	10.91	18.97	4.30
"	" "	Huntington,	11.72	18.93	3.28
None,	F. A. Stock,	Salem,	9.60	18.34	5.02
"	" "	Fitchburg,	10.32	18.66	4.84
"S,"	Imperial Milling Co.,	Salem,	9.38	18.42	6.34
Flour,	Washburn, Crosby Co.,	Athol,	10.23	18.00	4.33
Standard,	" " "	Gardner.	10.16	17.62	4.86
None,	J. M. & B. S.,		9.19	18.48	5.06
"	Narragansett Milling Co.,	Bridgewater,	10 02	17.05	5.10
R. D. Fancy,	Unknown,	Fitchburg,	8.75	19.80	4.99
"E."	"	Cambridge,	10.36	18.06	5.33
Fancy,	"	Cambridge,	9.50	15.45	2.55
Daisy,	"	Orange,	9.95	19.66	5.32
None,	"	No. Adams.	10.99	18.43	4.25
"	"	Westfield,	9.56	17.06	2.78
Winter wheat,	"	Middleboro,	9.37	17.94	4.96
None,	"	Ashburnham,	10.14	14.85	3.27
Daisy Flour,	Daisy Roller Mills Co.,	N. Wilbraham,	9.98	18.34	4.94
" "	" " " "	G.Barrington,	10.21	19.59	5.00
Star Middlings,	Star & Crescent Mill. Co.,	Concord,	10.24	18.28	5.40
None,	Stratton & Co.,	Newburyport,	10.57	15.22	4.03
"	Hunter Bros.,	Ware,	9.53	16.75	3.95
St. Louis No. 1,	" "	N.Brookfield,	10.94	16.06	3.28
Dexter,	Chapin & Co.,	Mittineague,	11.49	19.98	4.89
White Pig,	Freeman Milling Co.,	Holyoke,	9.41	18.57	5.89
None,	M. & M. Co.,	So. Acton,	10.73	16.09	5.14
	Highest,			**22.23**	**6.34**
	Lowest,			**14.85**	**2.55**
	Average,		**10.14**	**18.34**	**4.64**

Red Dog.

None,	Grand Republic Mills,	Taunton,	10.46	17.24	3.44

Wheat Middlings show practically no adulteration. One sample unmarked, contains but 14.85 per cent of protein, and is inferior. Hunter Bros. and Pittsburg's "B" middlings are rather inferior to most of the others here reported. Middlings will vary in composition, as is illustrated by the various brands sold by C. A. Pillsbury. These private marks, such as Daisy X X, Daisy B, "A," and "B," without guaranty, are a blank to most purchasers. It is certainly no more than fair, that the farmer should be given the opportunity to know the *quality of the goods* he desires to purchase.

Mixed Feeds.

Brand.	Manufactured by:	Collected at:	Water.	Protein.	Fat.
Acme,	Acme Milling Co.,	Huntington,	10.51	16.84	4.33
"	" " "	Natick,	10.71	15.78	3.99
"	" " "	Springfield,	11.41	16.18	4.11
"	" " "	Lawrence,			
"	" " "	Lexington,			
"	" " "	Marshfield,			
"	" " "	Palmer,	10.00	16.75	4.27
"	" " "	Shelb'ne F'lls			
"	" " "	Concord,			
"	" " "	N. Brookfield			
Anchor,	Anchor Milling Co.,	Gt. Barrington,	10.70	17.86	4.94
"	" " "	Lawrence,	8.76	16.41	5.05
"	" " "	Orange,	10.47	17.09	5.16
"	" " "	Marlboro,			
Hiawatha,	Wm. Listman Milling Co.	Williamstown,	9.66	16.59	4.72
"	" " " "	Holyoke,	10.00	17.03	4.83
"	" " " "	Huntington,	9.83	17.01	4.62
"	" " " "	Worcester,	9.93	17.80	4.59
"	" " " "	Gardner,	9.83	16.75	5.02
"	" " " "	Concord,			
"	" " " "	Athol,	9.69	16.88	4.65
"	" " " "	Lexington,			
Fancy,	Listman Milling Co.,	Worcester,	10.78	17.00	4.61
Maume,	Maume Valley Milling Co.	Worcester,	10.68	16.23	4.73
Vermont,	Chapin & Co.,	Hubbardston,	9.91	18.64	4.72
Superior,	Lake Superior Mills,	Hudson,	10.64	18.92	4.56
"	" " "	Milford,	9.72	17.61	4.61
"	" " "	Baldwinsville,	9.05	16.76	5.16
"	" " "	Fitchburg,	9.23	18.14	4.69
"	" " "	Princeton,			
"	" " "	Lowell,			
"	" " "	Mansfield,			
"	" " "	Shelb'ne F'lls	10.33	17.56	4.70
"	" " "	Greenfield,			
"	" " "	Webster,			
Quincy,	Taylor Bros.,	Ayer,	9.41	16.77	4.45
"	" "	Fitchburg,	9.11	16.35	4.30
"	" "	New Bedford,	10.72	16.60	4.12
"	" "	Ayer,	9.71	15.75	3.90
"	" "	Winchendon,			
Daisy,	Daisy Roller Mills Co.,	Wakefield,	9.89	18.51	4.64
"	" " " "	Taunton,	9.14	18.51	4.72
Minkota,	Minkota Milling Co.,	Lynn,	11.27	17.65	3.83
"	" " "	Hudson,	10.91	15.78	4.49
"	" " "	Worcester,	10.41	17.14	4.60
Jersey,	Brooks, Griffiths Co.,	Haverhill,	10.16	18.41	5.20
"	" " "	Needham,	10.76	18.46	5.19
"	" " "	Westboro,	10.13	16.94	4.76

Mixed Feeds (continued).

Brand.	Manufactured by:	Collected at:	Water.	Protein.	Fat.
Boston,	Imperial Milling Co.,	Brockton,	10 69	16.90	4.79
"	" " "	Concord,	8.88	19.76	4.56
"	" " "	Newburyport }	9.52	15.75	4.27
"	" " "	Medfield, }			
None,	Washburn, Crosby & Co.,	Bridgewater,	10.88	18.27	4.59
"	Blish Milling Co.,	Salem,	9.36	16.88	4.43
"	" " "	Wakefield,	8.82	15.93	4.47
"	Model Roller Mills,	Lexington,	8.84	16.68	3.85
Mill Feed,	Eldred Mill Co.,	Lawrence,	9.85	14.98	4.44
Concord,	B. W. Brown,	Concord,	8.62	16.41	5.05
Daisy,	C. A. Pillsbury,	Norwood,	10.57	19.98	4.43
Buckeye W Feed,	A. M. Cereal Co.,	Williamstown,	10.57	15.66	4.44
" "	" " "	Gt.Barrington,	10.96	15.69	4.40
" "	" " "	Princeton,	9.59	15.88	4.46
" "	" " "	Fall River,	9.62	15.44	4.13
Hosier,	Geo. T. Evans,	Walpole,	9.02	16.25	4.31
Rex,	Rex Milling Co.,	Waltham,	9.81	17.06	4.51
Snowflake,	Lawrenceb'gRollerMillCo	Newb'ryport, }	9.72	16.50	4.32
"	" " "	Princeton, }			
"	" " "	E. Braintree, }			
"	" " "	N.Brookfield }			
None,	F. W. Stock,	Winchendon,	9.24	15.28	4.36
"	Unknown,	Lawrence,	9.35	16.44	4.47
"	"	Salem,	9.42	16.92	4.60
"	Chapin & Co.,	Winchendon,	8.23	17.94	4.87
"	Unknown,	Haverhill,	10.92	15.87	4.77
"	"	New Bedford,	9.22	16.69	4.79
"	"	Athol,	8.84	17.22	4.75
"	"	Greenfield,	8.89	17.34	4.96
"	"	Northampton,	10.10	17.06	4.72
St. Louis,	"	Concord,	9.61	16.44	3.70
None,	"	Greenfield,	9.22	7.94	1.69
"	"	So.Framingham	9.41	16.44	4.27
"	"	Lexington,	10.05	15.22	3.88
"	"	Gardner,	9.43	10.59	2.89
"	"	Fall River,	9.75	17.56	4.32
"	"	Franklin,	9.73	16.09	5.05
"	"	Lowell,	12.16	9.31	3.58
"	"	So. Deerfield,	10.10	16.84	4.65
Heilman's,	Heilman Milling Co.,	Worcester,	10.20	10.88	3.70
"	" " "	Wilbraham,	10.22	11.03	3.51
"	" " "	Ashburnham,	10.08	10 63	3.30
Lexington,	Lexington Roller Mill Co.	Worcester,	10.61	13.82	4.27
	Highest,			**19.98**	**5.20**
	Lowest,			**7.94**	**1.69**
	Average,		**9.93**	**16.30**	**4.43**

Mixed feeds with few exceptions show only ordinary variations, and are free from adulteration. An average of a large number of determinations shows these feeds to consist of about 76 per cent bran and coarse middlings, and 24 per cent flour middlings or red dog. They cannot be considered as being worth over 5 per cent more than bran. *Heilman's mixed feed* (see above) containing but 11 per cent of protein, is very inferior. Several mixed feeds, without name, said by dealers to have come from the Heilman Co. show only from 7.94 to 10.59 per cent protein. These feeds contain large quantities of woody material ground fine. *They are not more than one-half as valuable as the genuine article, and all farmers are especially cautioned against their use.* The Lexington mixed feed is also below the average in quality.

H. O. Dairy Feed.

Brand.	Manufactured by:	Collected at:	Water.	Protein.	Fat.
	H. O. Company,	Pittsfield,	6.50	19.97	4.61
	" "	Westboro,	6.41	20.55	3.75
	" "	Haverhill,	8.15	20.28	4.73
	" "	Lynn,	7.73	19.78	4.40
	" "	Haverhill,	8.75	19.72	4.08
	Average,		**7.51**	**20.06**	**4.31**

This feed shows a very even composition. See its comparative value with other feeds on page 23.

Miscellaneous.

Protena,	National Dairy Feed Co.,	Lowell,	7.99	27.86	9.54
"	" " " "	Waltham,	9.68	26.35	8.39
Malt Sprouts,	Niagara F'lls Brewing Co.	Concord,	12.03	26.34	1.20
" "	Unknown,	Concord,	11.24	25.38	1.35
Brewers' Grains,	"	Taunton,	9.10	22.44	7.26

Malt sprouts and brewers' grains are of average quality. Protena is evidently a mixture of several feeds. Its value would be about equal to the better class of gluten feeds.

II. Starchy (Carbohydrate) Feeds.

Corn Meal.

Brand.	Manufactured by:	Collected at:	Water.	Protein.	Fat.
	F. L. Worthy & Co.,	E. Brookfield,	11.84	9.18	3.13
	Garland & Lincoln,	Spencer,	11.61	9.26	3.70
	Cutler Co.,	Spencer,	7.28	9.15	2.74
	Potter & Sons,	So. Amherst,	13.43	8.64	3.58
	J. L. Holly,	So. Amherst,	14.01	8.94	3.08
	Unknown.*	Lowell,	8.13	10.79	8.56
	Unknown,	Plymouth,	12.42	9.14	3.76
	Smith & Northam,	Needham,	13.33	9.03	3.66
	Average,		**11.51**	**9.27**	**4.03**

*White Corn.

The above analyses of corn meal show it to be free from adulteration.

Oat Feeds.

Quaker,	Am. Cereal Co.,	Cheshire,	7.54	11.68	3.70
"	" " "	Dalton,	7.58	10.15	2.78
"	" " "	Uxbridge,	6.65	10.83	3.33
"	" " "	Hubbardston,	7.35	10.32	2.89
"	" " "	Pepperell,	8.42	11.63	3.79
"	" " "	Somerville,	8.61	7.63	3.28
"	" " "	Middleboro,	7.40	8.76	2.61
"	" " "	Gardner,	6.95	10.55	3.34
"	" " "	Gardner, }	7.85	9.78	3.20
"	" " "	Salem, }			
	Average,		**7.62**	**10.11**	**3.21**
Windsor,	Unknown,	Huntington,	8.36	13.23	4.28
None,	"	Dalton,	6.93	5.91	2.18
"	"	Worcester,	8.09	8.99	3.30
Oatintine,	"	So. Amherst,	7.66	9.35	3.52
None,	"	Lynn,	9.23	7.18	2.76
A No. 1,	"	Lowell,	7.28	8.63	3.96
None,	"	Lynn,	6.24	5.93	2.03
"	"	Taunton,	6.83	8.28	3.17
"	"	Salem,	5.63	8.38	3.25
"	"	Lowell,	5.43	7.93	3.40
"	"	Wakefield,	7.15	5.92	2.40
"	"	Fall River,	6.91	9.87	3.92
"	"	Westminster,	8.44	9.24	3.33

Oat Feeds (continued).

Brand.	Manufactured by:	Collected at:	Water.	Protein.	Fat.
Oatena,	Des Plaines Valley Co.,	Lynn,	9.07	8.31	3.70
X,	Unknown,	Lawrence,	7.56	7.07	2.82
Vim,	American Cereal Co.,	Lexington,	7.97	3.59	1.39
X,	" " "	Haverhill.	8.95	7.25	2.61
None,	Unknown,	New Bedford.	8.57	10.38	3.43
"	"	Milford,	8.44	5.06	1.61
"	"	Newburyport,	8.05	6.25	1.86
"	"	Taunton,	6.63	6.44	2.63
"	"	East Braintree,	8.43	7.97	2.52
	Highest,			**13.23**	**4.28**
	Lowest,			**3.59**	**1.39**
	Average,		**7.63**	**7.78**	**2.92**

Oat feeds, as is well known, consist of the residue from the oat meal mills. They are liable to show wide fluctuations in feeding value. Oat feeds average about 46 per cent of hulls and 54 per cent of fine material. Quaker oat feed runs fairly constant in composition. Farmers are cautioned against purchasing oat feeds not *marked or guaranteed.* Many of the analyses given above, show only 5 to 7 per cent of protein. Such feeds have a *very inferior feeding value* and are not worth over one-half as much as corn meal.

Corn and Oat Feeds.

Victor,	American Cereal Co.,	Pittsfield,	7.83	11.05	4.45
"	" " "	Springfield,	8.32	8.38	2.38
"	" " "	Gt. Barrington,	9.23	9.21	4.23
"	" " "	Palmer,	8.88	7.43	2.59
"	" " "	Pepperell,	10.62	8.65	3.85
"	" " "	Gardner,	9.12	8.53	3.45
"	" " "	Norwood,	6.78	11.43	3.75
" " " "	" " "	Taunton, Pittsfield, Springfield, Northampton,	9.49	8.31	3.44
Provender,	Sprague & Williams,	S. Framingham,	9.67	8.28	3.41
"	Cutler & Co.,	Milford,	10.68	8.46	3.26
None,	F. L. Worthy & Co.,	E. Brookfield,	11.71	10.05	3.91
"	" " "	So. Amherst,	11.50	9.01	3.42
"	J. L. Holly,	"	10.95	9.33	3.66
"	Unknown,	"	11.67	9.02	3.48
Provender,	"	Concord,	11.54	8.27	2.91

Corn and Oat Feeds (continued).

Brand.	Manufactured by:	Collected at:	Water.	Protein.	Fat.
Acme Provender,	Acme Milling Co.,	Clinton,	10.58	9.64	5.35
Provender,	R. C. Snow,	Ware,	12.28	9.83	4.13
"	Narragansett Milling Co.,	Bridgewater,	12.96	9.99	3.22
Iroquois Prov'd'r	Iroquois Grain Co.,	Clinton,	11.54	8.18	3.08
Provender,	J. Cushing & Co.,	Ayer,	10.75	10.49	4.19
Banner Oat Feed	Unknown,	Northboro,	8.91	9.31	3.06
Windsor,	"	Lowell,	7.70	9.41	2.95
Provender,	M. L. & M. W. Graves,	Northampton,	11.98	10.31	4.33
SterlingProv'd'r	M. L. Chittenden,	North Adams,	9.90	9.06	4.07
	Highest,			**11.43**	**5.35**
	Lowest,			**7.43**	**2.38**
	Average,		**10.11**	**9.10**	**3.59**

The many corn and oat feeds and "provender" now in our markets consist of oat feed as a basis, mixed with more or less corn. Ground oats and corn are rarely found, except when prepared by the local miller. Corn and oat feeds are of uncertain value, depending on the amount of oat refuse they contain. They are generally worth from 70 to 90 per cent as much as corn meal.

Corn, Oat and Barley Feed.

None,	Am. Cereal Co.,	No. Wilbraham,	7.83	12.81	4.77
"	" " "	Worcester,	7.94	11.39	4.42
Schumachers,	" " "	Westboro,	9.31	10.22	3.77
"	" " "	Westfield,	8.86	11.53	4.31
"	" " "	Worcester,	9.56	11.28	4.43
None,	Henry C. Rolfe,	Lowell,	9.14	12.32	4.26
	Average,		**8.78**	**11.59**	**4.33**

Corn oat and barley feed is worth rather more (5 to 10 per cent) than "corn and oat feed."

Hominy Feeds.

Mohawk,	Unknown,	Princeton,	8.06	11 03	7.31
None,	"	Fitchburg,	9.03	10.69	8.76
"	Des Plaines Valley Co.,	Needham,	10.26	10.65	6.61
"	Unknown,	Taunton,	11.71	10.87	8.70
"	"	Fall River,	10.15	11.55	8.77
"	"	New Bedford,	9.61	11.44	7.07
"	Hollister, Crane & Co.,	Princeton,	8.04	11.38	9.71
"	Unknown,	Concord,	8.31	10.94	9.01
"	"	Worcester,	7.35	11.31	9.32
Shelbarkers,	"	Shelburne Falls,	8.52	11.31	8.46
	Average,		**9.11**	**11.11**	**8.37**

Hominy feeds are free from adulteration, and show a value equal to cornmeal.

Miscellaneous.

Brand.	Manufactured by:	Collected at:	Water.	Protein.	Fat.
H. O. Horse,	H. O. Company,	Pittsfield,	8.66	10.68	3.61
Oat Meal,	Unknown,	Lynn,	8.54	11.82	4.43
"	"	Salem,	9.02	10.75	3.54
Rye Feed,	"	Northampton,	9.39	13.89	2.47
"	F. L. Worthy & Co.,	N. Wilbraham,	10.69	13.41	2.23
"	" " "	Westfield,	9.40	13.00	2.81
Chop Feed,	R. J. Hardy & Sons,	Franklin,	9.42	8.52	3.64
"	" " "	"	8.80	8.16	2.68
Comb. Feed,	Davis Feed Co.,	Wakefield,	10.54	9.28	3.00

For comparative values of H.O. horse and chop feeds, see page 23.

III. Poultry Foods.

American,	American Cereal Co.,	Dedham,	8.68	14.68	5.79
"	" " "	Somerville,	10.11	15.53	5.73
"	" " "	Westminster,	9.42	13.59	4.82
"	" " "	Lawrence,	8.74	13.53	5.90
H. O.,	H. O. Company,	Lawrence,	8.31	17.58	5.63
"	" "	Haverhill,	8.93	17.88	4.75
Dessicated Fish,	Red Star Mnfg. Co.,	Leominster,	8.30	45.21	1.70
Concent'd Meal,	Darling Fertilizer Co.,	Fall River,	7.34	34.23	11.80
Animal Meal,	Bowker Fertilizer Co.,	Winchendon,	5.16	37.59	11.06
Meat & Bone Meal,	Beach Soap Co.,	Lawrence,	3.79	33.90	12.13
Superior Meat "	Bradley Fertilizer Co.,	Baldwinsville,	6.08	42.80	17.55
" "	" " "	New Bedford,	6.23	43.19	15.85
Pure Beef Scraps,	Darling Fertilizer Co.,	Fall River,	10.11	56.63	16.51

The poultry feeds prepared by the American Cereal Co. and by the H. O. Company are mixtures of oat feed, corn, and some nitrogenous feed stuff, the latter added to raise the protein to 14—17 per cent. A mixture of 100 pounds of wheat middlings, 75 pounds of corn meal or cracked corn, and 25 pounds of gluten meal, would make a feed equally valuable, which would cost about 90 cents per 100 pounds. The various meat scraps and meat meals are mixtures of meat, containing some fat, and bone. Those running highest in protein contain the least bone and are the most valuable. They are generally sold at a fair price.

D. CHEAPEST FEEDS AT PRESENT PRICES.

At *present* market prices as here given, those feeds are cheapest that stand first in the list, and those the most costly that stand last. *These results have been obtained by using the Key under F.*

		Feeds.	Present retail price.
I. Starchy Feeds.	1.	Corn meal,	$17 per ton.
	2.	Victor corn and oat feed, and hominy feed,	$16 and $18 " "
	3.	Quaker oat feed,	$16 " "
	4.	Oat feed and chop feed,	$16 and $17 " "
II Protein Feeds.	1.	Gluten meals and gluten feeds,	$20 and $17 per ton.
	2.	Cottonseed meal,	$23 " "
	3.	Dried brewers' grains,	$16 " "
	4.	Wheat middlings,	$17 to $19 " "
	5.	Mixed feed (bran and red dog),	$16 " "
	6.	Wheat bran,	$16 " "
	7.	Linseed meal and H. O. dairy feed,	$27 and $20 " "

Because corn meal is the cheapest of the starchy feeds, and gluten meal or feed the cheapest of the protein feeds, it does not follow that either corn or gluten meal should be fed exclusively. A judicious combination of the starchy and protein feeds is desirable, and various graiu mixtures are recommended below. Prices are liable to fluctuate, and the above relative values may be changed at any time.

E. GRAIN MIXTURES TO BE FED DAILY WITH COARSE FEED.

I.

100 lbs. corn or hominy meal.
100 lbs. bran, mixed, or chop feed.
75 lbs. cotton, gluten or linseed meal.
Mix and feed 8 to 9 quarts daily.

II.

200 lbs. chop feed.
100 lbs. cotton, gluten or linseed meal.
Mix and feed 7 to 8 quarts daily.

III.

100 lbs. oat feed.
100 lbs. Buffalo or Golden glu'n feed.
Mix and feed 8 quarts daily.

IV.

H. O. dairy feed.
Feed 6 to 8 quarts daily.

V.

Gluten feeds.
Feed 5 to 6 quarts daily.

VI.

100 lbs. fine middlings.
100 lbs. brewers' grains or malt sprouts.
Mix and feed 7 to 8 quarts daily.

VII.

50 lbs. linseed meal.
50 lbs. cottonseed meal.
100 lbs. oat feed or chop feed.
Mix and feed 7 to 8 quarts daily.

VIII.

100 lbs. corn meal.
50 lbs. bran.
50 lbs. cottonseed meal.
Mix and feed 7 quarts daily.

F. KEY TO COMPARATIVE VALUES OF CONCENTRATED FEEDS.

Starchy (carbohydrate) **feeds,**	**Corn meal,**	**100**
	Hominy meal or chop,	**100**
	Cerealine feed,	**100**
	Chop feed,	**80***
	Quaker oat feed,	**85**
	Oat feeds (excessive hulls),	**75**
	Victor corn and oat feed,	**95**
	H. O. horse feed,	**95**
Protein feeds,	**Wheat bran,**	**85**
	Wheat middlings,	**100—110****
	Mixed feed,	**90—95***
	Dried brewers' grains,	**100**
	Malt-sprouts,	**100**
	H. O. dairy feed,	**103**
	Buffalo and Golden gluten feeds,	**125**
	Other gluten feeds,	**120**
	Gluten meals,	**152**
	Cleveland flax meal,	**138**
	O. P. linseed meals,	**135**
	Cotton seed meal,	**152**

The above feedstuffs are divided into starchy and protein feeds. The former are purchased primarily to increase the digestible matter in the daily ration, while the latter are bought not alone to give more digestible material but to increase the *protein* in the ration feed to the animal.

How to use the Key.

It is not possible in this connection to show the relative effects of the various feed stuffs on the flow of milk or the production of beef. The figures are offered rather as a key to the *comparative commercial values* of the different feeds based on the nutrients contained in them. Thus if corn meal is worth 100, Quaker oat feed would be worth 85; or if wheat bran is worth 85, cottonseed meal would be worth 152. These figures can be easily converted into dollars. Thus if corn meal is worth $16 per ton or 100, Quaker oat feed

*Estimated but not actually determined.

**The 110 value refers to fine light colored middlings with 19 per cent protein.

would be worth 85 per cent of $16 or $13.60, the amount the farmer can afford to pay for the oat feed. Again with cottonseed meal worth $22, what can the farmer afford to pay for old process linseed meal? Cottonseed meal equals 152, or $22, and linseed meal 135 or $19.60. We have a case in simple proportion. 152 : 135 : : $22 : x =$19.60, the value of a ton of linseed. It must not be forgotten that these figures do not take into consideration the mechanical condition, or the particularly favorable effect which some feeds are supposed to exert upon the general health of the animal.

SPECIAL NOTICE.

Bulletins containing information concerning Concentrated Feed Stuffs, and analyses of the same, will hereafter be sent only to those especially desiring them. If you wish for these, send your name AT ONCE to the Director, Hatch Experiment Station, Amherst, Mass.

HATCH EXPERIMENT STATION

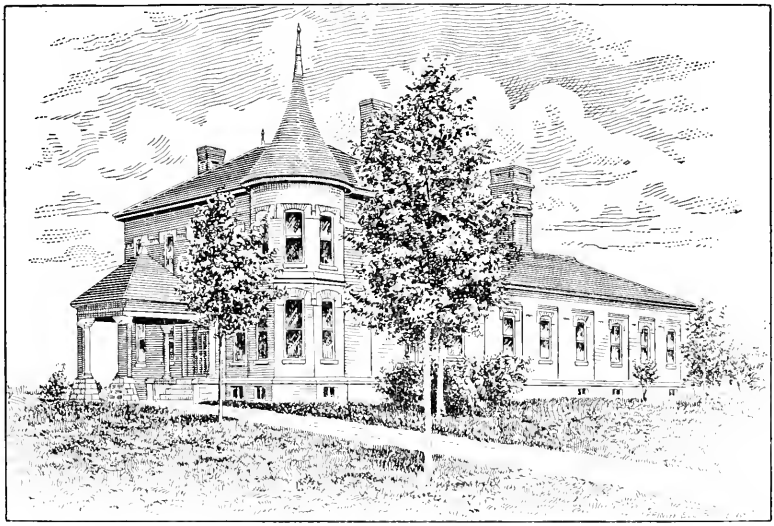
OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

BULLETIN NO. 57.

I. ANALYSES OF MANURIAL SUBSTANCES SENT ON FOR EXAMINATION.

II. ANALYSES OF LICENSED FERTILIZERS COLLECTED BY THE AGENT OF THE STATION DURING 1898.



CHEMICAL LABORATORY.

NOVEMBER, 1898.

The Bulletins of this Station will be sent free to all newspapers in the State and to such individuals interested in farming as may request the same.

AMHERST, MASS.:
PRESS OF CARPENTER & MOREHOUSE,
1898.

HATCH EXPERIMENT STATION

OF THE

Massachusetts Agricultural College,

AMHERST, MASS.

By act of the General Court, the Hatch Experiment Station and the State Experiment Station have been consolidated under the name of the Hatch Experiment Station of the Massachusetts Agricultural College. Several new divisions have been created and the scope of others has been enlarged. To the horticultural, has been added the duty of testing varieties of vegetables and seeds. The chemical has been divided, and a new division, "Foods and Feeding," has been established. The botanical, including plant physiology and disease, has been restored after temporary suspension.

The officers are :—

HENRY H. GOODELL, LL. D.,	*Director.*
WILLIAM P. BROOKS, PH. D.,	*Agriculturist.*
GEORGE E. STONE, PH. D.,	*Botanist.*
CHARLES A. GOESSMANN, PH. D., LL. D.,	*Chemist* (Fertilizers).
JOSEPH B. LINDSEY, PH. D.,	*Chemist* (Foods and Feeding).
CHARLES H. FERNALD, PH. D.,	*Entomologist.*
SAMUEL T. MAYNARD, B. SC.,	*Horticulturist.*
J. E. OSTRANDER, C. E.,	*Meteorologist.*
HENRY M. THOMSON, B. SC.,	*Assistant Agriculturist.*
RALPH E. SMITH, B. SC.,	*Assistant Botanist.*
HENRI D. HASKINS, B. SC.,	*Assistant Chemist* (Fertilizers).
CHARLES I. GOESSMANN, B. SC.,	*Assistant Chemist* (Fertilizers).
SAMUEL W. WILEY, B. SC.,	*Assistant Chemist* (Fertilizers).
EDWARD B. HOLLAND, M. SC.,	*First Chemist* (Foods and Feeding).
FRED W. MOSSMAN, B. SC.,	*Ass't Chemist* (Foods and Feeding).
BENJAMIN K. JONES, B. SC.,	*Ass't Chemist* (Foods and Feeding).
PHILIP H. SMITH, B. SC.,	*Assistant in Foods and Feeding.*
ROBERT A. COOLEY, B. SC.,	*Assistant Entomologist.*
GEORGE A. DREW, B. SC.,	*Assistant Horticulturist.*
HERBERT D. HEMENWAY, B. SC.,	*Assistant Horticulturist.*
ARTHUR C. MONAHAN,	*Observer.*

The co-operation and assistance of farmers, fruit-growers, horticulturists, and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the

HATCH EXPERIMENT STATION, Amherst, Mass.

DIVISION OF CHEMISTRY.

C. A. GOESSMANN.

I.

ANALYSES OF COMMERCIAL FERTILIZERS AND MANURIAL SUBSTANCES SENT ON FOR EXAMINATION.

WOOD ASHES.

582-586.
I. Received from Marshfield Centre, Mass.
II. Received from Sherborn, Mass.
III. Received from Lexington, Mass.
IV. Received from Sunderland, Mass.
V. Received from Sunderland, Mass.

	Per Cent.				
	I.	II.	III.	IV.	V.
Moisture at 100° C.,	6.42	16.16	12.35	19.73	14.94
Potassium oxide,	6.84	8.36	8.06	3.15	2.70
Phosphoric acid,	1.30	1.22	1.46	1.22	1.16
Ferric and Aluminum oxide,	7.10	6.50	8.70	*	*
Calcium oxide,	33.74	32.96	35.84	31.68	34.00
Insoluble matter,	16.46	6.65	8.76	10.72	10.58

587-591.
I. Received from Sunderland, Mass.
II. Received from Sunderland, Mass.
III. Received from Boston, Mass.
IV. Received from Deerfield, Mass.
V. Received from North Amherst, Mass.

*Not determined.

	Per Cent.				
	I.	II.	III.	IV.	V.
Moisture at 100° C.,	25.70	4.83	3.11	1.36	17.63
Potassium oxide,	4.46	3.86	6.72	3.71	4.94
Phosphoric acid,	1.05	1.26	1.55	.83	1.51
Calcium oxide,	24.06	40.04	39.58	29.21	30.00
Insoluble matter,	14.96	10.87	3.27	16.91	10.43

An examination of the results of the above stated ten samples recently sent on for analysis at the station shows the following variation in their composition :

		No. of samples.
Moisture from	1 to 3%	1
" "	3 to 6%	2
" "	6 to 10%	1
" "	10 to 15%	2
" "	15 to 20%	3
" above	20%	1
Potassium oxide above	8%	2
" " from	7 to 8%	0
" " "	6 to 7%	2
" " "	5 to 6%	0
" " "	4 to 5%	2
" " "	3 to 4%	3
" " below	3%	1
Phosphoric acid above	2%	0
" " from	1 to 2%	9
" " below	1%	1

The average of Calcium oxide (lime) amounts to 33.11 per cent., varying from 24.06 to 40.04 per cent. in different samples.

Mineral matter (coal ash, sand,) insoluble in diluted hydrochloric acid :

Below	5%	1
From	5 to 10%	2
"	10 to 15%	5
"	15 to 20%	2

LIME-KILN ASHES AND MARL.

592-593. I. Lime-kiln ashes received from So. Hadley, Mass.
II. Marl received from Amherst, Mass.

	Per Cent.	
	I.	II.
Moisture at 100° C.,	1.20	21.73
Potassium oxide,	2.25	.54
Phosphoric acid,	1.22	trace.
Magnesium oxide,	*	1.30
Calcium oxide,	42.23	39.05
Insoluble matter,	6.52	1.09

ASHES FROM PEACH TREE TRIMMINGS.

594. I. Received from Marshfield Centre, Mass.

	Per Cent.
Moisture at 100° C.,	.54
Potassium oxide,	4.92
Phosphoric acid,	2.44
Ferric and Aluminum oxide,	10.50
Calcium oxide,	18.74
Sodium oxide,	7.53
Sulphuric acid,	2.20
Insoluble matter,	13.54

The ashes had evidently received some addition of earthy matter.

ANALYSES OF POTATOES (air dried).

595-599. No's I., II., III., IV., and V. received from Amherst, Mass.

	Per Cent.				
	I.	II.	III.	IV.	V.
Moisture at 100° C.,	6.99	6.69	6.78	6.70	7.12
Potassium oxide,	1.36	1.29	2.74	1.48	2.40
Phosphoric acid,	.39	.48	.36	.27	.42
Nitrogen,	1.65	1.93	1.40	1.61	1.41

*Not determined.

600-603. No's VI., VII., VIII., and IX. received from Amherst, Mass.

	Per Cent. VI.	VII.	VIII.	IX.
Moisture at 100° C.,	8.33	6.88	7.38	6.52
Potassium oxide,	2.49	1.66	1.21	2.40
Phosphoric acid,	.44	.35	.36	.52
Nitrogen,	1.32	1.49	1.92	1.48

SWEET CLOVER HAY.

604-606. I. Received from Amherst, Mass.
II. Received from Amherst, Mass.
III. Received from Amherst, Mass.

	Per Cent. I.	II.	III.
Moisture at 100° C.,	13.54	12.69	11.29
Nitrogen,	3.23	2.87	2.02

TOBACCO STEMS AND HOP REFUSE.

607-608. I. Tobacco stems received from Hatfield, Mass.
II. Hop refuse rec'd from a Brewery, Springfield, Mass.

	Per Cent. I.	II.
Moisture at 100° C.,	8.40	83.92
Potassium oxide,	6.10	.05
Phosphoric acid,	.32	.11
Organic matter,	*	1.71
Nitrogen,	2.23	.49
Insoluble matter,	*	.83

DRIED BLOOD AND PEAT.

609-610. I. Dried Blood received from Amherst, Mass.
II. Peat received from North Middleboro, Mass.

	Per Cent. I.	II.
Moisture at 100° C.,	7.09	28.22
Phosphoric acid,	1.50	*
Organic matter,	*	69.12
Ash,	*	2.66
Nitrogen,	9.40	1.11

*Not determined.

SULPHATE OF AMMONIA AND SULPHATE OF POTASH AND MAGNESIA.

611-612. I. Sulphate of Ammonia received from Amherst, Mass.
II. Sulphate of Potash and Magnesia received from Amherst, Mass.

	Per Cent. I.	Per Cent. II.
Moisture at 100° C.,	1.20	4.91
Potassium oxide,	*	25.72
Nitrogen,	21.44	*

TANKAGE.

613-614. I. Received from Fall River, Mass.
II. Received from Amherst, Mass.

	Per Cent. I.	Per Cent. II.
Moisture at 100° C.,	5.41	7.07
Total Phosphoric acid,	14.96	14.72
Reverted Phosphoric acid,	*	7.68
Insoluble Phosphoric acid,	*	7.04
Nitrogen,	6.63	5.64

BONE MEAL.

615-519. I. Received from Amherst, Mass.
II. Received from Amherst, Mass.
III. Received from Marshfield Centre, Mass.
IV. Received from Marshfield Centre, Mass.
V. Received from Florence, Mass.

	Per Cent. I.	II.	III.	IV.	V.
Moisture at 100° C.,	4.88	7.98	7.72	3.96	8.21
Total Phosphoric acid,	24.86	24.82	23.62	28.84	27.06
Reverted Phosphoric acid,	12.30	6.78	9.16	11.82	9.35
Insoluble Phosphoric acid,	12.34	18.04	14.46	17.02	17.71
Nitrogen,	2.98	4.08	2.79	1.26	3.79

MECHANICAL ANALYSIS OF NO. V.

Fine Bone,	48.90
Fine Medium,	37.70
Medium,	13.40

*Not determined.

COMPLETE FERTILIZERS.

620-623. I. Received from Ashby, Mass.
II. Received from North Orange, Mass.
III. Received from Granby, Mass.
IV. Received from Amherst, Mass.

	Per Cent.			
	I.	II.	III.	IV.
Moisture at 100° C.,	2.53	5.88	7.79	65.28
Potassium oxide,	*	9.04	1.18	.73
Total Phosphoric acid,	23.92	11.82	13.58	.48
Soluble Phosphoric acid,	*	*	5.50	*
Reverted Phosphoric acid.	11.76	2.36	5.00	*
Insoluble Phosphoric acid,	12.16	9.46	3.08	*
Nitrogen,	1.26	3.64	1.08	.24
Insoluble matter,	*	*	*	3.56

624-625. V. Received from Greenfield, Mass.
VI. Received from Greenfield, Mass.

	Per Cent.	
	V.	VI.
Moisture at 100° C.,	7.65	9.56
Potassium oxide,	10.34	7.37
Total Phosphoric acid,	5.70	6.60
Soluble Phosphoric acid,	1.40	1.54
Reverted Phosphoric acid,	2.26	2.50
Insoluble Phosphoric acid,	2.04	2.56
Nitrogen,	6.42	3.42

BARNYARD MANURES.

626-629. No's I.,II.,III., and IV.received from Amherst,Mass.

	Per Cent.			
	I.	II.	III.	IV.
Moisture at 100° C.,	73.21	74.30	73.13	65.23
Potassium oxide,	.51	.56	.50	.63
Phosphoric acid,	.28	.23	.28	.34
Nitrogen,	.41	.42	.41	.53
Insoluble matter,	1.97	2.06	2.49	3.05

*Not determined.

630-633. No's V., VI., VII. and VIII. received from Amherst, Mass.

	Per Cent. V.	VI.	VII.	VIII.
Moisture at 100° C.,	57.09	72.53	71.46	65.28
Potassium oxide,	.88	.26	.64	.73
Phosphoric acid,	.48	.16	.46	.48
Nitrogen,	.36	.43	.66	.24
Insoluble matter,	17.48	18.83	6.50	3.56

SEWAGE.

434. I. Sewage received from Concord, Mass.

	Per Cent. I.
Moisture at 100° C.,	99.80
Solid residue,	.20
Nitrogen,	.30
Nitrogen as nitrates and albuminoids,	.27
Nitrogen as ammonia,	.03
Chlorine,	.033

*Not determined.

II. ANALYSES OF COMMERCIAL FERTILIZERS COLLECTED DURING 1898, IN THE GENERAL MARKETS BY THE AGENT OF THE HATCH EXPERIMENT STATION OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

Laboratory No.	Name of Brand.	Name of Manufacturer.	Sampled at
	Compound Fertilizers.		
12	High Grade Special for Tobacco,	National Fertilizer Co., Bridgeport, Conn.,	Sunderland.
18	Complete Manure for General Use,	H. J. Baker & Bros., New York City,	Sunderland.
24	Tobacco Ash Constituents,	Mapes Formula and Peruvian Guano Co., N. Y. City,	Sunderland.
28	Chittenden's Complete Tobacco Fertilizer,	National Fertilizer Co., Bridgeport, Conn.,	Sunderland.
32	Tobacco and Onion Fertilizer,	E. Frank Coe & Co., New York City,	Sunderland.
45	Market Garden Fertilizer,	Bowker Fertilizer Co., Boston, Mass.,	Northboro,
56	Grass and Lawn Top Dressing,	Bradley Fertilizer Co.. Boston. Mass.,	Hudson.
64	Potato Manure,	Clark's Cove Fertilizer Co., Boston, Mass.	Hudson.
75	Hill and Drill Phosphate,	Bowker Fertilizer Co., Boston, Mass.,	Boston.
98	Lawn Dressing,	Lowell Fertilizer Co,, Boston, Mass.,	Salem.
120	Complete Manure with 10 per cent Potash,	Bradley Fertilizer Co., Boston, Mass.,	Beverly.
125	All Soluble,	Armour Fertilizer Works, Chicago,Ill.,	Salem.
149	Cleveland Potato Phosphate,	Cleveland Dryer Co., Bostor, Mass.,	Dighton.
151	Hill and Drill Phosphate,	Bowker Fertilizer Co., Boston, Mass.,	Plymouth.
165	Ammoniated Bone Phosphate,	Berkshire Mills Co., Bridgeport, Conn.,	Dighton.
170	Universal Fertilizer,	Packers'Union Fertilizer Co., New York City,	Easthampton.
193	Dry Ground Fish,	Wilcox Fertilizer Works, Mystic,Conn.,	Fall River.
195	Cabbage Manure,	H. J. Baker & Bro., New York City,	Fall River.
238	All Soluble,	Armour Fertilizer Works, Chicago, Ill.,	Springfield.
241	Grain Grower,	Armour Fertilizer Works, Chicago, Ill.,	Springfield.
261	Corn Manure,	Quinnipiac Co., Boston, Mass..	Westfield.
296	Tobacco and Onion Fertilizer,	E. Frank Coe & Co., New York City,	Amherst.
300	Grain Grower,	Armour Fertilizer Works, Chicago, Ill.,	Amherst.
302	All Soluble,	Armour Fertilizer Works, Chicago, Ill.,	Amherst.
316	Dry Ground Fish,	Wilcox Fertilizer Works, Mystic, Conn.,	Amherst.
322	Corn Manure,	Quinnipiac Co., Boston, Mass.,	No. Amherst.

Laboratory Number.	Name of Brand.	Moisture.	Nitrogen in 100 lbs.		Phosphoric Acid in 100 lbs.							Potassium Oxide in 100 lbs.	
								Total.		Available.			
			Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
	Compound Fertilizers.												
12	High Grade Special for Tobacco, ...	5.37	5.89	5.7-6.5	4.98	1.92	.52	7.42	8-10	6.90	6-8	11.13	10-11*
18	Complete Manure for General Use, ...	13.88	2.74	2.47-3.29	5.38	3.26	1.16	9.80	9-10	8.64	8-10	6.26	6-7
24	Tobacco Ash Constituents,................	11.78	.66	.5	—	2.56	3.58	6.14	5.70	2.56	—	15.08	15.
28	Chittenden's Complete Tobacco Fertilizers,	11.38	3.70	3.3-4.1	2.18	7.16	1.54	10.88	9.16-10.99	9.34	8-11	4.50	5.4-6.48
32-296	Tobacco and Onion Fertilizers,............	7.66	3.67	3.29-4.00	5.38	1.98	1.28	8.64	8-10	7.36	6-8	9.88	8-9
45	Market Garden Fertilizer, ...	9.55	2.70	2.47-3.30	2.74	3.30	4.20	10.24	8-12	6.04	6-8	10.88	10-12
56	Grass and Lawn Top Dressing, ...	8.58	3.95	3.01-4.78	3.08	2.62	1.16	6.86	6-9	5.70	5-7	2.03	2-3
64	Potato Manure,..........................	5.87	2.96	2.47-3.30	2.14	3.22	2.44	7.80	7-11	5.36	6-9	5.19	4-6
75-151	Hill and Drill Phosphate,..................	13.64	2.44	2.25-3.25	6.02	4.84	1.80	12.66	12-13	10,86	9-11	2.18	2-3
98	Lawn Dressing, ...	6.41	4.36	4.12-4.94	5.12	3.46	2.94	11.52	9-12	8.58	8-10	4.71	5-6
120	Complete Manure with 10 per cent Potash,	12.14	3.03	3.30-4.13	1.84	5.38	2.04	9.26	7-10	7.22	6-9	10.42	10-12
125-238-302	All Soluble, ...	3.44	3.12	2.88-3.70	5.06	5.22	3.02	13.30	10-12	10.28	8-10	7.07	4.-5
149	Cleveland Potato Phosphate, ...	18.65	2.08	2.06-2.88	5.76	3.82	1.80	11.38	10-13	9.58	8-10	3.07	3-4
165	Ammoniated Bone Phosphate, ...	12.39	2.80	1.65-2.47	4.14	3.92	3.32	11.38	10-12	8.06	8-10	2.20	2-3
170	Universal Fertilizer, ...	14.46	.77	.82-1.65	7.08	3.16	1.66	11.90	9-15	10.24	8-12	7.06	5-8
193-316	Dry Ground Fish, ...	7.19	8.90	8.5-10.	—	3.68	3.94	7.62	6-9	3.68	4-6	—	—
195	Cabbage Manure, ...	11.40	4.85	4.75.5.95	4.22	2.42	.90	7.54	6-7	6.64	4-5	7.68	7-8
241-300	Grain Grower,...........................	8.38	2.55	1.65-2.47	4.22	4.96	3.86	13.04	10-12	9.18	8-10	1.81	2-3
261-322	Corn Manure, ...	10.61	2.33	2.06-2.88	4.60	4.74	2.56	11.90	10-14	9.34	9-14	1.58	1.5-2.5

*Sulphate of Potash, the source of Potash.

II. ANALYSES OF COMMERCIAL FERTILIZERS COLLECTED DURING 1898, IN THE GENERAL MARKETS BY THE AGENT OF THE HATCH EXPERIMENT STATION OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

Laboratory No.	Name of Brand.	Name of Manufacturer.	Sampled at
	Compound Fertilizers.		
25	Soluble Potato Manure,	Rogers & Hubbard Co., Middletown, Conn.,	Sunderland.
43	Seeding Down Fertilizer,	Bowker Fertilizer Co., Boston, Mass.,	Marlboro.
47	High Grade Fertilizers.	Bowker Fertilizer Co., Boston, Mass.,	Marlboro.
48	Bone and Potash,	Bowker Fertilizer Co., Boston, Mass.,	Marlboro.
82	Fish and Potash,	Russia Cement Co., Gloucester. Mass.,	Beverly.
102	Rawson's Formula,	W. W. Rawson & Co., Boston, Mass.,	Boston.
117	Potato Fertilizer,	Russia Cement Co., Gloucester, Mass.,	Beverly.
123	High Grade Fertilizer,	Bowker Fertilizer Co., Boston Mass.,	Beverly.
142	Fish and Potash,	Russia Cement Co., Gloucester, Mass.,	Taunton.
161	Tobacco Grower,	M. E. Wheeler & Co., Rutland, Vt.,	Easthampton.
169	Guano,	Pacific Guano Co., Boston, Mass.,	Plymouth.
174	Americus Corn Phosphate,	Williams & Clark Fertilizer Co., Boston, Mass.,	Northampton.
178	Grass Manure,	Williams & Clark Fertilizer Co., Boston, Mass.,	Northampton.
202	Special Strawberry Fertilizer,	Parmenter & Polsey Fertilizer Co., Peabody, Mass.,	Dighton.
214	Fish and Potash,	Russia Cement Co., Gloucester, Mass.,	Hadley,
220	Fish and Potash,	Russia Cement Co., Gloucester, Mass.,	Worcester.
251	Potato and Root Crop Fertilizer,	Prentiss, Brooks & Co., Holyoke, Mass.,	Holyoke.
252	Potato Fertilizer,	Clark's Cove Fertilizer Co., Boston, Mass.,	Springfield.
255	Special with 10 per cent Potash,	Quinnipiac Co., Boston, Mass.,	Westfield.
267	Grass Fertilizer,	Quinnipiac Co., Boston, Mass.,	Pittsfield.
274	Fish and Potash,	Russia Cement Co., Gloucester, Mass.,	Pittsfield.
282	Champion Garden Fertilizer,	D. Whithed, Lowell, Mass.,	Amherst.
288	Animal Fertilizer,	W. H. Abbott, Holyoke, Mass.,	Amherst.
297	Bone and Blood,	Armour Fertilizer Works, Chicago, Ill.,	Amherst.
323	Fish and Potash,	Wilcox Fertilizers Works, Mystic, Conn.,	Amherst.

Laboratory Number.	Name of Brand.	Moisture.	Nitrogen in 100 lbs.		Phosphoric Acid in 100 lbs.							Potassium Oxide in 100 lbs.	
								Total.		Available.			
			Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
	Compound Fertilizers.												
25	Soluble Potato Manure,	11.13	4.85	5.-6.60	1.34	5.18	3.46	9 98	10-12	6.52	7-8.50	5.81	5-6*
43	Seeding Down Fertilizer,	11 62	2.75	2.25 3.25	2.90	3.64	4.34	10.88	10-12	6.54	6-8	8.98	10-12
47-123	High Grade Fertilizer,	14 01	2.52	2.25-3.25	5.66	3.94	1.02	10.62	10-13	9.60	8 10	3.93	4-6
48	Bone and Potash,	7.61	1.79	1.23-2.06	1.46	5.36	7.12	13.94	12-14	6.82	6-8	2.13	2-3
82-142-214-220-274	Fish and Potash.	9.93	2.48	2-3	3.66	4.92	5.24	13.82	12-14	8.58	10-11	2.32	2.25-3.25
102	Rawson's Formula,	12 54	3.31	2.88-3.71	6.02	2.80	1.80	10 62	8-10	8 82	6-8	7.03	7-8
117	Potato Fertilizer,	8.37	2.39	2.25-3 00	4.48	4.12	3.46	12 06	9-11	8.60	7-8	5.39	5-6*
161	Tobacco Grower,	9.28	2.93	2.88 3.71	4.34	2.04	1.48	7.86	7-10	6.38	6-8	6.88	7-9
169	Guano,	18.71	1.25	1.15-1.50	6.32	3.14	1.54	11 00	8-14	9.46	7-12	2.13	2-3
174	Americus Corn Phosphate,	13.40	1.94	2.06-2.88	7.62	1.58	1.16	10 36	10-14	9 20	9-12	1.34	1.5-2.5
178	Grass Manure,	6.05	5.79	3.91-4.73	1,02	4.36	1.28	6.66	6-9	5.38	5-7	2.70	2-3
202	Special Strawberry Fertilizer,	13.10	3.62	2.47-3.29	4.34	5.76	.64	10.74	10-12	10.10	9-11	5.20	6-7
251	Potato and Root Crop Fertilizer,	6 52	4.14	3.30-4.12	.12	6.08	6.98	13 18	8-10	6.20	5-6	8.60	7-9
252	Potato Fertilizer,	10 55	2.39	2.06-2.88	3.58	6.26	3.08	12.92	9-13	9 84	8-11	3.38	3-4
255	Special with 10 per cent. Potash,	13 08	3.21	2.47-3.30	4.98	1.64	1.82	8.44	7-11	9.62	6-9	9.13	10-11
267	Grass Fertilizer,	8.34	4.85	3.91-4.74	1.80	5.36	1.16	8.32	6-9	7.16	5-7	2.28	2-3
282	Champion Garden Fertilizer,	5.34	3.84	3.94	.26	1.40	12.16	13.82	19.70	1.66	—	6.70	5.30
288	Animal Fertilizer,	13 68	3.75	3.5-4.5	—	8.26	13.62	21.88	21-22	8.26	9-10	—	—
297	Bone and Blood,	6.45	5.84	5.76-6.58	—	4.74	7.16	11.90	10-12	4.74	5-7	—	—
323	Fish and Potash,	22.06	3.35	2.5-3.5	3.50	2.64	.90	7.04	6 8	6.14	5-7	3.15	2-4

*Sulphate of Potash, the source of Potash.

II. ANALYSES OF COMMERCIAL FERTILIZERS COLLECTED DURING 1898, IN THE GENERAL MARKETS BY THE AGENT OF THE HATCH EXPERIMENT STATION OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

Laboratory No.	Name of Brand.	Name of Manufacturer.	Sampled at
	Compound Fertilizers.		
35	Eagle Brand for Grass and Grain,	W. H. Abbott, Holyoke, Mass.,	Sunderland.
40	Potato Manure,	Bradley Fertilizer Co., Boston, Mass.,	Hudson.
41	X. L. Superphosphate,	Bradley Fertilizer Co., Boston, Mass.,	Hudson.
61	Fruit and Vine Fertilizer,	Lowell Fertilizer Co., Boston, Mass.,	Hudson.
73	Potato and Vegetable Manure.	Bradley Fertilizer Co., Boston, Mass.,	Beverly.
81	X. L. Superphosphate,	Bradley Fertilizer Co., Boston, Mass.,	Lowell.
95	Potato Manure,	Bradley Fertilizer Co., Boston, Mass.,	Lowell.
100	Fruit and Vine Fertilizer,	Lowell Fertilizer Co., Boston, Mass.,	Lowell.
104	Potato and Vegetable Manure,	Bradley Fertilizer Co., Boston, Mass.,	Boston.
111	Potato Manure,	Bradley Fertilizer Co., Boston, Mass.,	Beverly.
122	Ammoniated Bone and Potash,	Armour Fertilizer Works, Chicago, Ill.,	Salem.
159	Complete Fertilizer for Potatoes and Onions,	Berkshire Mills Co., Bridgeport, Conn.,	Easthampton.
193	Dry Ground Fish Guano,	Wilcox Fertilizer Works, Mystic, Conn.,	Fall River.
216	Fertilizer for Roots,	Berkshire Mills Co., Bridgeport, Conn.,	Dighton.
233	Oats and Top Dressing Fertilizer,	Rogers & Hubbard Co., Middletown, Conn.,	Holyoke.
234	Potato and Vegetable Manure,	Bradley Fertilizer Co., Boston, Mass.,	Holyoke.
240	Fertilizer for all Soils and all Crops,	Rogers & Hubbard Co., Boston, Mass.,	Holyoke.
268	Potato and Vegetable Manure,	Bradley Fertilizer Co., Boston, Mass.,	Pittsfield.
269	Potato Manure,	Bradley Fertilizer Co., Boston, Mass.,	Pittsfield.
289	Farm and Field,	Benj. Randall, Boston, Mass.,	Amherst.
293	Eagle Brand for Grass and Grain,	W. H. Abbott, Holyoke Mass.,	Amherst.
298	Ammoniated Bone with Potash,	Armour Fertilizer Co., Chicago, Ill.,	Amherst.
319	X. L. Superphosphate,	Bradley Fertilizer Co., Boston, Mass.,	Amherst.
328	Potato Manure,	Bradley Fertilizer Co.. Boston, Mass.,	Amherst.
334	Complete Fertilizer for Potatoes and Onions,	Berkshire Mills Co., Bridgeport, Conn.,	Amherst.
336	Complete Fertilizer for Potatoes and Onions,	Berkshire Mills, Co., Bridgeport, Conn.,	No. Amherst.
316	Dry Ground Fish Guano,	Wilcox Fertilizer Works, Mystic, Conn.,	Amherst.

Laboratory Number.	Name of Brand.	Moisture.	Nitrogen in 100 lbs.		Phosphoric Acid in 100 lbs.							Potassium Oxide in 100 lbs.	
								Total.		Available.			
			Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
	Compound Fertilizers.												
35-293	Eagle Brand for Grass and Grain,	6.27	3.70	3-4	—	8.70	8.70	17.40	16-18	8.70	9-10	10.00	10-11
40-95-111-269-328	Potato Manure,	11.40	2.31	2.5-3.25	2.68	3.20	3.20	9.08	8-10	5.88	6-8	4.64	5-6
41-81-319	X. L. Superphosphate	11.47	2.81	2.5-3.25	6.14	3.84	2.18	12.16	11-14	9.98	9-11	1.72	2-3
61-100	Fruit and Vine Fertilizer,	11.02	3.05	2.47-3.30	5.50	3.84	1.02	10.36	8-10	9.34	7-8	4.75	6-7
73-104-234-268	Potato and Vegetable Manure,	11.80	3.24	3.30-4.12	2.86	5.82	2.44	11.12	9-13	8.68	8-11	7.18	7-8
122-298	Ammoniated Bone and Potash,	7.15	2.95	2.47-3.29	4.86	3.72	3.32	11.90	8-10	8.58	6-8	2.24	2-3
159-216-334-336	Comp. Fertilizer for Potatoes and Onions,	11.71	2.60	2.47-3.30	5.76	2.56	3.58	11.90	10-12	8.32	8-10	5.10	6-8
233	Oats and Top Dressing Fertilizer,	5.60	7.82	8.80-9.70	—	4.12	5.42	9.54	7.85-8.75	4.12	—	8.28	8.35-9.25
240	Fertilizer for all Soils and all Crops,	10.58	1.77	2.30-3.00	9.68	1.64	2.30	13.62	12-14	11.32	10-12	3.01	3-4
289	Farm and Field,	20.77	2.67	2-3	.79	4.69	2.38	7.86	9.16-11.45	5.48	6-8	2.43	2-3
316-193	Dry Ground Fish Guano,	7.19	8.90	8.29-9.89	—	3.68	3.94	7.62	6-9	3.68	4-6	—	—

II. ANALYSES OF COMMERCIAL FERTILIZERS COLLECTED DURING 1898, IN THE GENERAL MARKETS BY THE AGENT OF THE HATCH EXPERIMENT STATION OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

Laboratory No.	Name of Brand.	Name of Manufacturer.	Sampled at
	Compound Fertilizers.		
37	Wood Ashes,	E. McGarvey & Co., London, Ontario, Can.,	Sunderland.
57	Corn, Grain and Fodder Corn Fertilizer,	Bowker Fertilizer Co., Boston, Mass.,	Marlboro.
79	Wood Ashes,	Wm. E. Fyfe & Co.. Clinton, Mass.,	Lowell.
90	Maple Wood Ashes,	F. R. Lalor, Danville, Ontario, Canada,	Fitchburg.
91	Sure Crop Bone Phosphate,	Bowker Fertilizer Co., Boston, Mass.,	Fitchburg.
97	Dissolved Bone and Potash,	Lowell Fertilizer Co., Boston, Mass.,	Salem.
103	Complete Cauliflower and Cabbage,	Russia Cement Co., Gloucester, Mass.,	Beverly.
109	Complete Manure for General Use,	Mapes Formula and Peruvian Guano Co., N. Y. City,	Boston.
110	Potato Fertilizer,	Bradley Fertilizer Co., Boston, Mass,,	Lowell.
112	Dissolved Bone,	Bradley Fertilizer Co., Boston, Mass.,	Boston.
129	Wood Ashes,	Bowker Fertilizer Co., Boston, Mass.,	Taunton.
145	Essex Lawn Dressing,	Russia Cement Co., Gloucester, Mass.,	Taunton.
152	Sure Crop Bone Phosphate,	Bowker Fertilizer Co., Boston, Mass.,	Plymouth.
168	Complete Manure for General Use,	Mapes Formula and Peruvian Guano Co., N. Y. City,	Taunton.
175	Tobacco Manure,	Lowell Fertilizer Co., Boston, Mass.,	Easthampton.
182	Wood Ashes,	Bradley Fertilizer Co., Boston, Mass.,	Northampton.
186	Asparagus Fertilizer,	H. J. Baker & Bro., New York City,	Fall River.
200	Cleveland Superphosphate,	Cleveland Dryer Co., Boston, Mass.,	Dighton.
207	Dry Ground Fish,	National Fertilizer Co., Bridgeport, Conn.,	Dighton.
225	Standard Un. X. Ld. Fertilizer,	H. J. Baker & Bro., New York City,	Springfield.
246	Potato Fertilizer,	Bradley Fertilizer Co., Boston, Mass.,	Holyoke.
275	Maple Wood Ashes,	F. R. Lalor, Danville, Ontario, Canada,	Pittsfield.
280	Vegetable and Vine Fertilizer,	E. Frank Coe & Co., New York City,	Amherst.
283	Bay State Phosphate,	E. Frank Coe & Co., New York City,	Amherst.
326	High Grade Fish and Potash,	Wilcox Fertilizer Works, Mystic, Conn.,	Amherst.

Laboratory Number.	Name of Brand.	Moisture.	Nitrogen in 100 lbs.		Phosphoric Acid in 100 lbs.							Potassium Oxide in 100 lbs.	
								Total.		Available.			
			Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
	Compound Fertilizers.												
37	Wood Ashes,	18.82	—	—	—	—	—	1.40	1	—	—	4.14	5.
57	Corn, Grain and Fodder Corn Fertilizer,	14.96	3.16	3-4	5 24	3.02	2.48	10.74	10-12	8.26	7-9	7.57	7-9
79	Wood Ashes,	2 01	—	—	—	—	—	1.80	—	—	—	6.18	—
90-275	Maple Wood Ashes,	14.78	—	—	—	—	—	1.22	1-2	—	—	5.22	4.5-7.5
91-152	Sure Crop Bone Phosphate,	16.72	1.08	.82-1.65	6.14	3.38	3.40	12.92	10-12	9.52	8-10	1.11	1-2
97	Dissolved Bone and Potash,	16.04	1.33	1-65-2.50	6.66	4.52	3.84	15.02	10-11	11.18	9-11	1.61	2-3
103	Complete Cauliflower and Cabbage,	10.57	4.45	4-5	3.70	4.24	3.32	11.26	9-11	7.94	7-8	6.63	7.5-8.5
109-168	Complete Manure for General Use,	16 08	3.44	3.29-4.12	3.08	5.06	2.58	10.72	10-12	8.14	8-10	4.54	4-5
110-246	Potato Fertilizer,	14.89	2.05	2.06-2.88	4.70	4.64	2.56	11.90	11-14	9.34	9-11	3.05	3.25-4-25
112	Dissolved Bone,	7.90	2.39	1.65-2.47	1.10	7.22	8.82	17.14	12-14	8.32	10-12	—	—
129	Wood Ashes,	5.87	—	—	—	—	—	1.45	1-2	—	—	7.08	4-5
145	Essex Lawn Dressing,	3.90	4.37	3.7-4.5	—	5.12	4.86	9.98	8-10	5.12	6-7	7.42	7-8
175	Tobacco Manure,	14.57	5.45	4.94-5.77	6.40	.24	.26	6 90	7-9	6.64	6-7	7.61	8-10
182	Wood Ashes.	12.68	—	—	—	—	—	1.62	2.	—	—	5.08	4-5
186	Asparagus Fertilizer,	16.08	4.59	4.12	4 30	2.22	.90	7.42	—	6 52	6.	7.76	9.
200	Cleveland Superphosphate,	17.08	2.10	2.06-2.88	6.90	2.82	1.80	11.52	11-14	9.72	9-11	2.01	2-3
207	Dry Ground Fish,	11.94	9.14	8.24-9.89	—	4.42	3.12	7.54	6-8	4.42	—	—	—
225	Standard Un. X. Ld. Fertilizer,	18.44	2.35	2.06-2.88	6.40	2.94	1.02	10.36	9-11	9.34	10.	2.59	2.25-3.
280	Vegetable and Vine Fertilizer,	11.74	2.39	2-3	6 02	1.66	2.56	10.24	10-13	7.68	8-10	8.34	6-7
283	Bay State Phosphate,	12.59	2.20	2.	7.04	2.44	2.68	12.16	11-13	9.48	9-12	2.32	1.85
326	High Grade Fish and Potash,	22.48	4.59	3.25 4.25	3.20	2.12	1.20	6.52	6-8	5.32	5.7	3.94	4-5

II. ANALYSES OF COMMERCIAL FERTILIZERS COLLECTED DURING 1898, IN THE GENERAL MARKETS OF THE AGENT OF THE HATCH EXPERIMENT STATION OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

Laboratory No.	Name of Brand.	Name of Manufacturer.	Sampled at
	Compound Fertilizers.		
80	Dissolved Bone,	Bowker Fertilizer Co., Boston, Mass.,	Beverly.
295	Success Fertilizer,	Lister's Agricultural Chemical Works, Newark, N. J.,	Amherst.
313	Tankage,	Bowker Fertilizer Co., Boston, Mass.,	Amherst.
314	Dissolved Bone,	Bowker Fertilizer Co., Boston, Mass.,	Amherst.
331	Potato and Tobacco Manure,	Clark's Cove Fertilizer Co., Boston, Mass.,	No. Amherst.
333	King Philip Alkaline Guano,	Clark's Cove Fertilizer Co., Boston, Mass.,	No. Amherst.
337	Potato and Root Fertilizer,	L. B. Darling Fertilizer Co., Pawtucket, R. I.,	Worcester.
339	Animal Fertilizer,	L. B. Darling Fertilizer Co., Pawtucket, R. I.,	Worcester.
341	Potato, Hop and Tobacco Fertilizer,	Crocker Fertilizer and Chemical Co., Buffalo, N. Y.,	Worcester.
342	New Rival Ammoniated Superphosphate,	Crocker Fertilizer and Chemical Co., Buffalo, N. Y.,	Worcester.
345	Ammoniated Wheat and Corn Phosphate,	Crocker Fertilizer and Chemical Co., Buffalo, N. Y.,	Worcester.
346	Ammoniated Bone Superphosphate,	Preston Fertilizer Co., Greenpoint, N. Y.,	Williamstown.
347	Pioneer Fertilizer,	Preston Fertilizer Co., Greenpoint, N. Y.,	Williamstown.
348	Potato and Onion Fertilizer,	Preston Fertilizer Co., Greenpoint, N. Y.,	Williamstown.
349	Standard Fertilizer,	Standard Fertilizer Co., Boston, Mass.,	Greenfield.
350	Fish and Potash,	Williams & Clark Fertilizer Co., Boston, Mass.,	Greenfield.
351	Hampden Lawn Dressing,	Bradley Fertilizer Co., Boston, Mass.,	Springfield.
	Bones.		
194	Ground Bone and Tankage,	Butchers' Rendering Association, Fall River, Mass.,	Fall River.
265	Bone Meal,	Quinnipiac Co., Boston, Mass.,	Pittsfield.
277	Ground Raw Bone,	B. Randall, Boston, Mass.,	Amherst.
288	Animal Fertilizer,	W. H. Abbott, Holyoke, Mass.,	Amherst.
301	Bone Meal,	Armour Fertilizer Works, Chicago, Ill.,	Amherst.
309	Steamed Bone Meal,	Bowker Fertilizer Co., Boston, Mass.,	Amherst.
310	Raw Bone Meal,	Rogers & Hubbard Co., Middletown, Conn.,	Amherst.
338	Pure Ground Bone,	L. B. Darling Fertilizer Co., Pawtucket R. I.,	Worcester.

Laboratory Number.	Name of Brand.	Moisture.	Nitrogen in 100 lbs. Found.	Nitrogen Guaranteed.	Phosphoric Acid in 100 lbs. Soluble.	Reverted.	Insoluble.	Total. Found.	Total. Guaranteed.	Available. Found.	Available. Guaranteed.	Potassium Oxide in 100 lbs. Found.	Potassium Oxide Guaranteed.
	Compound Fertilizers.												
80-314	Dissolved Bone, ...	5.25	4.64	2.47-3.30	3.70	10.76	3.96	18.42	16-18	14.46	12-14	—	—
295	Success Fertilizer, ...	14.61	1.86	1.24-1.65	8.58	3.06	1.54	13.18	11.5-13.	11.64	9.5-12	2.32	2-3*
313	Tankage, ...	7.07	5.64	4.94-5.77	—	7.68	7.04	14.72	14-16	7.68	—	—	—
331	Potato and Tobacco Manure, ...	13.57	2.38	2.-2.39	5.88	3.52	2.94	12.34	9-13	9.40	8-11	3.43	3-4
333	King Philip Alkaline Guano, ...	12.21	1.38	1.03-1.65	5.06	3.90	1.92	10.88	9-13	8.96	8-10	2.41	3-5
337	Potato and Root Fertilizer, ...	11.78	2.33	2.30	3.46	5.72	2.20	11.38	10	9.18	9	4.85	7
339	Animal Fertilizer, ...	11.22	3.46	3.30	4.74	6.54	1.74	12.02	10	11.28	8	4.07	4
341	Potato, Hop and Tobacco Fertilizer, ...	10.08	2.38	2.06-2.88	5.20	4.58	1.74	11.52	11-14	9.78	10-12	3.13	3.24-4.32
342	New Rival Ammoniated Superphosphate, ..	13.10	1.34	1.24-2.06	5.50	6.22	1.08	12.80	11-15	11.72	10-12	.95	1.62-2.70
345	Ammoniated Wheat and Corn Phosphate, ..	9.37	2.10	2.06-2.88	6.72	3.84	.82	11.38	11-15	10.56	10-13	1.50	1.62 2.70
346	Ammoniated Bone Superphosphate, ...	8.94	2.14	2.5-3.5	4.18	6.20	4.98	15.36	—	10.38	6-9	2.49	2-3
347	Pioneer Fertilizer, ...	10.53	1.34	1.25-1.50	5.38	3.78	3.58	12.74	—	9.16	8-10	1.70	1.75-2
348	Potato and Onion Fertilizer, ...	5.94	2.46	2.25-3-25	1.16	4.48	4.86	10.50	—	5.64	6-8	6.10	6-7
349	Standard Fertilizer, ...	12.46	2.65	2-3	5.42	3.60	2.82	11.84	10 15	9.02	8-12	2.03	2-3
350	Fish and Potash, ...	19.88	2.40	2-2.60	1.64	3.50	2.66	7.80	6-9	5.14	4-6	4.06	4-6
351	Hampden Lawn Dressing, ...	18.35	4.24	3.30-4.12	1.02	4.84	1.62	7.48	7-9	5.86	6-8	1.64	2-3

Laboratory Number.	Name of Brand.	Moisture.	Nitrogen Found.	Nitrogen Guaranteed.	Soluble.	Reverted.	Insoluble.	Total. Found.	Total. Guaranteed.	Available. Found.	Available. Guaranteed.	Mechanical Analysis: Fine.	Fine Med'm	Med'm	Coarse Med'm
	Bones.														
194	Ground Bone and Tankage, ...	18.54	4.29	—	--	10.12	6.90	17.02	—	10.12	--	22.76	16.96	21.28	39.00
265	Bone Meal, ...	6.04	2.69	2.47-4.12	—	7.10	13.18	20.28	20-25	7.10	—	60.59	25.64	13.77	—
277	Ground Raw Bone, ...	13.48	3.53	3.25-4.00	—	7.82	10.10	17.92	20-23	7.82	—	47.06	29.50	23.44	—
288	Animal Fertilizer, ...	13.68	3.75	3.5-4.5	—	8.26	13.62	21.88	21-22	8.26	9-10	56.46	24.40	19.40	—
301	Bone Meal, ...	5.63	3.29	2.47-3.29	—	9.86	15.22	25.08	24-28	9.86	10-14	45.99	35.99	13.48	4.54
309	Steamed Bone Meal, ...	4.87	2.98	2.25-3.25	—	12.52	12.34	24.86	22-26	12.52	5-7	57.22	22.68	16.38	3.72
310	Raw Bone Meal, ...	7.98	4.08	—	—	6.78	18.04	24.82	—	6.78	—	63.70	33.70	2.63	—
338	Pure Ground Bone, ...	3.14	2.89	2.88-3.30	—	9.00	16.84	25.84	24-26	9.00	—	61.74	27.63	10.64	—

*Sulphate of Potash, the source of Potash.

II. ANALYSES OF COMMERCIAL FERTILIZERS COLLECTED DURING 1898, IN THE GENERAL MARKETS BY THE AGENT OF THE HATCH EXPERIMENT STATION OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

Laboratory No.	Name of Brand.	Name of Manufacturer.	Sampled at
	Chemicals.		
3	Nitrate of Soda,	National Fertilizer Co , Bridgeport, Conn.,	Sunderland.
5	Low Grade Sulphate of Potash,	Lucien Sanderson, New Haven, Conn.,	Sunderland.
11	Muriate of Potash,	Lucien Sanderson, New Haven, Conn.,	Sunderland.
13	Low Grade Sulphate of Potash,	National Fertilizer Co., Bridgeport, Conn.,	Sunderland.
27	Low Grade Sulphate of Potash,	National Fertilizer Co., Bridgeport, Conn.,	Sunderland.
31	Nitrate of Soda,	Lucien Sanderson, New Haven, Conn.,	Sunderland.
53	Nitrate of Soda,	Bradley Fertilizer Co., Boston, Mass.,	Hudson.
60	Muriate of Potash,	Bradley Fertilizer Co., Boston, Mass.,	Hudson.
85	Sulphate of Magnesia,	Bowker Fertilizer Co., Boston, Mass.,	Fitchburg.
92	Muriate of Potash,	Mapes Formula and Peruvian Guano Co., New York.,	Haverhill.
126	Muriate of Potash,	Bowker Fertilizer Co., Boston, Mass.,	Beverly.
134	Nitrate of Soda,	National Fertilizer Co., Bridgeport, Conn.,	Dighton.
139	High Grade Sulphate of Potash,	National Fertilizer Co., Bridgeport, Conn.,	Dighton.
172	Nitrate of Soda,	Williams & Clark Fertilizer Co., Boston, Mass.,	Northampton.
173	Muriate of Potash,	Williams & Clark Fertilizer Co., Boston, Mass.,	Northampton.
176	Low Grade Sulphate of Potash	Williams & Clark Fertilizer Co., Boston, Mass.,	Northampton.
185	Muriate of Potash,	Bowker Fertilizer Co., Boston, Mass.,	Fall River.
221	High Grade Sulphate of Potash,	Prentiss Brooks & Co., Holyoke, Mass.,	Holyoke.
232	Nitrate of Soda,	Prentiss Brooks & Co., Holyoke, Mass.,	Holyoke.
235	Muriate of Potash,	Prentiss Brooks & Co., Holyoke, Mass.,	Holyoke.
236	Nitrate of Soda,	Bradley Fertilizer Co., Boston, Mass.,	Holyoke.
249	Muriate of Potash,	Bradley Fertilizer Co., Boston, Mass.,	Holyoke.
304	Muriate of Potash,	Bowker Fertilizer Co., Boston, Mass.,	Amherst.
307	High Grade Sulphate of Potash,	Bowker Fertilizer Co., Boston, Mass.,	Amherst.

Laboratory Number.	NAME OF BRAND.	Moisture.	Nitrogen in 100 lbs.		Potassium Oxide in 100 lbs.	
			Found.	Guaranteed	Found.	Guaranteed.
	Chemicals.					
3-134	Nitrate of Soda,	2.15	15.40	15.64	—	—
5	Low Grade Sulphate of Potash,	8.63	—	—	23.32	27·02-29.72
11	Muriate of Potash,	1.18	—	—	51.10	50.54-53.70
13	Muriate of Potash,	.90	—	—	51.50	50.54-53.70
27	Low Grade Sulphate of Potash,	2.61	—	—	25.44	25.93-29.72
31	Nitrate of Soda,	1.55	15.20	15.64-15.97	—	—
53-236	Nitrate of Soda,	2.05	15.20	15.48	—	—
60-249	Muriate of Potash,	.37	—	—	48.90	50.54-53.70
85	Sulphate of Magnesia,*	24.82	—	—	—	—
92	Muriate of Potash,	2.45	—	—	48.40	—
126-185-304	Muriate of Potash,	1.02	—	—	50.20	50-52
139	High Grade Sulphate of Potash,	.43	—	—	48.50	48.63-51.34
172	Nitrate of Soda,	1.51	14.48	15.48-15.81	—	—
173	Muriate of Potash,	1.54	—	—	49.90	48-52
176	Low Grade Sulphate of Potash,	1.46	—	—	24.00	25.93-28.10
221	High Grade Sulphate of Potash,	.45	—	—	48.70	49.70-51.87
232	Nitrate of Soda,	1.55	15.72	15-64-16.14	—	—
235	Muriate of Potash,	.68	—	—	50.20	50.
307	High Grade Sulphate of Potash,	.43	—	—	49.30	48.63

*Magnesium oxide (Mg O) 17.51 per cent.

II. ANALYSES OF COMMERCIAL FERTILIZERS COLLECTED DURING 1898, IN THE GENERAL MARKETS BY THE AGENT OF THE HATCH EXPERIMENT STATION OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

Laboratory No.	Name of Brand.	Name of Manufacturer.	Sampled at
	Chemicals.		
4	Dissolved Bone Black,	National Fertilizer Co., Bridgeport, Conn.,	Sunderland.
19	Sulphate of Ammonia,	Lucien Sanderson, New Haven, Conn.,	Sunderland.
30	Dissolved Bone Black,	Lucien Sanderson, New Haven, Conn.,	Sunderland.
33	Prime Cotton Seed Meal,	American Cotton Oil Co., New York City,	Sunderland.
70	Dissolved Bone Black,	Bowker Fertilizer Co., Boston, Mass.,	Beverly.
72	Nitrate of Soda,	Bowker Fertilizer Co., Boston , Mass.,	Beverly.
87	Dissolved Bone Black,	Mapes Formula and Peruvian Guano Co. New York,	Haverhill.
118	Cotton Seed Meal,	J. E. Soper & Co., Boston, Mass.,	Beverly.
133	Dissolved Bone Black,	Bowker Fertilizer Co., Boston, Mass.,	Taunton.
136	Sulphate of Ammonia,	Bowker Fertilizer Co., Boston, Mass.,	Taunton.
196	Nitrate of Soda,	Bowker Fertilizer Co., Boston. Mass.,	Fall River.
205	Prime Cotton Seed Meal,	American Cotton Oil Co., New York City,	No. Hadley.
206	Prime Cotton Seed Meal,	American Cotton Oil Co., New York City.,	No. Hadley.
215	Prime Cotton Seed Meal,	American Cotton Oil Co., New York City,	Hadley.
227	Cotton Seed Meal,	J. E. Soper & Co., Boston, Mass.,	Springfield.
256	Prime Cotton Seed Meal,	American Cotton Oil Co., New York City,	Westfield.
303	Nitrate of Soda,	Bowker Fertilizer Co., Boston, Mass.,	Amherst.
305	Acid Phosphate,	Bowker Fertilizer Co., Boston, Mass.,	Amherst.
306	Sulphate of Potash - Magnesia,	Bowker Fertilizer Co., Boston, Mass.,	Amherst.
308	Sulphate of Ammonia,	Bowker Fertilizer Co., Boston, Mass.,	Amherst.
311	Dissolved Bone Black,	Bowker Fertilizer Co., Boston, Mass.	Amherst.
312	Dried Blood,	Bowker Fertilizer Co., Boston, Mass.,	Amherst.

Laboratory Number.	Name of Brand.	Moisture.	Nitrogen in 100 lbs.		Phosphoric Acid in 100 lbs.							Potassium Oxide in 100 lbs.	
								Total.		Available.			
			Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
	Chemicals.												
4	Dissolved Bone Black,	12.68	—	—	15.10	2.98	.08	18.16	—	18.08	16-18	—	—
19	Sulphate of Ammonia,	2.62	19.44	19.78-20.60	—	—	—	—	—	—	—	—	—
30	Dissolved Bone Black,	14.01	—	—	15.10	.44	.06	15.60	16-18	15.54	—	—	—
33-205-206-215-256	Prime Cotton Seed Meal,	7.49	7.99	7.	—	—	—	—	—	—	—	—	—
70-133-311	Dissolved Bone Black,	14.67	—	—	13.56	2.68	.26	16.50	16-20	16.24	15-18	—	—
72-196-303	Nitrate of Soda,	.50	15.78	15.64-16.14	—	—	—	—	—	—	—	—	—
87	Dissolved Bone Black,	9.13	—	—	15.78	2.50	.52	18.80	17-19	18.28	15-16	—	—
118-227	Cotton Seed Meal,	11.67	7.28	7.	—	—	—	—	—	—	—	—	—
136-308	Sulphate of Ammonia,	1.26	21.44	19-20	—	—	—	—	—	—	—	—	—
305	Acid Phosphate,	15.10	—	—	12.92	1.92	.26	15.10	15-17	14.84	13-15	—	—
306	Sulphate of Potash—Magnesia,	4.91	—	—	—	—	—	—	—	—	—	25-72	—
312	Dried Blood,	7.09	9.40	9.89.11.53	—	—	—	—	—	—	—	—	—

TRADE VALUES OF FERTILIZING INGREDIENTS IN RAW MATERIALS AND CHEMICALS.

	1898. Cents per pound.
Nitrogen in ammonia salts,	14.
" nitrates,	13.
Organic nitrogen in dry and fine ground fish, meat, blood, and in high-grade mixed fertilizers,	14.
" " " cottonseed meal,	12.
" " " fine bone and tankage,	13.5
" " " medium bone and tankage,	10.
Phosphoric acid soluble in water,	4.5
" " soluble in ammonium citrate,	4.
" " in fine ground fish, bone and tankage,	4.
" " in cottonseed meal, castor pomace and wood ashes,	4.
" " in coarse bone and tankage,	3.5
" " insoluble (in am. cit.) in mixed fertilizers,	2.
Potash as Sulphate, free from Chlorides,	5.
" " Muriate,	4.25

The market value of low priced materials used for manurial purposes, as salt, wood ashes, various kinds of lime, barnyard manure, factory refuse and waste materials of different description, quite frequently does not stand in a close relation to the current market value of the amount of essential articles of plant food they contain. Their cost varies in different localities. Local facilities for cheap transportation and more or less advantageous mechanical conditions for a speedy action, exert as a rule, a decided influence on their selling price.

The market value of fertilizing ingredients like other merchandise is liable to changes during the season. The above stated values are based on the condition of the fertilizer market in centers of distribution in New England, during the six months preceding March 1898.

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

BULLETIN NO. 58.

MANURIAL REQUIREMENTS OF CROPS.

MARCH, 1899.

The Bulletins of this Station will be sent free to all newspapers in the State and to such individuals interested in farming as may request the same.

AMHERST, MASS.:
PRESS OF CARPENTER & MOREHOUSE,
1899.

HATCH EXPERIMENT STATION

OF THE

Massachusetts Agricultural College,

AMHERST, MASS.

By act of the General Court, the Hatch Experiment Station and the State Experiment Station have been consolidated under the name of the Hatch Experiment Station of the Massachusetts Agricultural College. Several new divisions have been created and the scope of others has been enlarged. To the horticultural, has been added the duty of testing varieties of vegetables and seeds. The chemical has been divided, and a new division, "Foods and Feeding," has been established. The botanical, including plant physiology and disease, has been restored after temporary suspension.

The officers are :—

HENRY H. GOODELL, LL. D.,	*Director.*
WILLIAM P. BROOKS, PH. D.,	*Agriculturist.*
GEORGE E. STONE, PH. D.,	*Botanist.*
CHARLES A. GOESSMANN, PH. D., LL. D.,	*Chemist* (Fertilizers).
JOSEPH B. LINDSEY, PH. D.,	*Chemist* (Foods and Feeding).
CHARLES H. FERNALD, PH. D.,	*Entomologist.*
SAMUEL T. MAYNARD, B. SC.,	*Horticulturist.*
J. E. OSTRANDER, C. E.,	*Meteorologist.*
HENRY M. THOMSON, B. SC.,	*Assistant Agriculturist.*
RALPH E. SMITH, B. SC.,	*Assistant Botanist.*
HENRI D. HASKINS, B. SC.,	*Assistant Chemist* (Fertilizers).
CHARLES I. GOESSMANN, B. SC.,	*Assistant Chemist* (Fertilizers).
SAMUEL W. WILEY, B. SC.,	*Assistant Chemist* (Fertilizers).
EDWARD B. HOLLAND, M. SC.,	*First Chemist* (Foods and Feeding).
FRED W. MOSSMAN, B. SC.,	*Ass't Chemist* (Foods and Feeding).
BENJAMIN K. JONES, B. SC.,	*Ass't Chemist* (Foods and Feeding).
PHILIP H. SMITH, B. SC.,	*Assistant in Foods and Feeding.*
ROBERT A. COOLEY, B. SC.,	*Assistant Entomologist.*
GEORGE A. DREW, B. SC.,	*Assistant Horticulturist.*
HERBERT D. HEMENWAY, B. SC.,	*Assistant Horticulturist.*
ARTHUR C. MONAHAN,	*Observer.*

The co-operation and assistance of farmers, fruit-growers, horticulturists, and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the

HATCH EXPERIMENT STATION, Amherst, Mass.

Division of Agriculture.

WILLIAM P. BROOKS.

MANURIAL REQUIREMENTS OF CROPS.

The results and conclusions stated in this bulletin are based upon experiments begun in 1889 and continued until the present time. A complete account of these experiments will be published in a later bulletin, where also will be found a statement of the leading results of similar experiments both in this and other countries as well as the summary, conclusions and practical advice herein given. The experiments have been conducted solely with reference to gaining light as to the particular requirements of different crops upon various soils. The fertilizers applied to the several plots, under the usual arrangement, have been the same from year to year, and were as follows:—

Plot 1. Nothing.
" 2. Nitrate of soda (160 lbs. per acre), furnishing nitrogen.
" 3. Dissolved bone-black (320 lbs. per acre), furnishing phosphoric acid.
" 4. Nothing.
" 5. Muriate of potash (160 lbs. per acre), furnishing potash.
" 6. { Nitrate of soda (160 lbs. per acre). Dissolved bone-black (320 lbs. per acre).
" 7. { Nitrate of soda (160 lbs. per acres). Muriate of potash (320 lbs. per acre).
" 8. Nothing.
" 9. { Dissolved bone-black (320 lbs per acre). Muriate of potash (160 lbs per acre).
" 10. { Nitrate of soda (160 lbs. per acre). Dissolved bone-black (320 lbs. per acre). Muriate of Potash (160 lbs. per acre).
" 11. Plaster (160 lbs. per acre).
" 12. Nothing.

These fertilizers have always been applied broadcast just before planting hoed crops and harrowed in. They have been applied in early spring to grass-land. The rotation upon the acre longest under experiment has been :—corn, corn, oats (with grass and clover seeds), grass and clover, grass and clover, corn, rye followed by white mustard as a catch crop, soy beans and white mustard following a failure to get onions started. The area of the plots in these experiments has always been one-twentieth of an acre.

The conclusions presented are based upon some thirty such experiments with corn, some six with oats, twelve with grass and clover, and one each with rye, soy beans, turnips and cabbages.

SUMMARY, CONCLUSIONS AND PRACTICAL ADVICE.

A brief statement is here made of the conditions affecting the experiments described in these pages. The reasons why the experiments were begun and the questions upon which it was hoped the experiments might shed light are stated; and a brief account of the leading results and conclusions, and practical advice based thereon are given.

CONDITIONS AFFECTING THE EXPERIMENTS HEREIN DESCRIBED.

1. Our soils, mostly of glacial origin, exhibit great variety in mechanical condition and composition.

2. These soils have been for the most part long cultivated, and profitable crops can be produced only when the soil is enriched.

3. The supply of home-made manure is in most cases insufficient; and our farmers purchase and use fertilizers in large quantities.

4. Their ideas as to what had best be purchased are in most instances vague; and they, in the majority of cases, buy either some "phosphate" or some "special complete" fertilizer.

5. These "specials" bear the name of the crop for which each is supposed to be suited. Most of them are nominally specialized with reference to the crop only. With few exceptions they contain about twice as much phosphoric acid as potash; in many cases there is four times as much. Fertilizers recommended for one and the same crop exhibit most astonishing variations. The same fertilizer is in many cases recommended for several crops, as for corn, oats and grass.

6. Our farmers, as a rule, sell no grain to carry away phosphates. They do sell hay, straw, vegetables and fruits, all of which contain more potash than phosphoric acid.

7. Many of our farmers are milk producers: they buy and feed large quantities of wheat bran, cottonseed meal, gluten meal, oats, etc. These foods are rich in phosphates and nitrogen, and consequently the manures of home production are rich in these elements.

REASONS WHY INQUIRY SEEMED CALLED FOR.

1. On account of the well known variation in soils.

2. Analyses of plants and agricultural products showed them, as a rule, to contain much more potash than phosphoric acid; while the fertilizers in most cases contained the latter in much the larger quantities.

3. It is known that plants vary widely in respect to their ability to gather food from the soil. One finds enough of a given element where another fails to do so; and this may be true even though the latter contains less of the element in question than the former. It did not appear that this factor, or what may be designated the *feeding capacity*, of crops had been sufficiently taken into consideration in compounding and selecting fertilizers for them.

QUESTIONS PROPOSED.

1. To what extent and in what way do the plant food requirements of different crops cultivated in rotation vary?

2. Are the *so-called complete "special" fertilizers* offered upon our markets rationally compounded?

3. Is the practice of our farmers in so frequently using phosphates alone wise, and calculated to insure the largest possible crops at the least cost?

RESULTS OF THE EXPERIMENTS.

With Corn:—This crop was grown upon the field reported upon in detail, in 1889, 1890 and 1894.

1. Potash applied in the form of muriate most largely increased the crops both of grain and stover. It greatly exceeded either nitrogen or phosphoric acid in its influence upon the crops.

2. In a large majority of the experiments tried in different parts of the state similar results were obtained.

Our conclusions for corn, then, stated with reference to the questions proposed are :—

1. This crop profits particularly from an application of potash salts.

2. The so-called "special" fertilizers for corn offered in Massachusetts markets are not rightly compounded. The average of such fertilizers in 1897 was: Nitrogen, 2.80 per cent.; phosphoric acid, 11.31 per cent; potash, 3.57 per cent. The best contained: Nitrogen, 4.04 per cent; phosphoric acid, 11.80 per cent; potash, 9.94 per cent. I would suggest the following proportions: Nitrogen, 3; phosphoric acid, 4, and potash, 11.

3. The use of phosphates to supplement natural supplies of manures is not wise and does not promise to insure largest crops at least cost.

With Oats:—Oats occupied the land in 1891, following corn which had been raised the two years previous.

1. Nitrogen in the form of nitrate of soda much more largely increased the oat crop than did either phosphoric acid or potash.

2. In the majority of the experiments in the different parts of the state similar results have been obtained.

Our conclusions for oats stated with reference to the questions proposed are :—

1. The requirements of oats are in a marked degree different from those of corn upon the same soil. The latter requires potash; oats are remarkable for their ability to extract potash from the natural stores of the soil; and profit from an application of nitrogen.

2. Fertilizers for oats offered in our markets are not properly compounded. The average of those offered in 1897 contained: Nitrogen, 2.65; phosphoric acid, 11.96, and potash 4.90 per cent. The best contained: Nitrogen, 8.92; phosphoric acid, 18.68, and potash, 10 per cent. I would suggest the following proportions: Nitrogen, 4; phosphoric acid, 3, and potash, 5 parts.

3. The extensive use of phosphates alone for oats does not promise to be profitable.

With Grass and Clover:—The field reported in detail was seeded to grass and clover with the oats in 1891. Two crops of hay were cut in each of the years 1892 and 1893.

1. Nitrogen in the form of nitrate of soda increased the yield of *grass* in a marked degree, while neither phosphoric acid nor potash exercised any great effect.

2. The potash applied controlled the development and growth of clovers.

3. The first cut in each year (mostly grasses) was most affected by the application of nitrate of soda; the second cut (rowen, mostly clovers) was increased chiefly by the potash.

4. Results which have been obtained in other parts of the state and by other investigators are in entire agreement with our own.

Our conclusions for grass and clover stated with reference to the three questions proposed are:—

1. Grass is similar in its requirements to oats (nitrogen in the form of nitrate of soda most beneficial): the clovers are to a considerable extent similar to corn in their dependence upon potash, but are more benefitted by phosphoric acid than the latter.

2. The "special" fertilizers for grass lands are not properly compounded whether for grasses or for the clovers. They contain too little nitrogen for the former; too little potash for the latter. The average of those offered in 1893 was: Nitrogen, 4.02; phosphoric acid, 8.30, and potash, 5.52 per cent. I would recommend for use, where timothy is to be grown, a fertilizer supplying the elements in the following proportions: Nitrogen, 8; phosphoric acid, 3; potash, 3. For manuring where clover is desired: Nitrogen, 2; phosphoric acid, 5, and potash, 10.

3. Maximum crops of hay at minimum cost, whether of grasses or clovers, are not to be looked for from the application of phosphates.

With Rye:—This crop was sown after corn in the fall of 1894.

1. Potash in the form of muriate increased the crop somewhat more largely than either nitrogen (nitrate of soda) or phosphoric acid (dissolved bone-black); but the rye showed a greater degree of dependence upon all the fertilizers applied than any preceding crop. This was no doubt in consequence of the greater degree of soil exhaustion resulting from one-sided manuring which had then been continued for six years.

2. The quality of the grain was superior on all plots where potash had been applied. The kernels were larger, plumper and of better color than on other plots.

3. That rye apparently cannot as readily as other cultivated plants appropriate the potash of the soil, has been noticed by other observers. This accounts for the beneficial effects of the application of this element.

Our conclusions for rye stated with reference to the questions proposed are :—

1. Rye shows a more general dependence upon applied fertilizers than the other crops under experiment. The difference in the degree of effectiveness of the elements applied (nitrogen, phosphoric acid and potash) is not great.

2. The same fertilizers are offered in Massachusetts, as a rule, under the name of "grain" fertilizers, both for oats and rye. This is not warranted by the facts brought out concerning the two crops. Nitrogen should be most prominent in fertilizers for oats; while for rye, the fertilizer must be richer in potash.

3. The results of our experiment do not encourage the belief that one-sided phosphate manuring for rye will give most profitable results.

With White Mustard, Cabbage and Swedish Turnips:—The white mustard was sown as a catch crop, after rye, in 1895; the cabbages and turnips were grown on similar soil, in 1896.

1. Phosphoric acid in the form of dissolved bone-black benefited all these crops more largely than either nitrogen or potash.

2. The potash when used in connection with phosphoric acid was also very beneficial to the cabbages and turnips.

Our conclusions are :—

1. These crops (all belonging to the same family) are markedly different in their requirements from any of the others experimented with—responding in highest degree to an application of phosphate, which none of the others have done.

2. There appear to be but few "special" fertilizers upon our markets for these crops.

3. The use of phosphates to supplement farm manures for these crops promises to be profitable.

With Soy Beans:—This crop followed the white mustard, occupying the field in 1896.

1. It showed a close dependence upon an application of potash—resembling corn and clovers in this respect.

2. The crop was not materially increased by the application of either nitrogen or phosphoric acid.

Our conclusions with reference to the questions proposed are:—

1. This crop differs widely in its requirements from both the rye and the mustard which had preceded it.

2. No "specials" are made for this crop in our state; but fertilizers for it should be rich in potash.

GENERAL CONCLUSIONS.

1. It has been shown that the widest differences in plant-food requirements exist between crops cultivated upon the same soil; corn, clovers, rye and soy beans being benefited mostly by potash; grasses and oats, by nitrogen; and mustard, cabbages and Swedish turnips, by phosphoric acid.

2. Our experiments indicate the desirability of changes in the composition of the *complete "special" fertilizers* offered in our markets. For most crops these fertilizers contain too much phosphoric acid. For oats and grass they contain too little nitrogen.

3. It is believed that for none of our crops, except those of the mustard family, is the application of phosphates to supplement farm manure called for.

PRACTICAL ADVICE.

Farmers are urged to try experiments with fertilizers with a view to getting light as to the requirements of different crops upon their own soils; for soils as well as crops differ in manurial needs. Plain directions for simple experiments will be sent upon application to all who desire to try such experiments.

Under existing conditions farmers are advised to purchase fertilizer materials and to make their own mixtures, rather than to purchase mixed or complete special fertilizers. This course is believed to be advisable for two reasons: first, because the "specials" are not properly compounded, and second, because the needed plant-food can be thus procured at lower cost.

Taking into consideration the present market prices of fertilizers, and the results of my experiments, I recommend the following mixtures of materials for the several crops dealt with in this bulletin. In every instance the quantities given are designed for one acre.

1. *For Corn on Sod Land in Fair Condition.*

Nitrate of soda,	100 pounds
Dry ground fish,	200 "
Acid phosphate,	250 "
Muriate of potash, (or high grade sulphate),	220 "

These materials furnish about: nitrogen, 30 pounds; phosphoric acid, 40 pounds, and potash, 110 pounds.

2. *For Corn on Land Rather Poor in Organic Matter.*

Nitrate of soda,	200 pounds
Dry ground fish,	200 "
Tankage,	100 "
Acid phosphate,	200 "
Muriate of potash (or high grade sulphate,	250 "

These materials furnish about: nitrogen, 42 pounds; phosphoric acid, 50 pounds, and potash, 125 pounds.

3. *For Corn in Connection with Farm Manure.*

Nitrate of soda,	50 pounds
Dry ground fish,	100 "
Acid phosphate,	100 "
Muriate of potash (or high grade sulphate),	100 "

These materials furnish about: nitrogen, $14\frac{1}{2}$ pounds: phosphoric acid, $21\frac{1}{2}$ pounds, and potash, 50 pounds.

4. *For Oats on Land in Good Condition.*

Nitrate of soda,	125 pounds
Acid phosphate,	100 "
Muriate of potash (or high grade sulphate),	50 "

These materials furnish nitrogen, 20 pounds; phosphoric acid, 14 pounds, and potash, 25 pounds.

5. *For Oats on Land in Low Condition.*

Nitrate of soda,	175 pounds
Dried blood,	100 "
Acid phosphate,	200 "
Muriate of potash (or high grade sulphate),	90 "

These materials will furnish about: nitrogen, 37 pounds; phosphoric acid, 27 pounds, and potash, 45 pounds.

6. *For Mixed Grasses or Timothy.*

Nitrate of soda,	150 pounds
Tankage,	125 "
Acid phosphate,	50 "
Muriate of potash (or high grade sulphate).	25 "

These materials will furnish about: nitrogen, 32 pounds; phosphoric acid, 15 pounds, and potash, 13 pounds.

7. *For Mowings with Considerable Clover.*

Nitrate of soda,	100 pounds
Acid phosphate,	300 "
Muriate of potash (or high grade sulphate).	160 "

These materials furnish about: nitrogen, 16 pounds; phosphoric acid, 40 pounds, and potash, 80 pounds.

8. *For Rye.*

Nitrate of soda,	125 pounds
Acid phosphate,	150 "
Muriate of potash (or high grade sulphate),	125 "

These materials furnish: nitrogen, 19 pounds; phosphoric acid, 20 pounds, and potash, 63 pounds.

9. *For Cabbages or Swedish Turnips.*

Nitrate of soda,	150 pounds
Dried blood,	200 "
Dry ground fish,	400 "
Bone meal,	200 "
Acid phosphate,	500 "
Sulphate of potash (high grade),	250 "

Furnishing nitrogen, 70 pounds; phosphoric acid, 141 pounds, and potash, 125 pounds.

10. *For Soy Beans.*

Nitrate of soda,	100 pounds
Dry ground fish,	150 "
Acid phosphate,	300 "
Sulphate of potash (high grade),	200 "

Furnishing nitrogen, 27 pounds; phosphoric acid, 52 pounds, and potash, 100 pounds.

The experimental work of the past few years indicates that the continuous use of muriate of potash may so far deplete the soil of lime that an occasional application of this material may be required in case of such use. We have also some results which indicate that the sulphate of potash is a safer material to use where a growth of clover is desired than the muriate. For these reasons it may often be wise to use the sulphate in such formulas as are given above where muriate is specified. The high grade sulphate should be selected. It costs about forty cents per hundred more than the muriate.

These materials should as a rule be mixed just before use, and applied broadcast (after plowing) and harrowed in just before planting the seed. Where nitrate of soda is to be used in quantities in excess of 150 pounds per acre, one-half the amount of this salt may be withheld until the crop is three or four inches high, when it may be evenly scattered near the plants. It is unnecessary to cover this, though it may prove more promptly effective in absence of rain if cultivated in.

The quantities recommended are in most cases moderate. On soils of good physical character it will often prove profitable to use about one and one-half times the amounts given.

Notes on the Proper Handling of Barnyard Manure.

C. WELLINGTON.

Every practical farmer knows certain facts about barnyard manure, which for present purposes may be summed up as follows:

1. "Barnyard manure" is the name given to mixtures of various excrements with a great variety of other material and cannot be fairly represented by a single analysis. Generally speaking it is a mixture of horse and cow manure, with straw or leaves or sawdust, which has served as litter. Sometimes earth is used in place of such litter. The mixture is then of a very different nature and will be referred to after barnyard manure with litter has been described.

2. Any one of these mixtures excepting that with earth is known in three different conditions, namely:—fresh manure, half-rotted and well-rotted, manure.

3. Of these, half-rotted manure gives the best results, and well-rotted the poorest, while fresh manure shows a medium effect.

The purpose of the present remarks is to explain why the last statement is true, and to note briefly the best manner according to present information in which to make barn-yard manure and to use it.

If a pile of fresh manure, that is, a mixture of solid and liquid excrement and straw, etc., lies for several months without disturbance it grows smaller and smaller. It is comparatively dry, the straw has disappeared and has become "humus."

The whole mixture is more uniform in color and character. It is *half-rotted*; then after a few more months the bulk has grown very much smaller and a black, moist, slimy, homogeneous mass results, and the manure is *well-rotted*.

Chemists have long known in a general way what changes take place during this process, but not until recently has anything like a satisfactory explanation of them been made. This explanation depends upon the discovery of the existence and the actions, in the manure, of three classes of very small microscopic organisms called bacteria. They are responsible not wholly, but chiefly, for the changes mentioned. Let us note here just what *chemical materials* are in the manure at the beginning and what they are changed into.

The fresh manure contains mineral substances like potash and phosphates, and also organic material of two kinds, namely: The nitrogenous, found in the liquid manure and to some extent in the solid, and the non-nitrogenous, which largely makes up the straw, leaves, sawdust, and solid excrement. It is just these two kinds of organic constituents and what they become, which concern us now.

In those portions of the manure which are accessible to the air, one class of bacteria live and breed in enormous numbers. They feed on the oxygen of the air and the nitrogenous portion of the manure, and, in *their excrements*, give off large quantities of nitrates, the latter being the direct products of the oxidation of nitrogenous organic matter anywhere, whether in the bodies of these bacteria or not. These nitrates being very soluble in water, drain down into the interior of the manure heap, just as they drain through the soil. But, instead of all going off in the drainage water and becoming lost, as they often do in the soil, they are chiefly lost by an entirely different process.

In the interior of the heap, shut away from the air, these nitrates fall prey to another class of bacteria known as "nitrate destroyers." They completely undo the work of the other bacteria or "nitrate formers." The "nitrate destroyers" live on the non-nitrogenous constituents of the straw and leaves and the oxygen of the nitrates. This liberates the nitrogen in the form of gas which escapes into the air and is lost to the farmer. The process also consumes the non-nitrogenous portion, which is chiefly the remainder of the litter. It is formed into water and carbonic acid gas which escape into the air and thus diminish the bulk of the pile. While the "nitrate formers" live near the surface of the manure and require air for their work, the "nitrate destroyers" live away from the air and do not need it. They are dependent, however, on food of a certain kind and must have plenty of it, otherwise they become inactive and can do no damage, though millions of them may exist in the interior of the manure pile. One of their principal foods, the non-nitrogenous material of the litter, they cannot use as food until it has been made soluble by a third class of bacteria which causes the rotting of the litter. Nitrates are also indispensable for their nourishment. If therefore they are deprived of either one of these constituents of their diet they either die or at least become harmless.

The work of the "nitrate formers" is beneficial; it converts organic nitrogen into nitrate, a most available form of plant food. Half-rotted manure contains nitrogen largely in this form. The work of "nitrate destroyers" is destructive. It removes the soluble nitrates from the manure. It converts half-rotted manure into well-rotted manure. In this way the different effects produced by manure in the three different conditions are explained. The nitrogen in fresh manure is largely organic and not immediately available. It therefore has a slower and less effect than half-rotted manure. The nitrogen in half-rotted manure is largely in the form of nitrates, and this is available. The nitrogen in well-rotted manure has all been converted into nitrate also, and was once available, but has subsequently been lost in the air. This is why the well-rotted condition is the least valuable of the three.

In handling manure the farmer should strive to place it at the disposition of the *growing* crop just at that moment when the most nitrate has been formed and before any has been destroyed. The most favorable conditions are obtained when fresh manure is packed as tightly as possible, away from the air, and kept in that condition till half-rotted, and then plowed under just before planting or sowing. Under these circumstances, although the third class of bacteria have in the rotting of the litter made soluble food of one kind for the "nitrate destroyers," the latter have been deprived of their other necessary food, the nitrates, for none could be formed in the tightly packed mass and they have remained harmless. But the heap has become half-rotted, even without them. After the manure is plowed in, the "nitrogen formers," now having plenty of air, rapidly produce nitrates which is beyond the reach of the destroyers; for by this time all their soluble non-nitrogenous food has been decomposed and has gone into the air leaving them to die. The growing plants, in the meantime, absorb the nitrates.

If fresh manure is plowed in directly before seeding, a poor result is obtained, for the nitrates are not formed until after the plants have passed their growing period, and they consequently starve. As might be supposed, winter crops fare better with this procedure than spring crops. By plowing in fresh manure several months before seeding, a much better result is obtained, because the nitrates are on hand and are being formed at the growing period of the crops. Experience has abundantly proven that it is better to plow manure into the soil and allow it to lie there rather than in the pile. Whether it is better to leave manure spread upon the surface of the land rather than to plow it in or leave it in the pile, depends chiefly on the amount of loss caused by surface drainage. This may be small, but if the ground is frozen, the surface inclined, and the manure half-rotted or more, the loss will be considerable. The nitrate destroying bacteria are of several species and have thus far been found in straw and various other litter, in soils, and in the dung of herbivorous animals. They have not been found in human excrement or that of the carnivora or birds.

When barnyard manures are made with bedding devoid of much decomposable organic matter, the nitrate-destroying bacteria cannot work in them, for they cannot obtain the soluble organic food necessary for their subsistence. Anything like sand, loam or turf, therefore, may be used for bedding without incurring the disadvantage due to litter.

Wherever much nitrate of soda is applied to crops, there is produced a relatively large yield of straw, which, in turn, leads to a large use of this material as litter. This excessive quantity of straw in the manure materially lessens its value in the manner described.

CONCLUSIONS:

Of the three common conditions of barnyard manure, half-rotted manure is the most valuable, and well-rotted manure the least, because of their relative amounts of nitrates.

Manure should be kept packed away from the air as tightly as possible, and if rotted should be plowed under just before planting, otherwise several months before that time.

The more litter used in the manure, the greater liability to loss of nitrogen.

The use of bedding material free from decomposable organic matter is a means of protection against loss of nitrogen.

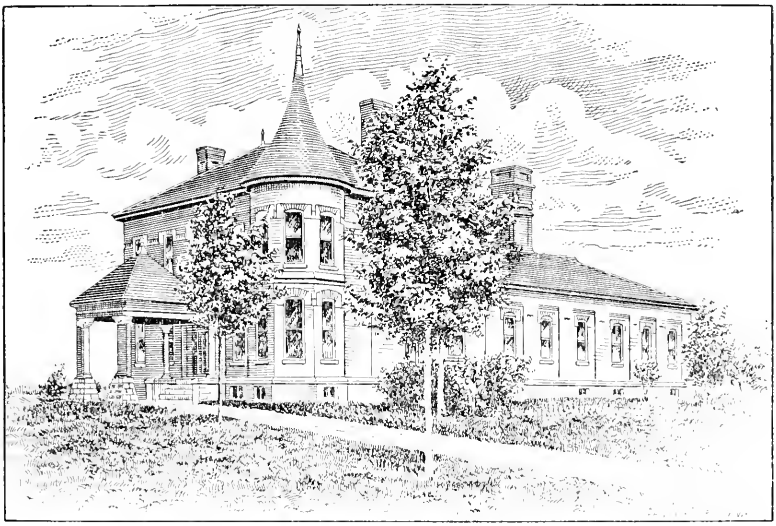
HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

BULLETIN NO. 59.

I. ANALYSES OF MANURIAL SUBSTANCES SENT ON FOR EXAMINATION.
II. ANALYSES OF LICENSED FERTILIZERS COLLECTED BY THE AGENT OF THE STATION DURING 1898.



CHEMICAL LABORATORY.

MARCH, 1899.

The Bulletins of this Station will be sent free to all newspapers in the State and to such individuals interested in farming as may request the same.

AMHERST, MASS.:
PRESS OF CARPENTER & MOREHOUSE,
1899.

HATCH EXPERIMENT STATION

OF THE

Massachusetts Agricultural College,

AMHERST, MASS.

By act of the General Court, the Hatch Experiment Station and the State Experiment Station have been consolidated under the name of the Hatch Experiment Station of the Massachusetts Agricultural College. Several new divisions have been created and the scope of others has been enlarged. To the horticultural, has been added the duty of testing varieties of vegetables and seeds. The chemical has been divided, and a new division, "Foods and Feeding," has been established. The botanical, including plant physiology and disease, has been restored after temporary suspension.

The officers are :—

Henry H. Goodell, LL. D.,	*Director.*
William P. Brooks, Ph. D.,	*Agriculturist.*
George E. Stone, Ph. D.,	*Botanist.*
Charles A. Goessmann, Ph. D., LL. D.,	*Chemist* (Fertilizers).
Joseph B. Lindsey, Ph. D.,	*Chemist* (Foods and Feeding).
Charles H. Fernald, Ph. D.,	*Entomologist.*
Samuel T. Maynard, B. Sc.,	*Horticulturist.*
J. E. Ostrander, C. E.,	*Meteorologist.*
Henry M. Thomson, B. Sc.,	*Assistant Agriculturist.*
Ralph E. Smith, B. Sc.,	*Assistant Botanist.*
Henri D. Haskins, B. Sc.,	*Assistant Chemist* (Fertilizers).
Charles I. Goessmann, B. Sc.,	*Assistant Chemist* (Fertilizers).
Samuel W. Wiley, B. Sc.,	*Assistant Chemist* (Fertilizers).
Edward B. Holland, M. Sc.,	*First Chemist*(Foods and Feeding).
Fred W. Mossman, B. Sc.,	*Ass't Chemist*(Foods and Feeding).
Benjamin K. Jones, B. Sc.,	*Ass't Chemist*(Foods and Feeding).
Philip H. Smith, B. Sc.,	*Assistant in Foods and Feeding.*
Robert A. Cooley, B. Sc.,	*Assistant Entomologist.*
George A. Drew, B. Sc.,	*Assistant Horticulturist.*
Herbert D. Hemenway, B. Sc.,	*Assistant Horticulturist.*
Arthur C. Monahan,	*Observer.*

The co-operation and assistance of farmers, fruit-growers, horticulturists, and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the

Hatch Experiment Station, Amherst, Mass.

DIVISION OF CHEMISTRY.

C. A. Goessmann.

I.

ANALYSES OF COMMERCIAL FERTILIZERS AND MANURIAL SUBSTANCES SENT ON FOR EXAMINATION.

WOOD ASHES.

635-638. I. Received from Orange, Mass.
II. Received from Concord, Mass.
III. Received from North Hatfield, Mass.
IV. Received from Concord, Mass.

	Per Cent.			
	I.	II.	III.	IV.
Moisture at 100° C.,	16.90	7.30	9.07	11.42
Potassium oxide,	4.87	4.93	5.12	4.50
Phosphoric acid,	1.64	1.28	1.42	1.24
Calcium oxide,	30.44	34.33	46.73	30.70
Insoluble matter,	7.68	28.87	13.60	8.96

639-642. I. Received from Concord, Mass.
II. Received from East Whately, Mass.
III. Received from Sudbury, Mass.
IV. Received from Milford, Mass.

	Per Cent.			
	I.	II.	III.	IV.
Moisture at 100° C.,	12.33	11.65	6.80	.48
Potassium oxide,	4.06	4.29	2.16	7.85
Phosphoric acid,	1.16	.99	.69	1.61
Calcium oxide,	28.62	31.83	9.68	42.88
Insoluble matter,	22.72	12.53	56.59	5.34

643-646. I. Received from Clinton, Mass.
II. Received from Sunderland, Mass.
III. Received from Concord, Mass.
IV. Received from Concord, Mass.

	Per Cent.			
	I.	II.	III.	IV.
Moisture at 100° C.,	.20	14.51	10.18	12.47
Potassium oxide,	8.20	6.66	5.91	4.77
Phosphoric acid,	1.98	1.68	1.41	1.37
Calcium oxide,	43.45	26.04	35.55	31.43
Insoluble matter,	16.25	13.76	11.40	16.94

647-648. I. Received from North Wilbraham, Mass.
II. Received from Concord, Mass.

	Per Cent.	
	I.	II.
Moisture at 100° C.,	14.35	7.82
Potassium oxide,	6.24	6.63
Phosphoric acid,	1.79	.31
Calcium oxide,	35.63	36.39
Insoluble matter,	9.71	14.50

Wood ashes for manurial purposes are in our State subject to official inspection, and dealers in that commodity have to secure a license to sell in Massachusetts before they can legally advertise their articles for sale. This circumstance makes it obligatory to the dealer to state the amount of potash and of phosphoric acid they guarantee in these materials; and to fasten that statement upon the package or car, etc., which contains it.

Some dealers in wood ashes have adopted of late the practice of stating merely the sum of both, phosphoric acid and potash instead of specifying the amount of each of them present. As phosphoric acid and potassium oxide contained in wood ashes are considered in our section of the country, pound for pound of a nearly equal commercial value, from 4.5 to 5 cents per pound each, no particular objection can be raised against a joint statement of both as far as the mere money value of the sample is concerned; yet as this mode of stating the guaranteed composition is apt to lead to misconception and abuse, it ought to be discouraged and discontinued.

As the dealer is only obliged to guarantee the amount of potash and of phosphoric acid present in a given quantity of wood ashes, no serious objection can be raised on the part of the buyer on account of moisture, etc., as long as the article contains the specified amount of both potash and phosphoric acid.

Wood ashes ought to be bought and sold by weight, and not by measure; for both moisture and the general character of foreign matters present are apt to seriously affect the weight of a given measure.

The majority of dealers guarantee from 4.5% to 5% of potassium oxide in their articles; from a review of our publications of the last year it will be seen that quite a number of the samples are below the lowest guarantees, showing on the whole that the quality of wood ash sold in 1898 as a potash source has been somewhat inferior as compared with the preceding year.

Whether this circumstance is due to a general decline of the article or to the management of any particular dealer or importer is difficult to decide on our part as long as farmers do not state the name of the party they have bought of and the cost per ton of the ashes they send on for examination.

It is for obvious reasons most desirable to ascertain whether the general character of the wood ash is gradually declining from general causes or whether some parties in particular handle inferior goods. All parties interested in the solution of this question will confer a favor on us by sending with their samples of wood ashes the names of the parties they bought the article of, and the cost per ton at the nearest depot for general distribution.

The large percentage of lime, from 30 to 40 per cent, found in genuine wood ashes, imparts a special agricultural value to them as a fertilizer, aside from the amount of potash and phosphoric acid they contain. Wherever an application of lime is desired, wood ashes deserve favorable consideration, on account of the superior mechanical condition of the lime they furnish.

LIME KILN ASHES AND MARL.

649-650. I. Lime Kiln Ashes received from Littleton, Mass.
II. Marl received from Lincoln, Mass.

	Per Cent. I.	Per Cent. II.
Moisture at 100° C.,	.67	31.71
Potassium oxide,	2.32	1.12
Phosphoric acid,	.70	.56
Calcium oxide,	52.90	38.49
Carbonic acid,	*	12.86
Insoluble matter,	1.71	7.14

GERMAN POTASH SALTS.

651-652. I. Muriate of Potash received from Hudson, Mass.
II. Sulphate of Potash and Magnesia received from North Hadley, Mass.

	Per Cent. I.	Per Cent. II.
Moisture at 100° C.,	.10	7.68
Potassium oxide,	50.20	19.55

NITRATE OF SODA.

653-654. I. Received from Hudson, Mass.
II. Received from North Hadley, Mass.

	Per Cent. I.	Per Cent. II.
Moisture at 100° C.,	.03	.10
Nitrogen,	15.85	14.56

DRIED BLOOD, MEAT AND BONE.

655-656. I. Dried blood received from Milford, Mass.
II. Meat and bone received from Milford, Mass.

	Per Cent. I.	Per Cent. II.
Moisture at 100° C.,	10.43	9.98
Nitrogen,	10.15	7.18
Total phosphoric acid,	*	14.71
Reverted phosphoric acid,	*	3.35
Insoluble phosphoric acid,	*	11.36

*Not determined.

FINE GROUND BONE.

657-660. I. Received from Wilbraham, Mass.
II. Received from Milford, Mass.
III. Received from Milford, Mass.
IV. Received from Milford, Mass.

	Per Cent.			
	I.	II.	III.	IV.
Moisture at 100° C.,	5.57	2.75	3.25	5.67
Total phosphoric acid,	23.92	26.08	24.44	23.74
Reverted phosphoric acid,	7.54	4.58	4.62	4.68
Insoluble phosphoric acid,	16.38	21.50	19.82	19.06
Nitrogen,	2.65	2.47	2.27	3.36

ACID PHOSPHATE AND BONE ASH.

661-662. I. Acid Phosphate received from Hudson, Mass.
II. Bone Ash received from Hudson, Mass.

	Per Cent.	
	I.	II.
Moisture at 100° C.,	2.73	.34
Total phosphoric acid,	11.60	39.14
Soluble phosphoric acid,	7.98	*
Reverted phosphoric acid,	3.18	*
Insoluble phosphoric acid,	.44	*

LIQUID FERTILIZER AND PLANT FOOD IN TABLET FORM.

663-664. I. Liquid Fertilizer received from Natick, Mass.
II. Plant food in tablets received from Newtonville, Mass.

	Per Cent.	
	I.	II.
Moisture at 100° C.,	90.46	3.39
Total phosphoric acid,	1.24	16.59
Soluble phosphoric acid,	1.24	14.58
Reverted phosphoric acid,	none	1.67
Insoluble phosphoric acid,	none	.34
Nitrogen,	1.12	7.65

*Not Determined.

Potassium oxide,	2.79	7.96
Sodium oxide,	1.67	6.19
Calcium oxide,	1.82	4.04
Magnesium oxide,	.07	5.30
Sulphuric acid,	none.	17.17
Chlorine,	.02	6.05
Insoluble matter,	none	14.33

VELVET BEANS AND TOBACCO DUST.

665-667. I. Velvet Beans (with pod) received from Fitchburg, Mass.
II. Velvet Beans (kernel) received from Fitchburg, Mass.
III. Tobacco Dust received from Boston, Mass.

	Per Cent.		
	I.	II.	III.
Moisture at 100° C.,	11.52	11.13	7.70
Potassium oxide,	1.31	1.23	5.72
Phosphoric acid,	.84	.63	.81
Nitrogen,	1.96	2.66	1.75
Insoluble matter,	.012	.036	*

DAMAGED GRAIN.

668-670. I. Received from Littleton, Mass.
II. Received from Littleton, Mass.
III. Received from Littleton, Mass.

	Per Cent.		
	I.	II.	III.
Moisture at 100° C.,	14.07	61.35	51.05
Potassium oxide,	.43	.16	.26
Phosphoric acid,	.83	.35	.47
Nitrogen,	1.97	.84	1.52

COMPLETE FERTILIZERS.

671-674. I. Received from Wilbraham, Mass.
II. Received from North Brookfield, Mass.
III. Received from North Brookfield, Mass.
IV. Received from North Brookfield, Mass.

*Not Determined.

	Per Cent. I.	II.	III.	IV.
Moisture at 100° C.,	16.18	10.55	6.26	5.38
Total phosphoric acid,	7.34	8.99	8.12	9.70
Soluble phosphoric acid,	4.30	2.78	1.57	.91
Reverted phosphoric acid,	2.06	4.36	2.02	3.33
Insoluble phosphoric acid,	.98	1.85	4.53	5.46
Nitrogen,	1.72	2.83	2.99	3.11
Potassium oxide,	7.24	7.03	2.62	3.27

WATER ABSTRACT OF DRY FOREST LEAVES.

675. Received from Amherst, Mass.

	Per Cent.
Moisture at 100° C.,	99.47
Solid residue at 100° C.,	.53
Nitrogen,	.0035
Potassium oxide,	.0287
Phosphoric acid,	.0220
Calcium oxide,	.0249
Ash,	.16

COTTON SEED MEAL.

676-677, I. Received from North Hatfield, Mass.
II. Received from South Deerfield, Mass.

	Per Cent. I.	II.
Moisture at 100° C.,	6.10	7.80
Nitrogen,	7.00	6.37

II. ANALYSES OF COMMERCIAL FERTILIZERS COLLECTED DURING 1898, IN THE GENERAL MARKETS BY THE AGENT OF THE HATCH EXPERIMENT STATION OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

Laboratory No.	Name of Brand.	Name of Manufacturer.	Sampled at
	Compound Fertilizers.		
28	Complete Tobacco Manure,	National Fertilizer Co., Bridgeport, Conn.,	Sunderland.
29	Tankage,	National Fertilizer Co., Bridgeport, Conn.,	Sunderland.
32	Tobacco and Onion Fertilizer,	E. Frank Coe Co., New York City,	Sunderland.
208	Dry Ground Fish,	Russia Cement Co., Gloucester, Mass.,	Hadley.
223	Dry Ground Fish.	Clark's Cove Fertilizer Co., Boston, Mass.,	Springfield.
224	Special Manure for Carnations,	Russia Cement Co., Gloucester, Mass.,	Worcester.
352	Pure Ground Bone,	Bartlett & Holmes, Springfield, Mass.,	Springfield.
354	Niagara Wheat and Corn Producer,	Niagara Fertilizer Works, Buffalo, N. Y.,	Amherst.
355	Niagara Potato, Tobacco and Hop,	Niagara Fertilizer Works, Buffalo, N. Y.	Amherst.
356	Niagara Triumph,	Niagara Fertilizer Works, Buffalo, N. Y.,	Amherst.
357	Crocker's Universal Grain Grower,	Crocker Fertilizer and Chemical Co., Buffalo, N. Y.,	Amherst.
358	New England Tobacco and Potato Grower,	Crocker Fertilizer & Chemical Co., Buffalo, N. Y.,	Amherst.
359	Grass and Grain Fertilizer,	Rogers & Hubbard Co., Middletown, Conn.,	Amherst.
361	Animal Fertilizer,	Burgess & Roy, So. Attleboro, Mass.,	Amherst.
364	Vegetable, Vine and Tobacco Fertilizer,	Great Eastern Fertilizer Co., Rutland, Vt.,	Amherst.
296	Tobacco and Onion Fertilizer,	E. Frank Coe Co., New York City,	Amherst.

NOTE.—The samples designated as, "sampled at Amherst," are certified samples forwarded by manufacturers,

Laboratory Number.	Name of Brand.	Moisture.	Nitrogen in 100 lbs.		Phosphoric Acid in 100 lbs.							Potassium Oxide in 100 lbs.	
			Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Total. Found.	Total. Guaranteed.	Available. Found.	Available. Guaranteed.	Found.	Guaranteed.
	Compound Fertilizers.												
28	Complete Tobacco Manure,†	11.38	3.70	3.3-4.1	2.18	7.16	1.54	10.88	9.16-10.99	9.34	8-11	4.50	5.4-6.48*
29	Tankage,	9.05	6.76	6.59	—	3.58	8.82	12.40	10	3.58	—	—	—
32-296	Tobacco and Onion Fertilizer,†	7.66	3.67	3.29-4.00	5.38	1.98	1.28	8.64	8-10	7.36	6-8	9.88	8-9*
208	Dry Ground Fish,	9.47	8.14	8.24-9.89	—	6.66	8.70	15.36	11-13	6.66	—	—	—
223	Dry Ground Fish,	7.26	8.52	7.41-9.06	—	2.28	4.22	6.50	7-8	2.28	—	—	—
224	Special Manure for Carnations,	9.16	3.18	2.88-3.71	5.28	3.88	1.16	10.32	8-10	9.16	6-8	6.72	6-7
352	Pure Ground Bone,	3.43	2.44	2-3	—	5.12	21.74	26.86	27-29	5.12	—	—	—
354	Niagara Wheat and Corn Producer,	9.21	1.53	1.23-2.05	6.30	2.92	.64	9.86	9-12	9.22	8-10	2.84	2.16-3.24
355	Niagara Potato, Tobacco and Hop,	7.25	1.87	1.64-2.40	6.08	3.38	.90	10.36	9-12	9.46	8-10	3.06	2.7-3.78
356	Niagara Triumph,	5.69	3.07	2.47-3.29	6.14	2.12	2.56	10.82	9-12	8.26	8-10	2.36	2.16-3.24
257	Crocker's Universal Grain Grower,	7.21	1.32	.82-1.64	4.98	2.96	1.80	9.74	8-12	7.94	7-10	3.46	2.7-4.00
358	New England Tobacco and Potato Grower,	6.81	3.77	3.29-5.00	5.30	1.40	.64	7.34	7-10	6.70	6-8	6.24	5.4-6.5
359	Grass and Grain Fertilizer,	11.18	2.54	2.5-3	—	7.26	10.88	18.14	16.5-18	7.26	—	11.66	12.5-13.5
361	Animal Fertilizer,	3.41	4.89	4-5	—	4.86	11.26	16.20	15-17	4.86	—	—	—
364	Vegetable, Vine and Tobacco Fertilizer,	9.93	2.45	2.06-2.88	8.58	1.66	.64	10.88	9-15	10.24	8-12	6.41	6-7

*Sulphate of Potash, the source of Potash.

†Republished from Bulletin 57, to give credit for potash in form of sulphate.

II. ANALYSES OF COMMERCIAL FERTILIZERS COLLECTED DURING 1898, IN THE GENERAL MARKETS BY THE AGENT OF THE HATCH EXPERIMEMT STATION OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

Laboratory No.	Name of Brand.	Name of Manufacturer.	Sampled at
	Compound Fertilizers.		
365	Northern Corn Special,	Great Eastern Fertilizer Co., Rutland, Vt.,	Amherst.
366	General Fertilizer,	Great Eastern Fertilizer Co., Rutland, Vt.,	Amherst.
367	Superior Truck Fertilizer,	M. E. Wheeler & Co., Rutland, Vt.,	Amherst.
368	High Grade Fruit Fertilizer,	M. E. Wheeler & Co., Rutland, Vt.,	Amherst.
369	High Grade Grass and Oats,	M. E. Wheeler & Co., Rutland, Vt.,	Amherst.
370	High Grade Farmers' Friend.	Read Fertilizer Co., New York City,	Amherst.
371	Bone, Fish and Potash,	Read Fertilizer Co., New York City,	Amherst.
372	Practical Potato Special,	Read Fertilizer Co., New York City,	Amherst.
373	Tankage,	Lowe Bros. & Co., Fitchburg, Mass.,	Amherst.
374	Fish, Bone and Potash,	Hiram Blanchard, Eastport, Me.,	Amherst.
375	Fish Scrap No. 2,	Hiram Blanchard, Eastport, Me.,	Amherst.
376	Imperial Liquid Plant Food,	Easton Chemical Co., Boston, Mass.,	Amherst.
477	Potato Manure,	Lucien Sanderson. New Haven, Conn.,	Amherst.
378	Formula "A,"	Lucien Sanderson, New Haven, Conn.,	Amherst.
280	Vegetable and Vine Fertilizer,	E. Frank Coe Co., New York City,	Amherst.
283	Bay State Phosphate,	E. Frank Coe Co., New York City,	Amherst.
379	Wood Ashes,	Wm. E. Fyfe & Co., Clinton, Mass.,	Amherst.

NOTE.—The samples designated as, "sampled at Amherst," are certified samples forwarded by manufacturers.

Laboratory Number.	Name of Brand.	Moisture.	Nitrogen in 100 lbs.		Phosphoric Acid in 100 lbs.							Potassium Oxide in 100 lbs.	
								Total.		Available.			
			Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
	Compound Fertilizers.												
365	Northern Corn Special,	9.44	3.37	2.88-3.70	6.66	3.30	2.44	12.40	9-15	9.96	8-12	2.02	2-4
366	General Fertilizer,	6.95	1.33	.82-1.50	7.30	3.06	1.40	11.76	9-15	10.36	8-12	4.77	4-6
367	Superior Truck Fertilizer,	9.37	3.36	3.29-4.10	3.40	2.44	3.50	9.34	8-11	5.84	7-9	8.52	8-10
368	High Grade Fruit Fertilizer,	12.60	—	—	7.62	1.72	1.66	11.00	12-17	9.34	10-14	8.42	8-10
369	High Grade Grass and Oats,	9.31	—	—	6.78	6.00	.90	13.68	12-16	12.78	11-14	2.42	2-4
370	High Grade Farmers' Friend,	5.46	4.26	3.30-4.00	3.96	6.78	2.82	8.32	6-8	10.74	5 6	10.82	10-11
371	Bone, Fish and Potash,	11.98	2.59	2.46	3.84	1.52	.90	6.26	5-00	5.36	4.00	4.18	4
372	Practical Potato Special,	12.17	1.00	.83-1.00	3.08	1.78	1.28	6.14	5-6	4.86	4 5	6 23	8-10
373	Tankage,	4.16	3.38	2-4	—	6.78	19.06	25.84	25-26	6.78	—	—	—
374	Fish, Bone and Potash,	14.16	4.96	4.47	—	2.30	4.48	6.78	5-12	2.30	—	5.24	6.00
375	Fish Scrap No. 2,	15.57	3.67	4.47	—	2.44	1.40	3.84	5-15	2.44	—	—	—
376	Imperial Liquid Plant Food,	90.46	1.21	1 00	1.39	—	—	1.39	1-00	—	—	1.37	1.00
377	Potato Manure,	5.50	2 30	1.65-3.30	3.96	2.26	6.44	12.66	9-10	6.22	5-6	8.77	6-7
378	Formula "A,"	8.32	3.89	3.30-4.12	4.74	4.72	5.12	14.59	10-12	9.46	6-8	6.40	6-8
280	Vegetable and Vine Fertilizer,†	11.74	2.39	2-3	6.02	1.66	2.56	10.24	10-13	7.68	8-10	8.34	6-7*
283	Bay State Phosphate,†	12.59	2.20	2.00	7.04	2.44	2.68	12.16	11-13	9.48	9-12	2.32	1.85*
379	Wood Ashes,	.20	—	—	—	—	—	1.98	—	—	—	8.20	—

*Sulphate of Potash, the source of Potash.

†Republished from Bulletin 57, to give credit for potash in form of sulphate.

TRADE VALUES OF FERTILIZING INGREDIENTS IN RAW MATERIALS AND CHEMICALS.

	1899. Cents per pound.
Nitrogen in ammonia salts,	15.0
" nitrates,	12.5
Organic nitrogen in dry and fine ground fish, meat, blood, and in high-grade mixed fertilizers,	14.0
" " " fine bone and tankage,	14.0
" " " medium bone and tankage,	10.0
Phosphoric acid soluble in water,	4.5
" " soluble in ammonium citrate,	4.0
" " in fine ground fish, bone and tankage,	4.0
" " in cottonseed meal, castor pomace and wood ashes,	4.0
" " in coarse fish, bone and tankage,	2.0
" " insoluble (in water and in am. cit.) in mixed fertilizers,	2.0
Potash as Sulphate, free from Chlorides,	5.0
" " Muriate,	4.25

The market value of low priced materials used for manurial purposes, as salt, wood ashes, various kinds of lime, barnyard manure, factory refuse and waste materials of different description, quite frequently does not stand in close relation to the current market value of the amount of essential articles of plant food they contain. Their cost varies in different localities. Local facilities for cheap transportation and more or less advantageous mechanical conditions for a speedy action, exert as a rule, a decided influence on their selling price.

The market value of fertilizing ingredients like other merchandise is liable to changes during the season. The above stated values are based on the condition of the fertilizer market in centers of distribution in New England, during the six months preceding March 1899.

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS

AGRICULTURAL COLLEGE.

BULLETIN NO. 60.

INSECTICIDES.
FUNGICIDES.
SPRAYING CALENDAR.

APRIL, 1899.

The Bulletins of this Station will be sent free to all newspapers in the State and to such individuals interested in farming as may request the same.

AMHERST, MASS.:
PRESS OF CARPENTER & MOREHOUSE,
1899.

HATCH EXPERIMENT STATION

OF THE

Massachusetts Agricultural College,

AMHERST, MASS.

By act of the General Court, the Hatch Experiment Station and the State Experiment Station have been consolidated under the name of the Hatch Experiment Station of the Massachusetts Agricultural College. Several new divisions have been created and the scope of others has been enlarged. To the horticultural, has been added the duty of testing varieties of vegetables and seeds. The chemical has been divided, and a new division, "Foods and Feeding," has been established. The botanical, including plant physiology and disease, has been restored after temporary suspension.

The officers are :—

Henry H. Goodell, LL. D.,	*Director.*
William P. Brooks, Ph. D.,	*Agriculturist.*
George E. Stone, Ph. D.,	*Botanist.*
Charles A. Goessmann, Ph. D., LL. D.,	*Chemist* (Fertilizers).
Joseph B. Lindsey, Ph. D.,	*Chemist* (Foods and Feeding).
Charles H. Fernald, Ph. D.,	*Entomologist.*
Samuel T. Maynard, B. Sc.,	*Horticulturist.*
J. E. Ostrander, C. E.,	*Meteorologist.*
Henry M. Thomson, B. Sc.,	*Assistant Agriculturist.*
Ralph E. Smith, B. Sc.,	*Assistant Botanist.*
Henri D. Haskins, B. Sc.,	*Assistant Chemist* (Fertilizers).
Charles I. Goessmann, B. Sc.,	*Assistant Chemist* (Fertilizers).
Samuel W. Wiley, B. Sc.,	*Assistant Chemist* (Fertilizers).
Edward B. Holland, M. Sc.,	*First Chemist* (Foods and Feeding).
Fred W. Mossman, B. Sc.,	*Ass't Chemist* (Foods and Feeding).
Benjamin K. Jones, B. Sc.,	*Ass't Chemist* (Foods and Feeding).
Philip H. Smith, B. Sc.,	*Assistant in Foods and Feeding.*
Robert A. Cooley, B. Sc.,	*Assistant Entomologist.*
George A. Drew, B. Sc.,	*Assistant Horticulturist.*
Herbert D. Hemenway, B. Sc.,	*Assistant Horticulturist.*
Arthur C. Monahan,	*Observer.*

The co-operation and assistance of farmers, fruit-growers, horticulturists, and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the

Hatch Experiment Station, Amherst, Mass.

Horticultural Division.

S. T. MAYNARD.

Spraying for the Destruction of Insects and Fungous Pests.

Farmers, fruit growers and gardeners are coming more and more to see the necessity of spraying their crops to protect them from insects and fungous pests, and as a rule those most successful in the above lines practice spraying systematically and have as complete equipment for this work as for the work of cultivation.

The results of spraying the past season have shown many interesting features and have led to some slight changes in the spraying calendar for 1899 accompanying this paper.

Many kinds of pumps and nozzles are in use, and some new features have been introduced, the most important of which perhaps, is the combined kerosene and water sprayer (kerosprayer). These pumps are made with two cylinders, one for the water and the other for the kerosene. These are worked by the same lever or handle, the kerosene being forced into the hose with the water and distributed from the same nozzle in a very fine mixed spray. The pump can be so regulated that 5, 10, 20, 25 and even 50% of kerosene may be used. With these pumps the kerosene may be used with the copper sulfate solution or the Bordeaux mixture, though with the latter it has not given as satisfactory results as with the former. Whatever the kind of pump purchased it is important that it be used carefully, that the spraying material, if containing coarse particles, be carefully strained before use, that all parts be kept well oiled and after using, that the pump be cleaned by pumping sufficient water through it to clear it of corroding materials.

Good judgment and considerable mechanical skill must be exercised to get the best results with any complicated machine, and only those persons possessing these qualifications should be allowed to use the pumps.

INSECTICIDES.

While there are many new insecticides offered, there is so little exact knowledge of their effect upon farm and garden crops that until further trial is made we can only recommend for general use *Paris green*, *arsenate of lead* and *hellebore* for chewing insects and *kerosene and water* and *kerosene emulsion* for sucking insects, with *pyrethrum* or insect powder in a very few cases.

PARIS GREEN.

This insecticide needs no description. Special care however should be taken that only pure Paris green be used. A much larger per cent of this may be used without injury to the foliage if mixed with the Bordeaux than if applied in water alone. The cherry, peach and Japanese plum cannot be sprayed with Paris green without injury to the foliage.

ARSENATE OF LEAD.

Formula. 11 oz. Acetate of Lead.
4 oz. Arsenate of Lead.
150 gallons water.

This insecticide has this advantage over Paris green that when used in large quantities it will not injure the foliage of the peach, cherry, Japanese plum or other trees of delicate nature. It is however more expensive and its effectiveness in destroying the common insects attacking our fruit and garden crops is not so well proven as that of Paris green. It should be given a thorough trial especially on those crops where Paris green is known to be injurious.

"*This insecticide is easily prepared by putting 11 oz. acetate of lead in 4 qts. of water in a wooden pail and 4 oz. arsenate of lead (50 per cent strength) in 2 qts. of water in another wooden pail and when entirely dissolved mixing in a hogshead or tank con-

*Prof. C. H. Fernald in 45th Annual Report of Mass. State Board of Agriculture, 1897.

HATCH EXPERIMENT STATION,

HORTICULTURAL DIVISION.

Correction for Bulletin No. 60.

ARSENATE OF LEAD.

The formula and direction for the use of the Arsenate of Lead should be changed as follows:

FORMULA.

11 oz. Acetate of Lead.
4 oz. Arsenate of SODA.
150 gallons of Water.

This insecticide has the advantage over Paris green that when used in large quantities it will not injure the foliage of the peach, cherry, Japanese plum or other trees of delicate nature. It is however more expensive and its effectiveness in destroying the common insects attacking our fruit and garden crops is not so well proven as that of Paris Green. It should be given a thorough trial especially on those crops where Paris green is known to be injurious.

"*This insecticide is easily prepared by putting 11 oz. acetate of lead in 4 qts. of water in a wooden pail and 4 oz. arsenate of *soda* (50 per cent strength) in 2 qts. of water in another wooden pail and when entirely dissolved mixing in a hogshead or tank containing 150 gallons of water, when a chemical reaction will take place forming arsenate of lead as a pure white powder in suspension in the water." If the common 50 gallon barrel or cask is used the formula would be $3\frac{2}{3}$ oz. acetate of lead and $1\frac{1}{3}$ oz. arsenate of *soda*.) "If cold water be used the solution of acetate of lead will require a little time, but however, if the water be hot it will dissolve quickly. It is customary to add from 1 to 4 qts. of glucose to the above amount of water to make the poison adhere more firmly, but this may not be necessary. If it is desired to use larger proportions of the arsenate of lead it is only necessary to use more acetate of lead and arsenate of *soda*, but *always* in the proportion given above."

*Prof. C. H. Fernald in 45th Annual Report of Mass. State Board of Agriculture, 1897.

taining 150 gallons of water, when a chemical reaction will take place forming arsenate of lead as a pure white powder in suspension in the water." (If the common 50 gallon barrel or cask is used the formula would be $3\frac{2}{3}$ oz. acetate of lead and $1\frac{1}{3}$ oz. arsenate of lead.) "If cold water be used the solution of acetate of lead will require a little time, but however, if the water be hot it will dissolve quickly. It is customary to add from 2 to 4 qts. of glucose to the above amount of water to make the poison adhere more firmly, but this may not be necessary. If it is desired to use larger proportions of the arsenate of lead it is only necessary to use more acetate of lead and arsenate of lead, but *always* in the proportion given above."

KEROSENE EMULSION.

Formula. $\frac{1}{2}$ lb. common bar soap.
2 gals. common kerosene.

Cut the soap into thin pieces or shavings and dissolve in about 2 gallons of hot water. While still hot, *as nearly boiling as possible*, pour in the kerosene and with the hand pump or syringe, pump it back and forth until a thick cream-like substance is formed. In this condition the kerosene is divided into very minute globules and will be readily diluted or suspended in water.

Before using, add water enough to make

(A) 10 gallons of emulsion
(B) 20 gallons of emulsion.

Formula A, to be used when the insects are in large numbers and the foliage is known not to be easily injured by it. Formula B, under other conditions.

KEROSENE AND WATER.

It has been found by numerous experiments that clear kerosene mixed with water if applied upon a bright clear day and in a condition of fine mist so as not to form drops may be used without injury to the foliage of most of the trees attacked by aphides and other sucking insects, the pear tree psylla and scale insects. This insecticide however cannot be recommended unless it is applied with an atomizer or with a pump by which a definite quantity can be applied. The amount* that may be used must depend upon the condition of the atmosphere. During a bright, dry, windy day a much larger quantity may be used than on a still day when the atmosphere is moist. *It should never be used in cloudy or rainy weather*, and this applies in a greater or less degree to the kerosene emulsion.

Pyrethrum Powder and *Hellebore* should be obtained in a perfectly fresh condition and be kept in sealed tin cans or glass stoppered jars.

FUNGICIDES.

BORDEAUX MIXTURE.

Formula. 4 lbs. Copper Sulfate, (*Blue Vitriol*).
4 lbs. Caustic Lime (Unslaked Lime.)

Dissolve the copper in hot water. If suspended in a basket or sack in a tub of cold water it will however dissolve in from two to three hours.

The lime is then slaked in another vessel adding water slowly that it may be thoroughly slaked, then add enough water to make 5 to 10 gallons of the liquid. When both are cool, pour the lime into the copper solution straining it through a fine meshed sieve or burlap strainer, and thoroughly mix. Before using, add water enough to make 50 gallons of the mixture, and strain again when poured into the pump. Many persons make the mistake when preparing the Bordeaux mixture of straining the lime mixture while too thick, under which condition much of its value is lost. Five to ten gallons of water should be added to the lime wash before it is strained into the vessel containing the copper sulfate solution. The fine particles of lime hold the copper and Paris green to the foliage and prevent injury, and if properly strained nearly all of this fine material will go through the nozzle without clogging.

Stock solutions of both lime and copper i. e. 20, 36 or 48 lbs. of

* It is best to begin with 10 to 15% and increase unless some injury is noticed.

each, may be prepared at one time and they will keep in good condition for a week or two but they should *never* be put together until ready to be used. Before mixing, the lime solution should be thoroughly stirred and diluted.

The copper solution will retain its strength and value indefinitely, but the lime mixture is never as good as *within an hour or two* of the time it is made and we would caution those purchasing the prepared Bordeaux mixture, not to expect as satisfactory results as from the fresh home-made mixture which is also much cheaper.

The active agent in this mixture is the copper, the lime being used simply to hold it in place upon the foliage and branches of the plants sprayed. Here it is given up with each rain, destroying the spores of the fungi as they are brought in contact with it by the surrounding atmosphere.

Should the lime be air slaked at all more than four pounds may be needed as it will have lost much of its strength.

This fungicide is recommended as more satisfactory than any other, from the fact that it adheres a long time to the branches, buds and leaves and seldom causes any injury to the foliage.

It has been found more effective if made up fresh for each application. Two or three thorough applications give better results than many light ones.

When both fungous growths and insects attack a crop, Paris green should be applied with the Bordeaux, as in a combined state both are as effective as if used singly, one-half of the labor being saved and the lime preventing injury to the foliage by the Paris green.

DILUTE COPPER SULFATE SOLUTION.

After the fruit has nearly matured it is often disfigured by the adhesion of the Bordeaux mixture especially the plum, peach, cherry and grape and in place of this we would advise the use of copper sulfate 2 to 4 oz. to 50 gallons of water. The foliage of many plants will stand a much stronger solution, but this is as concentrated as can be generally used.

It must be remembered that this solution will be washed off by every hard rain, and to keep the copper on the foliage or fruit during frequent rains will sometimes require spraying every day. This has been done in some cases and with profit, for often without it the crop is a total failure. The expense of this work however, for the few days or a week when cherries, peaches and plums are near ripening is not so great as at first appears for only the simple solution is used and there can be no clogging of the nozzles to delay the work.

SPRAYING CALENDAR.

SPRAYING CALENDAR.

PLANT.	FIRST APPLICATION.	SECOND APPLICATION.
APPLE . . . . *(Scab, codlin moth, bud moth. Tent caterpillar, canker worm, plum curculio.)*	When buds are swelling, Bordeaux.	If canker worms are abundant just before blossoms open, Bordeaux and Paris green.
BEAN . . . . *(Anthracnose, leaf blight.)*	When third leaf expands, Bordeaux.	10 days later, Bordeaux.
CABBAGE . . . . *(Worms.)*	Insect powder 1 lb. to 25 lbs. of plaster or cheap flour dusted into the head.	7-10 days later, repeat.
CHERRY* . . . . *(Rot, aphis, slug. Plum curculio. Black knot.)*	As buds are breaking, Bordeaux; when aphis appears, kerosene emulsion or kerosene and water.	When fruit has set, Bordeaux. If slugs appear, dust leaves with air slaked lime or hellebore. Try arsenate of lead for plum curculio.
CURRANT / GOOSEBERRY . . . . . . *(Worms. Leaf blight.)*	At first appearance of worms, hellebore. Thorough application in water.	10 days later, hellebore. Bordeaux.
GRAPE . . . . *(Fungous diseases. Rose bug.)*	In Spring when buds swell, Bordeaux.	Just before flowers unfold, Bordeaux and Paris green.
NURSERY STOCK . . . *(Fungous diseases.)*	When first leaves appear, Bordeaux.	10-14 days, repeat first.
PEACH, NECTARINE* . . *(Rot, mildew.)*	As the buds swell, Bordeaux. Arsenate of lead for plum curculio.	When fruit has set, Bordeaux. Arsenate of lead for curculio.
PEAR . . . . *(Leaf blight, scab, psylla. codlin moth, blister mite.)*	As buds are swelling, Bordeaux.	Just before blossoms open, Bordeaux. Kerosene and water or kerosene emulsion when leaves open for psylla.
PLUM* † . . . . *(Curculio. Black knot, leaf blight, brown rot.)*	When buds are swelling, Bordeaux.	When blossoms have fallen, Bordeaux and Paris green. Begin to jar trees for curculio.
QUINCE . . . . *(Leaf and fruit spot.)*	When blossom buds appear, Bordeaux.	When fruit has set, Bordeaux.
RASPBERRY / BLACKBERRY / DEWBERRY . . . . . . *(Rust, anthracnose, leaf blight.)*	Before buds break, Bordeaux.	Bordeaux, just before the blossoms open.
STRAWBERRY . . . . . . *(Rust.)*	As soon as growth begins, with Bordeaux.	When first blossoms open, spray both young and old plantation. Bordeaux.
TOMATO . . . . *(Rot, blight, flea beetle.)*	Before appearance of blight or rot, Bordeaux.	Repeat first if diseases are not checked. Fruit can be wiped if disfigured by Bordeaux.
POTATO . . . . *(Flea beetle, Colorado beetle, blight and rot.)*	Spray with Paris green and Bordeaux when about ⅓ grown.	Repeat before insects become numerous.

*Paris green cannot be used on foliage of cherry, peach or Japanese plum without injury.

†Black knot on plums or cherries should be cut and burned as soon as discovered.

THIRD APPLICATION.	FOURTH APPLICATION.	FIFTH APPLICATION.
When blossoms have fallen, Bordeaux and Paris green.	8-12 days later, Bordeaux and Paris green.	10-14 days later, Bordeaux.
14 days later, Bordeaux.	14 days later, Bordeaux.	Spraying with Bordeaux after the pods are one-half grown will injure them for market.
7-10 days later, repeat.	Repeat in 10-14 days if necessary.	
10-14 days if rot appears, Bordeaux. Arsenate of lead for plum curculio.	10-14 days later, weak solution of copper sulfate.	Repeat after every rain when fruit begins to color.
If worms persist, hellebore.	2 to 4 weeks later, if any disease appears, weak solution of copper sulfate.	After fruit is gathered, Bordeaux.
When fruit has set, Bordeaux and Paris green.	2 to 4 weeks later, Bordeaux.	Weak solution of copper sulfate.
10-14 days repeat first.	10-14 days repeat first.	5-7 days later, repeat.
When fruit is one-half grown, Bordeaux.	5-7 days later, weak solution of copper sulfate.	10-14 days later, weak solution of copper sulfate.
After blossoms have fallen, Bordeaux and Paris green. Kerosene emulsion, if necessary or kerosene and water.	8-12 days later, repeat third.	10-20 days later, weak solution of copper sulfate.
10-14 days later, Bordeaux. Paris green cannot be safely used on Japanese varieties.	10-20 days later, Bordeaux.	10-20 days later, copper sulfate solution as fruit is ripening.
10-20 days later, Bordeaux.	10-20 days later, Bordeaux.	
(Orange or red rust is treated best by destroying the plants attacked in its early stages.)	Spray after fruit is gathered with Bordeaux.	
Spray young plantation Bordeaux.	Repeat third if weather is moist.	
Repeat first when necessary.	Try weak solution of copper sulfate.	
Repeat for blight, rot and insects as potatoes approach maturity.		

*For aphides or plant lice use kerosene emulsion or kerosene and water.

Wm. P. Burke.