Public Document No. 31

TWENTY-SECOND ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

PART I.,

BEING PART III. OF THE FORTY-SEVENTH ANNUAL REPORT OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1910.

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PART I.

DETAILED REPORT OF THE EXPERIMENT STATION.

INTRODUCTION.

In accordance with the provisions of the amended act relative to the publication of the reports of the Massachusetts Agricultural College, passed by the Legislature of 1909, the report of the experiment station, which is a department of the college, is presented in two parts. Part I. will contain the formal reports of the director, treasurer and heads of the departments, and papers of a technical character giving the results of investigations carried on in the station. This will be sent to agricultural colleges and experiment stations and to workers in these institutions, as well as to libraries. Part I. will be published also in connection with the report of the Secretary of the State Board of Agriculture, and will reach the general public through that channel. Part II. will contain papers of a popular character, and will be sent to persons on our general mailing list.

WM. P. BROOKS,

Director.

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PART I.

MASSACHUSETTS

AGRICULTURAL EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

TWENTY-SECOND ANNUAL REPORT.

Part I.

ORGANIZATION.

Committee on Experiment Department.

Station Staff.

Charles A. Goessmann, Ph.D., LL.D., Honorary Director and Expert Consulting Chemist, 40 North Pleasant Street.
William P. Brooks, Ph.D., Director and Agriculturist, Massachusetts Agricultural College.
Joseph B. Lindsey, Ph.D., Vice-Director and Chemist, 47 Lincoln Avenue.
George E. Stone, Ph.D., Botanist and Vegetable Pathologist, Mt. Pleasant.
Charles H. Fernald, Ph.D., Entomologist, 3 Hallock Street.
James B. Paige, D.V.Sc., Veterinarian, 42 Lincoln Avenue.
Frank A. Waugh, M.Sc., Horticulturist, Massachusetts Agricultural College.
John E. Ostrander, C.E., Meteorologist, 33 North Prospect Street.
Henry T. Fernald, Ph.D., Associate Entomologist, 44 Amity Street.
Edward B. Holland, M.Sc., Associate Chemist, 28 North Prospect Street.
Henri D. Haskins, B.Sc., Chemist (Fertilizer Control), 89 Pleasant Street.
Philip H. Smith, B.Sc., Chemist (Food and Dairy Control), 102 Main Street.
Fred C. Sears, M.Sc., Pomologist, Mt. Pleasant.
Henry J. Franklin, Ph.D., Assistant Entomologist (Cranberry Investigations), 56 Pleasant Street.
Erwin S. Fulton, B.Sc., Assistant Agriculturist, North Amherst.
Edwin F. Gaskill, B.Sc., Second Assistant Agriculturist, R. J. Goldberg's, North Pleasant Street.
George H. Chapman, B.Sc., Assistant Botanist, Fearing Street.
Jas. C. Reed, B.Sc., Assistant Chemist.
Jacob K. Shaw, M.S., Assistant Horticulturist.

JOSEPH F. MERRILL, B.Sc., Assistant Chemist, 32 North Prospect Street.
CARL D. KENNEDY, B.Sc., Assistant Chemist, 88 Pleasant Street.
JOHN N. SUMMERS, Assistant Entomologist, 66 Pleasant Street.
FRED C. KENNEY, Treasurer, Mount Pleasant.
CHARLES R. GREEN, B.Agr., Librarian, Mount Pleasant.
ROSE J. BROWN, Secretary to the Director, Draper Hall, Massachusetts Agricultural College.
JAMES T. HOWARD, Inspector, Feed and Dairy Division, North Amherst.
ROY F. GASKILL, Assistant in Animal Nutrition, Massachusetts Agricultural College.
C. M. DAMON, Observer, 20 South College, Massachusetts Agricultural College.
JESSIE V. CROCKER, Stenographer, Department of Botany and Vegetable Pathology, Sunderland.
HARRIET COBB, Stenographer, Department of Plant and Animal Chemistry, 35 East Pleasant Street.
BRIDIE E. O'DONNELL, Stenographer, Department of Entomology, Hadley.

REPORT OF THE DIRECTOR.

The work of the station during the past year has followed the usual lines. There has been some increase in the amount of research work. This has been made possible by the increase in the amount received from the Adams fund for the current year. Especial attention is called to the fact that immediate results cannot in most cases be expected from such fundamental scientific investigations as are allowed under the Adams fund. A number of important problems are receiving most careful investigation and study. Among them, the more important are the following: —

Studies in milk secretion.
Molasses and digestion depression.
Why arsenicals burn foliage.
Plant breeding, and subsidiary thereto, variation in garden peas and apples.
Determination of physiological constants.
Investigation to determine the economic importance of digger wasps in relation to agriculture.
Studies of pyrallidæ and tortricidæ.
Experiments to determine the plant food requirements of asparagus.
Cranberry investigations to determine plant food requirements.
Relations of climate to plants in health and disease.
Cranberry insect work.

In some of the investigations, results, from which practical lessons which seem to be of importance even now, have been obtained; but no one of them has yet been carried to completion, and most of them are of such a nature that long and patient research will undoubtedly be essential before the fundamental laws which determine the results can be determined.

Particular attention is called to the fact that the passage of the Adams act has not in the slightest degree increased the amount of station funds available for more popular and directly practical station work. Indeed, in one direction the passage of the Adams act has imposed an additional tax upon other station funds, for the act provides that the expense of publication of the results of Adams fund research work cannot be paid from that fund. Such expense must be borne by other station funds. There has been no change in the amount of such funds available to this station, with the exception of an addition of $500 made about seven years ago, during the past twenty-one years. Meanwhile, there have been constantly increasing demands upon the station for work of various kinds, while there has inevitably been a tendency to broaden the scope of such experiments as are already carried on under these funds. The fertilizer control work, moreover, now encroaches upon ordinary station funds. The costs of the collection of samples, analytical work and the publication of the bulletin now considerably exceed the amount of license fees received. This topic will be more fully discussed later in the report, but is mentioned here simply to emphasize the fact that available station resources are not sufficient to cover the costs of such additions to our work as are called for. Poultry men, tobacco growers and cranberry growers, particularly, are urging the experiment station to undertake experiments for the promotion of these industries. Every possible economy has been used in the expenditure of station funds. A small amount has been made available for co-operative experiments with tobacco, and some work with cranberries will be undertaken during the coming year. The possibilities, however, of carrying on such work as the men engaged in these industries would like to see undertaken are comparatively small. The demands upon the station during the past twenty-one years have greatly increased, and they have never increased at a more rapid rate than within the past year. It would seem to be quite time, therefore, to ask for increased funds to provide for the growth in station work which the times demand.

Changes in Staff.

There has been no change in the heads of departments in the station staff during the past year. This fact has been favorable to station efficiency, although in this connection it may not be out of place to point out the fact that the rapid growth of the college has imposed much additional work upon the educational side upon most heads of departments in the station. This fact has necessarily reduced the time and energy available for station work, and the further growth of the college will force upon those responsible for station management a careful consideration of the question whether there should not be connected with the station a larger number of men who have had such training and experience, and who possess such natural ability, that they are competent, without immediate supervision, to originate and carry on investigations of the highest order.

The chemical research work of the station suffered a serious break in the resignation of Dr. R. D. MacLaurin. The place left vacant by his resignation has not been filled, but an additional assistant in chemistry is now employed, thus making it possible to push chemical research investigations which are in progress under Mr. Holland more rapidly than it has been possible to do heretofore.

The connection of Mr. F. A. Johnson with the experiments pertaining to cranberry insects has ceased during the past year. The station, however, has been fortunate in once more obtaining the services of Henry J. Franklin, Ph.D., for entomological work. Dr. Franklin will devote a large share of his time to cranberry insects, but will be placed in local charge of other experimental work with cranberries in the cranberry district. He will be available also for other entomological investigations as time permits.

Mr. P. V. Goldsmith has resigned during the past year to accept a more lucrative position as a sugar chemist. The two new assistants in chemistry are J. F. Merrill, B.Sc., and Carl D. Kennedy, B.Sc.

Buildings.

No important new buildings have been erected during the past year. We have, however, put up, by use of ordinary station funds, three portable brooder houses. These houses are of the Cornell University pattern. They are heated by gasoline and each will accommodate 200 chickens.

Extensive improvements have been made in the old station barn and stables. A large part of the old floor in the main barn has been torn out and a concrete floor put in its place. A cellar 25 by 56 feet in size has been made under the stables. This will provide greatly needed additional room for winter storage of fruits and vegetables. The old stable partitions and fittings have been removed, and a solid concrete floor has been laid over the old plank floor, while new stall partitions and fittings will take the place of the old. These improvements have been carried out with funds appropriated by the last Legislature.

Particular attention is called to the fact that additional room must be provided in our chemical laboratory. The provision of such room is made imperative by the demands made upon us for research work, the rooms upon one side of the laboratory being used in the fertilizer control and those on the other side in the feed and dairy control work. These rooms are fairly sufficient for the control work; but they do not provide either the space or the conditions essential for chemical research work. In spite of all possible efforts to prevent such results it is inevitable that the analytical work connected with the examination of fertilizers and feeds will sometimes load the air with fumes which might vitiate absolutely the research work going on, and this might mean a tremendous loss of time and the sacrifice of the results of much skilled work. To undertake to carry on research work under such risks must, of course, be extremely unsatisfactory; but even could such risks be avoided, the working conditions in a laboratory where control work is being prosecuted are not favorable to research work. Research work requires undisturbed quiet. In the presence of numerous men engaged in ordinary routine chemical work there must necessarily be a certain amount of movement and confusion. Research work side by side with routine control work cannot therefore be made to give the best results.

Plans for the provision of accommodations needed for research work have received the careful attention of the members of the station staff most concerned. It will be necessary, in order to carry out plans which will be at all adequate to our needs, to secure a special appropriation from the Legislature.

Station Activities.

Station activities have embraced work along all the different lines mentioned in our last annual report. These lines are experiment, research, dissemination of information and control work. As already pointed out, there has been little change in the amount of practical experimental work during the year. Research work has been somewhat increased, as has also been pointed out. In the lines of work which come under the head of dissemination of information there has been comparatively little change during the year, although some heads of departments have called attention to the fact that, since the organization of an extension department in the college, there is a slight decrease in the number of calls for information coming to the station. This has been noticeable chiefly in the number of letters of inquiry. It must be regarded as desirable, from the standpoint of station efficiency, that the members of the station staff should be relieved as far as may seem possible of the necessity of doing routine extension work. Such relief will mean more time and energy for investigational work, which must be regarded as the most important function of the experiment station.

The amount of control work during the past year has been greater than in any previous year. The increase has been due chiefly to the fact that a greater number of samples of fertilizers have been collected and a greater number of analyses of fertilizers carried out.

Attention is called to the fact that three of our neighboring New England States have seed laws. These laws must tend to prevent to some extent the sale of inferior seed in these States, and it would seem probable that since there must always be a certain amount of such seed, there will be increased probability that it will seek a market in those States not having seed laws. This, it seems likely, will mean an increase in the amount of inferior seed brought into Massachusetts for sale. The laws in our neighboring States have not yet been long in effect, and the tendency to which I have referred has not yet shown itself. Should it seem, however, that Massachusetts is becoming a dumping ground for inferior seed, it will clearly be the part of wisdom to endeavor to secure the enactment of a law for the protection of honest dealers (who, it is believed, are in a large majority in the State) and of the buyers and users of farm and garden seeds.

The investigation carried on by Dr. Burton N. Gates and the correspondence of the experiment station have made it perfectly apparent that both European and American foul brood are common among bees in various parts of the State. The existence of this disease threatens an industry which is already of considerable importance, and which might, with great advantage to our citizens, receive much greater attention. The passage of an act providing for an inspector of apiaries would be most desirable. The work of this inspector would be largely and no doubt chiefly educational. These diseases can be eradicated or controlled. Many beekeepers would no doubt undertake to rid their apiaries of disease could they be shown how to do the work. Under existing conditions, however, a beekeeper unfortunate enough to have either of the varieties of foul brood would have little encouragement to rid his apiary of the disease for the reason that he must anticipate re-infection from the apiaries of beekeepers who should neglect to carry out remedial treatment with the thoroughness essential to success. The inspector of apiaries, therefore, must be given authority to compel remedial treatment, or, if other measures fail, to destroy infected colonies. New York and Connecticut now have laws providing for such work as has been indicated, and it is quite time that Massachusetts also should enact such a law.

It seems probable that a national law covering the manufacture and sale of insecticides and fungicides will be enacted by the Congress now in session. Such a law has been under joint consideration by the Bureau of Entomology of the Department of Agriculture, a committee of Economic Entomologists and prominent manufacturers. A law was introduced into the last Congress, and has now been brought into such form that it seems to be fairly satisfactory to all interests involved. This law, of course, can be effective in the States only in governing interstate transactions, but since practically all manufacturers of insecticides and fungicides do an interstate business, the passage of the national law will probably prove effective in controlling the manufacture and trade in these materials.

Publications during 1909.

The new plan for the publication of the annual report of the station referred to in my last report became effective for the first time during the past year. Under this plan a larger proportion of the material published by the station will appear in the annual report than has been customary heretofore. Thus, for example, the two parts of the annual report for 1909 make a total of 300 pages, whereas the annual report for 1908 included 172 pages only. The amount of matter to be published in bulletin form is reduced by the change just referred to, and the number of such publications during the past year has been considerably less than in 1908. The total number of printed pages, including both bulletins and reports is, however, the same for the two years.

The amount of circular matter sent out is also practically the same, namely, 30 pages in 1909 and 32 pages in 1908. A full list of the publications for the year follows: —

Publications during 1909.

Annual report: —

Parts I. and II. 300 pages.

Bulletins: —

No. 128. Inspection of Commercial Feed Stuffs, P. H. Smith and P. V. Goldsmith. 56 pages.

No. 129. Beekeeping in Massachusetts, Burton N. Gates. 32 pages.

No. 130. A Summary of Meteorological Observations, J. E. Ostrander. 28 pages.

Circulars: —

No. 20. The Use of Lime in Massachusetts Agriculture, Wm. P. Brooks. 6 pages.

No. 21. The Control of Onion Smut, G. E. Stone. 2 pages.
No. 22. Poultry Manures, their Treatment and Use, Wm. P. Brooks. 4 pages.
No. 23. A Parasite of the Asparagus Beetle, H. T. Fernald. 4 pages.
No. 24. An Act to provide for the Protection of Dairymen. The Babcock Test, J. B. Lindsey. 8 pages.
No. 25. Cottonseed Meal, J. B. Lindsey. 8 pages.

Publications Available for Free Distribution.

Bulletins: —

No. 33. Glossary of Fodder Terms.
No. 41. Use of Tuberculin.
No. 68. Fertilizer Analyses.
No. 76. The Imported Elm-leaf Beetle.
No. 83. Fertilizer Analyses.
No. 84. Fertilizer Analyses.
No. 89. Fertilizer Analyses.
No. 90. Fertilizer Analyses.
No. 103. Fertilizer Analyses.
No. 113. Fertilizer Analyses.
No. 115. Cranberry Insects.
No. 117. Trade Values, and Fertilizer and Soil Analyses.
No. 121. Seed Separation and Germination.
No. 123. Fungicides, Insecticides and Spraying Directions.
No. 124. Bee Diseases in Massachusetts.
No. 125. Shade Trees.
No. 126. Insects Injurious to Cranberries, and how to fight them.
No. 127. Inspection of Commercial Fertilizers.
No. 129. Beekeeping in Massachusetts.
No. 130. Meteorological Summary — Twenty Years.
Technical Bulletin No. 2. The Graft Union.
Technical Bulletin No. 3. The Blossom End Rot of Tomatoes.
Index to bulletins and annual reports of the Hatch Experiment Station previous to June, 1895.
Index to reports and bulletins, 1888–1907.

Annual reports: —

Annual reports of the station for the following years are available: 10th (1898), 11th (1899), 12th (1900), 13th (1901), 14th (1902), 15th (1903), 16th (1904), 17th (1905), 20th (1908), and 21st, Parts I. and II. (1909).

Of some few other bulletins and reports we have a very limited supply. These will be furnished only in order to complete sets for libraries.

Examination of the above list makes it apparent that relatively few of our earlier bulletins can now be furnished. The publications printed by the station during the early years of its existence were naturally issued in comparatively small editions. The demand was limited. The growth of interest in improved methods in agriculture was not fully anticipated. It is now apparent that it would have been well had many of our bulletins and reports, which are of a character to make their contents of some permanent value, — even if only for purposes of library reference, — been issued in larger numbers. Many institutions, especially those devoted to agricultural education, and hundreds of individuals, are now vainly seeking to complete files of station publications. We cannot recall the past. Its mistakes are irremediable; but we should heed its lessons. The growth of interest in such matters as station reports and bulletins treat will continue, and the rate of such growth will be more rapid in the future than in the past. It would clearly seem unwise to figure our editions too close to present demand, and yet to this course we seem to be compelled on account of the pressure upon station funds, made greater by the last grant from the federal government, — the Adams fund, — since this fund provides means for increased research, while the act granting it expressly stipulates that no part of the fund shall be used in meeting the costs of publication of results. These costs are, therefore, an increased burden on funds already fully utilized in meeting the expenses of other lines of work.

It may be urged that under the conditions above outlined the amount of work in other lines should be decreased, but this is an alternative which the demands of the times render most difficult, and which I believe would be decidedly unwise. We are under constant pressure to undertake more experimental work and in new lines. The various special agricultural interests urge us to more fully recognize them. Poultrymen, asparagus growers, cranberry growers, tobacco growers, hothouse men and many others have their special problems, which they look to us, and rightly, to help them solve. We need more funds then, rather than less, for our experimental work, and hence the necessity of a more generous provision for publication. The size of our editions should be increased, but under existing appropriations this is impossible.

A committee of the American Association of Agricultural Colleges and Experiment Stations, after a most careful study of the whole subject of station publications, has recently made a report strongly urging, among other things, that, with a view to making provision for future demands, station publications should be electrotyped when issued. The adoption of this course now does not seem to me to be our most pressing necessity, but some such provision in the near future will no doubt be desirable.

The demand for general bulletins of information, referred to at some length in my last report, shows no sign of abatement. On the contrary, it is ever increasing. The information which may be furnished by such bulletins is greatly needed. Could it be placed in the hands of persons calling for it, marked improvement in agricultural methods might be confidently anticipated. I believe, however, that this demand should be chiefly met by private enterprise. Certainly it cannot be met by the station without special provision to cover its costs. Meeting it, however, would seem to be in the nature of extension rather than experimental work, and therefore, under the modern conception of respective functions, perhaps belongs rather to the college than to the station.

Letters of Inquiry.

The number of letters of inquiry annually received in the different departments of the experiment station continues to increase. During the past year the total number of such letters received and answered was 6,500. Attention to these letters consumes a very considerable proportion of the time and energy of members of the station staff, thus materially curtailing the amount of attention which can be given to investigation. The numerous letters of acknowledgment received from correspondents receiving suggestions and advice make it apparent that the assistance which the station is able to render by answering these letters is appreciated. The amount of work of this character which the public will call upon the Massachusetts Agricultural Experiment Station to do is sure to increase. This line of work is highly important and useful, and it would seem to be the part of wisdom to make special provision for it in order that station workers may be more free to devote themselves to investigation.

Lectures and Demonstrations.

Members of the station staff have been frequently called upon during the past year to deliver public lectures and to conduct demonstrations. The number of lectures and demonstrations given during the year was 56, while a large number of invitations to accept such engagements were, of necessity, declined. Work of this character makes heavy inroads upon the time of station workers, for it involves in the long run the use of much time in travel and in preparation. In so far, however, as station men have special knowledge of certain subjects, it seems desirable that they should address a reasonable number of important meetings, since in this way the results of the work of the station are carried to the public, while the lecturer on his part is brought into closer and wholesome touch with the public which he aims to serve.

Miscellaneous Analyses.

The chemist reports the usual large number of miscellaneous analyses. Work of this character done during the year may be summarized as follows: —

Water,	99
Milk,	389
Cream,	2,933
Feed stuffs,	98
Fertilizers and fertilizer materials,	234
Soils,	42
Miscellaneous substances,	45

This summary includes simply the analytical work carried out for individuals. The results of these analyses are of interest in most cases only to the persons sending in the material. It is recognized that this work has its value; but investigational work is of wider interest and of greater value. It has been our policy, therefore, and must continue to be our policy, to confine work of this kind to relatively narrow limits. Should we comply with all requests for work of this character, it is probable that the time of all the chemists at present employed would be very largely occupied in this work.

The most marked increase in demands for private analytical work is for soil analyses. There appears to be a widespread misconception as to the probable value to the individual of a chemical analysis of his soils. This subject was rather fully discussed in my last annual report; but it seems wise once more to repeat that the results of such analysis do not constitute a satisfactory basis for determining either the crop adaptation or the manurial requirements in the great majority of cases. No accurate count has been made, but it is believed that the number of requests for such analyses made during the past year has been at least 300. To have made this number of complete analyses would have required the continuous services of two chemists for a year; while to have determined simply the leading fertilizer elements must have required the full time of one chemist.

The leading soil types found in the State have already been analyzed repeatedly in most cases. Fertilizer requirements appear to be determined in the majority of instances more largely by the crop than by peculiarities in the chemical composition of the soil. It is particularly pointed out, therefore, that correspondents need only to state the type of soil, the character of the subsoil, the recent manurial treatment and the crop in order to give us a basis for suggestions in relation to the selection of fertilizers. Samples of soil, if sent, will not usually be analyzed, unless the type of soil or the conditions which have affected it appear to be of unusual character.

Control Work.

The amount of work connected with the execution of the fertilizer and feed laws increases from year to year. During the past year 1,042 samples of fertilizers have been examined in accordance with the requirements of the fertilizer law, and 946 samples of cattle feeds have been analyzed. Conditions as affecting the trade in feed stuffs have been on the whole satisfactory. The fertilizer inspection has, however, resulted in the discovery of a larger number of fertilizers not equal to guarantee than has been found in any previous year. It has not been thought best to make any prosecutions during the past year; but the particular attention of dealers is called to the fact that such conditions as existed this year must not continue, and that prosecutions will undoubtedly be necessary should serious shortages again occur. Details of the inspection work will be found in the report of the chemist.

Testing Pure-bred Cows.

Attention was called in the last report to the fact that a small increase in the scale of charges for testing pure-bred cows had been found necessary. There was at first some criticism of the station for making such an increase, but it is believed that the necessity for it was made clear to parties interested in the work. The new scale of charges now excites no opposition, while the amount of such work steadily increases. The fact that its results are profitable to the parties concerned is made sufficiently apparent by the fact that the number of cows offered for test continues to increase. The present scale of charges is believed to be sufficient to fairly cover the cost, and it must, therefore, be regarded as satisfactory both to the interested public and to the station.

Mailing Lists.

During the past year we have undertaken, by correspondence with postmasters throughout the State, to revise our general mailing list. The last revision was made two years ago; but as the result of the revision now in progress we have cancelled 1,441 addresses because of death or removal as reported by the postmasters. Postmasters have also reported over 2,000 changes in address. Before these changes are made, we shall address the individuals concerned, and shall re-enter them under new addresses only in those cases in which they reply to the postal card inquiry. It seems probable that the total number of addresses dropped from our list as the result of the revision will be at least 2,500. The facts stated make it apparent that postmasters do not as a rule comply with the postal regulations affecting station publications, and return them in the event of non-delivery. These facts make it very apparent also that frequent revision of mailing lists is a necessity if wasteful distribution of reports and bulletins is to be avoided. There is little doubt that our lists for other States and for foreign countries also need revision, and this work will be undertaken as soon as conditions make it possible.

The extent to which our general publications circulate is made apparent by the following statement of the numbers in our lists: —

Residents of Massachusetts,	13,098
Residents of other States,	2,102
Residents of foreign countries,	196
Newspapers,	512
Libraries,	288
Exchanges,	112

The number of additions to our general mailing lists on direct application of the parties concerned during the past year has been 1,500.

In addition to the above lists, our publications are sent to those on the general Washington list, which includes members of the faculties and station staffs in agricultural colleges and experiment stations. The total number of addresses on this list is 2,350.

We use also the following special mailing lists: —

Cranberry growers,	1,424
Beekeepers,	2,475
Meteorological,	373

Asparagus Substation, Concord.

The work at this substation has made very satisfactory progress. All details connected with the local execution of plans for planting, fertilization and culture have been, as heretofore, faithfully and skillfully looked after by Mr. Charles W. Prescott, from whom the land in use has been leased, and to whom the work has from the first been indebted for many valuable suggestions and services characterized by most unusual enthusiasm and devotion.

No new lines of work have been undertaken. Our principal investigations, it will be remembered, are of two general classes, — breeding experiments and fertilizer experiments.

Breeding Experiments. — During the past year good progress has been made in these experiments, which have for their object the production of more rust-resistant types of asparagus, which shall at the same time possess desirable market characteristics. The number of varieties in the experimental plots at the present time is 65. Mr. J. B. Norton, who began observations in Concord last year, has devoted practically all of his time during the past season to the asparagus breeding experiments. It will be remembered that in this work we enjoy the cooperation of the United States Department of Agriculture, and Dr. B. T. Galloway, Chief of the Bureau of Plant Industry, under whose direct charge work of this description comes, has definitely assigned Mr. Norton to take local charge of the work in Concord. Mr. Norton succeeded during the past season in making numerous promising selections and a large number of artificial fertilizations. Some of the seed resulting from this work will be planted in Washington, and a close preliminary study of the plants produced will be made there during the coming winter. It is hoped to shorten the time needed for testing the value of different types by following this course. Those which seem promising will be taken to Concord for further testing and observation. It is a pleasure to testify to the enthusiasm and faithful industry of Mr. Norton, who, besides devoting himself to the breeding experiments, has proved very helpful in taking observations and making records on the fertilizer experiments as well. An exhaustive chemical study of the roots as affected by the varying fertilizer treatment is now in progress and appears to promise results of importance and great value.

Fertilizer Experiments. — The conditions in the fertilizer plots continue to be highly satisfactory. There was, it is true, considerable rust, as was the case almost everywhere in Concord last fall; but it did not begin as early in the fertilizer plots as in many beds in the district, and it is believed that the injury was not serious. No differences in the extent of rust injury which could be attributed to variations in fertilizer treatment could be detected. Cutting continued longer this year than last. The first cutting was on May 7, and the last on June 6. The quality of the product was especially good, as was perhaps only natural on a vigorous new bed. There were considerable differences in yield on the different plots; but the product will not be reported at this time, as it is not clear that the differences recorded were connected with varying fertilizer treatment. The preparation of the entire area, as was pointed out last year, was so thorough that the growth even on the plots receiving least fertilizer is still unusually vigorous.

Tent Experiments. — The fact was reported last year that it is the plan to conduct experiments for the purpose of determining the influence of tent shade as affecting (1) yield; (2) quality of product; (3) extent of injury from rust. It was, however, found that conditions in the different plots of the old asparagus bed, in which this work was begun, were not sufficiently uniform to warrant the continuance of the work on that bed. During the past season, however, a new bed has been set for the purpose of continuing these experiments.

Cranberry Substations.

It will be remembered that our cranberry work follows two principal lines of inquiry relating (1) to the fertilizer requirements of the crop; (2) to the insect enemies of cranberries.

The only work done in connection with insects during the past year has been of a preliminary nature, as during the early part of the season we did not enjoy the services of an entomologist who could be assigned to this work. The station, however, has been fortunate in concluding an engagement with Dr. Franklin, who conducted insect work which gave such valuable results two or three years ago. Dr. Franklin returns to this experiment station as an assistant in entomology; but it is our expectation that he will be put in local charge of all our experimental work with cranberries, although he will, as heretofore when connected with the station, devote his time principally to a study of insects in their relations to the crop. Dr. Franklin was unable to take up this work earlier than October 1, but he spent several weeks in the cranberry sections of the State laying plans and making preparations for the work of another year.

The past year has been characterized by a significant development in the relations of cranberry growers to our work. As a result of extended correspondence and conference, a committee representing the Cape Cod Cranberry Growers' Association came to the decision to solicit contributions towards the financial support of experimental work with cranberries. The committee prepared a circular letter asking for *pro rata* contributions, and this letter, in printed form, was sent to all known cranberry growers in the State. This letter follows: —

To the Cranberry Growers of Massachusetts.

A legislative committee appointed by the Cape Cod Cranberry Growers' Association has conferred with Messrs. Brooks, Preston and Damon of the State Experimental Station, and finds them heartily in sympathy with a plan for a substation to be located in the cranberry-growing district. They are willing to help us in every way if we will help ourselves by bearing a reasonable proportion of the expense. As cranberry growing is limited to certain areas, they do not feel justified in asking the State to bear the whole burden.

Such a station would investigate cranberry insects and their parasites, giving particular attention to the ravages of the fruit worm. It would also consider the various diseases of the cranberry, and would determine the best methods of spraying and flooding. Systematic experiments with fertilizers would be carried on with relation to their effect on the color, quantity, size and keeping qualities of the fruit, and to determine their retentive values in the soil. The propagation of new varieties, the destruction of weeds and mosses and the study of climatic conditions, with the probable assistance of the United States Weather Bureau, would all be included in this work. The station would, in short, be here to serve us.

We have every reason to believe that, by acting *promptly,* we can secure the services of Mr. Henry J. Franklin for this undertaking. Most of the growers are familiar with the earnest, conscientious investigations which he made during his connection with the Amherst station. His bulletin, "How to fight cranberry insects," and the mounted specimens which he prepared for us, prove his ability.

If every grower will contribute one cent for each barrel of berries that he shipped last year, we believe that, with the co-operation of the station, the necessary funds can be raised. If you are willing to contribute that amount, will you please fill in the enclosed postal card. We do not want the money now, and shall not ask for it unless a sufficient amount is pledged to insure the success of the plan. A prompt answer will be greatly appreciated.

A large number of growers responded favorably, and the total amount of money pledged toward the support of experimental work as a result of this movement was about $1,000.

It is with especial satisfaction that this action on the part of cranberry growers and its results are reported, for it is believed that this policy of self-help on the part of special interests has much to commend it. These interests may fairly be asked to contribute to the support of work especially designed to benefit them; but this is by no means the only reason for the approval of this policy. It means a greater interest on the part of the growers in the work which is going on, for human nature is so constituted that what costs something is valued more highly than that which is a free gift. This policy means, moreover, closer co-operation, wholesome supervision and helpful criticism. It is to be hoped that the results of this initial movement in the direction of private support of experimental work on the part of special interests will so commend themselves to cranberry growers that not alone will they be inclined to continue a measure of support, but that other special interests, recognizing the advantages of the system, may be led to adopt a similar plan of co-operation.

It must be at once recognized that, in order that the experiments contemplated in the interests of cranberry producers may be carried on under satisfactory conditions, it will be necessary to control a moderate area of cranberry land and the buildings necessary for handling the crop, and to provide moderate laboratory accommodations. Unless the work can be located in permanent quarters, fully under the control of the experiment station, it cannot possibly be prosecuted in a satisfactory manner. Two methods of acquiring control of such property as is needed are to be considered: (1) the needed land and buildings might be leased for a number of years; (2) the needed property might be acquired by purchase. The second of the two plans would seem to possess considerable advantages as compared with the first. Cranberry land ordinarily returns so large an income that the rental which would undoubtedly be expected by an owner would be large. Moreover, questions of possible damage to the property as a result of experimental work might arise, which would be difficult to settle in a satisfactory manner. Should the second plan be adopted there is little doubt that the net income derived from the crops produced would be sufficient to constitute a material contribution to the funds available to pay the costs of experimental work. If, therefore, the needed property can be purchased at a satisfactory price, the methods of support of experimental work would be largely settled. It would seem, therefore, to be extremely desirable either that growers unite in the purchase of the property to be placed at the disposal of the station, or that the State be asked to appropriate money for the purpose. It is quite impossible that the cost either of leasing the needed property or of purchasing it should be met by the use of ordinary station funds. Such funds are quite inadequate in amount to meet so large an added expenditure.

The co-operation of the United States government in certain lines of investigation has been asked for, and we are already assured of material assistance in the study of plant diseases and the climatic conditions which affect the crop.

Fertilizer Experiments. — The fertilizer experiments at Red Brook Bog, lying at Waquoit, have been continued. This includes 33 plots of one-twentieth of an acre which are subjected to varying fertilizer treatment. The use of fertilizers has been so planned that the results must ultimately afford a valuable basis for determining what should be the composition of cranberry fertilizers. It is recognized, of course, that conditions vary in different bogs, and that no one formula can possibly be the best under all conditions. Our object is to learn if possible the specific effects of different fertilizer elements. When these are understood, it will be possible to adapt the fertilizer to meet varying conditions in different bogs.

Most of the plots in our experiment gave a fairly good crop in 1909, but, owing to a misunderstanding on the part of men employed in harvesting the fruit upon portions of the bog outside the fertilizer plots, the product from a few of the plots was mixed, and a complete record of results would be impossible. There were, moreover, a few plots in which considerable damage was done by insects. The results, therefore, are not to be reported in detail at this time, but the following conclusions seem to be fully warranted as the result of observations and records so far made.

1. The use of some fertilizer will clearly prove profitable on many bogs. The average product on the no-fertilizer plots (7 in number) in our experiments this year was 7.5 bushels per plot, or at the rate of 150 bushels per acre. The average product on the fertilizer plots (19 in number) was 13.4 bushels per plot, or at the rate of 268 bushels per acre. The average product on the 10 plots to which a complete fertilizer was applied was at the rate of 306.5 bushels per acre. A complete fertilizer was made up by the mixture of nitrate of soda, acid phosphate and a potash salt.

2. The use of nitrate of soda greatly promotes the growth of vines, and seems also to be favorable to fruitfulness. Even with the smallest quantity of nitrate used in our experiments (at the rate of 200 pounds per acre) the growth of the vines has been very luxuriant, — so luxuriant that the fruit, although abundant, was poorly colored and probably inferior in keeping qualities. The vine growth was so rank that another year the rate at which nitrate is used will be greatly reduced. *It is believed that nitrate in excess of 100 pounds per acre will seldom be necessary.*

3. The influence of high-grade sulfate of potash appears to be decidedly favorable. It promotes fruitfulness, good color and high quality. The highest yield obtained on any of the plots (22½ bushels, which is at the rate of 450 bushels per acre) was produced where the maximum quantity of sulfate of potash was used in connection with a moderate amount of nitrate of soda and acid phosphate. The total fertilizer application to this plot was at the rates per acre: —

	Pounds.
Nitrate of soda,	200
Acid phosphate,	400
High-grade sulfate of potash,	400

4. Phosphoric acid appears in these experiments to have less effect than either of the other fertilizers employed, though it appears probable that when applied in soluble form, such as acid phosphate, it will be likely to promote early ripening, and will be favorable to fruit of relatively high color.

WM. P. BROOKS,
Director.

REPORT OF THE TREASURER.

ANNUAL REPORT

Of Fred C. Kenney, Treasurer of the Massachusetts Agricultural Experiment Station of the Massachusetts Agricultural College,

For the Year ending June 30, 1909.

The United States Appropriations, 1908–09.

	Hatch Fund.	Adams Fund.
Dr.		
To receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1909, under acts of Congress approved March 2, 1887 (Hatch Fund), and March 16, 1906 (Adams fund),	$15,000 00	$11,000 00
Cr.		
By salaries,	$12,734 18	$8,163 08
labor,	479 84	1,004 41
publications,	6 50	–
postage and stationery,	103 23	46 75
freight and express,	21 48	32 20
heat, light, water and power,	103 88	230 76
chemical supplies,	91 64	338 80
seeds, plants and sundry supplies,	362 92	302 75
fertilizers,	254 53	260 48
feeding stuffs,	241 28	–
library,	143 04	24 85
tools, implements and machinery,	–	–
furniture and fixtures,	244 00	50 00
scientific apparatus,	113 03	513 04
live stock,	10 25	–
traveling expenses,	20	31 26
contingent expenses,	15 00	–
buildings and land,	75 00	1 62
	$15,000 00	$11,000 00

State Appropriation, 1908–09.

To balance on hand,	$7,529 52	
Cash received from State Treasurer,	13,500 00	
from fertilizer fees,	5,210 00	
from farm products,	2,387 57	
from miscellaneous sources,	4,825 17	
		$33,452 26
Cash paid for salaries,	$8,616 19	
for labor,	8,155 03	
for publications,	1,837 45	
for postage and stationery,	992 11	
for freight and express,	853 48	
for heat, light, water and power,	423 66	
for chemical supplies,	336 41	
for seeds, plants and sundry supplies,	1,670 95	
for fertilizers,	586 10	
for feeding stuffs,	1,115 02	
for library,	318 71	
for tools, implements and machinery,	10 07	
for furniture and fixtures,	337 47	
for scientific apparatus,	566 61	
for live stock,	12 00	
for traveling expenses,	1,882 73	
for contingent expenses,	95 00	
for buildings and land,	604 77	
Balance,	5,538 50	
		$33,452 26

REPORT OF THE AGRICULTURIST.

DEPARTMENT OF AGRICULTURE.

WM. P. BROOKS, AGRICULTURIST; E. S. FULTON, E. F. GASKILL, ASSISTANTS.

The work in the department of agriculture in the experiment station has followed the usual lines during the past year. The most important investigations in progress have reference to what in general may be denominated fertility problems. They are designed to throw light upon various questions connected with the selection, use and methods of application of manures and commercial fertilizers. A considerable number of the experiments in progress has already continued for a number of years, and the results are becoming increasingly valuable, as they afford, with the passage of the years, surer indications as to the ultimate effects to be expected. The number of field plots on the station grounds used in the experiments the past year was 351.

Pot experiments have been continued and have been designed chiefly to throw light upon the relative values of different materials which may be used, respectively, as sources of nitrogen, phosphoric acid and potash. Tests of this character afford the surest indications as to the relative availability of different materials. The principal crops used in this work are Japanese barnyard millet, soy beans and dwarf Essex rape. We have used 346 pots during the past year. In some phases of our work, mainly as a check upon field results, we use closed plots, and the number of these in use the past season was 167.

The experiments in progress will not be taken up in detail in this report; but attention is called to some of the more striking results.

I. The experiments on Field A, which have for their object the determination of the relative value, as sources of nitrogen, of some of the leading materials which may be used to furnish that element, have been continued. These experiments were begun in 1890. The crops grown in order of their succession have been: oats, rye, soy beans, oats, soy beans, oats, soy beans, oats, oats, clover, potatoes, soy beans, potatoes, soy beans, potatoes, oats and peas, corn and clover for the last two years. These two crops have been considerably mixed with grass. The best crop of the year was produced where dried blood was used as a source of nitrogen, but the crop produced upon nitrate of soda was practically the same. On the basis of 100 for nitrate of soda, the relative standing of the different nitrogen fertilizers and the no-nitrogen plots (total yield) was as follows: —

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	100.50
Sulfate of ammonia,	87.14
Barnyard manure,	83.00
No nitrogen,	72.34

The relative standing of the different materials for the twenty years during which the experiments have continued is as follows: —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	94.05
Dried blood,	92.34
Sulfate of ammonia,	86.47
No nitrogen,	70.99

On the basis of increase in crop as compared with the no-nitrogen plots the average of the twenty years shows the following relative standing: —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	79.51
Dried blood,	73.62
Sulfate of ammonia,	53.36

It will be seen that the nitrate of soda has given a much larger average increase in crop than any of the other materials.

There would seem to be little doubt, therefore, that this material must be regarded as one of the most satisfactory of the nitrogen fertilizers, and since it can usually be purchased at a lower average cost per unit of nitrogen than other fertilizers containing that element, it would seem to be the part of wisdom to use it as largely as soil and crop conditions will permit.

II. The experiments on Field B, for determining the relative value for different crops of the muriate and high-grade sulfate of potash when used in equal amounts, have been continued. These experiments began in 1892. Five pairs of plots are under comparison. Up to 1899 the potash salts were used in quantities (varying in different years, but always in equal amounts on the two members of pairs of plots) ranging from 350 to 400 pounds per acre. Since 1900 the quantity used has been uniform on all the plots, and at the rate of 250 pounds per acre annually. In connection with the potash we have used the same amount of fine ground bone annually for each plot throughout the entire period of the experiment. The rate of application of the bone is 600 pounds per acre. The season of 1909 is the eighteenth year of these experiments. The crops during that year were corn on two pairs of plots, asparagus and rhubarb occupying each a portion of one pair of plots, raspberries and blackberries each occupying a portion of one pair, carrots on one pair of plots and cabbages on the other. The yield of berries was very small, on account of serious winterkilling. This was less on the sulfate of potash than on the muriate. On both pairs of plots occupied by corn the sulfate gave a heavier yield of grain, while the muriate gave a larger yield of stover. The difference in favor of the grain amounted to about 5 bushels. The difference in stover in favor of the muriate was at the rate of about 600 pounds per acre. The asparagus gave much the heavier crop on the muriate, at the rate of 6,002 pounds per acre on that salt against 3,257 pounds on the sulfate. The rhubarb gave a crop at the rate of 22,786 pounds per acre of stalks on the muriate and 28,349 pounds on the sulfate. The carrots gave a better yield on the sulfate, at the rate of 822.4 bushels per acre against 799.1 bushels on the muriate. The cabbages gave much the larger yield of hard heads on the sulfate, the figures being at the following rates per acre: —

	Pounds.
Muriate of potash: —	
Hard heads,	17,466
Soft heads,	6,878
High-grade sulfate of potash: —	
Hard heads,	21,966
Soft heads,	2,434

III. In Field C we have under comparison for use in connection with manure three different materials used as a source of nitrogen, — sulfate of ammonia, nitrate of soda and dried blood, — and the two potash salts, muriate and high-grade sulfate, each salt being used with each of the three nitrogen fertilizers and in connection with a liberal application of dissolved bone black, the same on all plots. The comparison of these different fertilizers in this field was begun in 1891, but up to the year 1898 they were used without manure. Since that time all plots receive annually a dressing of stable manure, at the rate of 30 tons per acre. A large variety of crops has been grown in this field. The crops the past year were asparagus, rhubarb, cauliflower and onions. Rhubarb and cauliflowers have given the heavier yields on sulfate of ammonia as a source of nitrogen; but both asparagus and onions have given smaller yields on this material than on either of the other nitrogen fertilizers. Nitrate of soda gave a yield of asparagus about 25 per cent. greater than sulfate of ammonia, while for onions the difference in favor of the nitrate of soda was in much greater proportion. With muriate as the source of potash, the yield of No. 1 onions on the different nitrogen fertilizers was at the following rates per acre: —

	Bushels.
Sulfate of ammonia,	359.2
Nitrate of soda,	565.1
Dried blood,	515.9

With sulfate of potash as the source of potash the rate of yield of No. 1 onions per acre for the different nitrogen fertilizers was as follows: —

	Bushels.
Sulfate of ammonia,	412.0
Nitrate of soda,	703.6
Dried blood,	557.5

The average yields on the different potash salts were at the following rates per acre: —

	Bushels.
Muriate of potash: —	
No. 1 onions,	480.10
Pickling onions,	77.80
Sulfate of potash: —	
No. 1 onions,	557.70
Pickling onions,	57.97

For rhubarb the muriate of potash gave the larger crop, at the rate per acre of 77,400 pounds, against 64,828.7 pounds on the sulfate.

The cauliflowers gave the better crop on the sulfate, the rates per acre being as follows: —

	Pounds.
Muriate of potash,	24,695
Sulfate of potash,	30,691

The asparagus gave the better yield on the sulfate, but the difference was small. The rates per acre were as follows: —

	Pounds.
Muriate of potash,	4,951.0
Sulfate of potash,	5,176.7

The results with onions and with cauliflowers are the most striking, and are in close agreement with results previously obtained. The cauliflower, like the cabbage, seems to be more certain to give a satisfactory crop on the sulfate than on the muriate on soils fairly retentive of moisture.

The crops on the plot in this field, where manure is used without fertilizers, are in most cases still nearly as good as on the plots where fertilizers are used in addition to the manure; but we would again point out that the history of this plot and its manurial treatment previous to its inclusion in this field were different from those of the other plots. Nevertheless, the fact that the crops on this plot still compare so favorably with those on the plots where fertilizer also is used raises the question whether the latter is a benefit.

IV. In the experiments comparing the different potash salts, which were begun in 1898, and in which these salts are used in quantities to furnish equal actual potash per acre annually, the crop the past year was hay, mixed timothy, red top and clovers. The average yield of the no-potash plots was at the following rates per acre: —

	Pounds.
Hay,	5,744
Rowen,	680

The average yield of all the potash plots, 35 in number, was at the following rates per acre: —

	Pounds.
Hay,	6,412.6
Rowen,	1,555.4

It will be noticed that the increase in the yield of hay was not very large, and that the yield without the potash was for both crops slightly in excess of 3 tons per acre. The rowen crop on the potash plots is much greater than on the no-potash plots because of the larger proportion of clover. The most striking result of the experiments, indeed, is the comparative failure of clover on the plots to which no potash was applied, and its great inferiority on the five plots to which kainit is annually applied. On these plots, and especially on the plots to which the kainit is applied, the yield of timothy was remarkably heavy, the proportion of this grass being much greater than on plots to which the other potash salts are applied.

V. In the field where ten of the leading materials which may be used as sources of phosphoric acid have been under comparison since 1897, the crop during the past year was soy beans. The phosphates used in this experiment are applied in connection with equal and liberal quantities of nitrogen and potash in available forms, at such rates as will furnish equal actual phosphoric acid per acre. The average yield of the three no-phosphate plots was at the rate of 6,668 pounds, or 27.8 bushels per acre. The average yield on the ten phosphatic fertilizers was at the rate of 1,835.2 pounds, or 30.6 bushels. The average increase on the phosphate plots as compared with the no-phosphate was at the rate of 167.2 pounds per acre. The highest increase, at the rate of 296 pounds per acre, was produced on the steamed bone meal. This increase is at the rate of 17.7 per cent. There was not a very wide difference between the crops produced on the different phosphates, and the most striking result of the experiment is the fact that the crop where no phosphate has been applied during the past thirteen years is nearly equal to the crops produced on the best of the phosphate plots. On the same plots last year, cabbage being the crop, the increase on the best phosphatic material of the year, bone meal, was 667 per cent. of the average crop produced on the no-phosphate plots. These facts serve to emphasize the point which I have previously many times referred to, that in considering the plant-food requirements of soils it is of the first importance that the crop be taken into consideration. For the successful cultivation of the cabbage on this soil a rapidly available form of phosphoric acid is essential; but for the soy bean, the application of phosphoric acid seems to have been relatively unimportant.

VI. The crop on the south corn acre, where manure at the rate of 6 cords to the acre annually has been under comparison since 1890 with an application per acre at the rate of 4 cords of manure and 160 pounds of high-grade sulfate of potash, during the past year was hay, mixed timothy, red top and clovers. The plots to which the large applications of manure alone have been made were materially larger than on the combination of a lesser amount of manure and potash. The following are the average rates per acre: —

	Pounds.
Manure alone: —	
Hay,	4,930
Rowen,	530
Manure and potash: —	
Hay,	3,670
Rowen,	490

The rowen crops of the past season were exceptionally small, on account of a very marked deficiency in rainfall. It is apparent, however, that although the combination of the lesser amount of manure and potash substantially equals the larger amount of manure for corn, which is grown in alternate two-year rotations with hay, it is not equal for the production of hay.

VII. On the north corn acre, where the combination of fertilizer materials rich in potash is under comparison with a combination of similar materials in different proportions, and furnishing less potash and much more phosphoric acid, the crop the past year was hay, mixed timothy, red top and clovers. This experiment was begun in 1891, and for the past fourteen years corn and hay, two years each, have regularly alternated. Owing to the very dry summer the field was cut but once. The average yields were at the following rates per acre: —

	Pounds.
On the fertilizer combination rich in phosphoric acid and relatively poor in potash,	5,094
On the fertilizer combination richer in potash and poorer in phosphoric acid,	5,320

The proportion of clover in the plots receiving the combination richer in potash is noticeably greater than on the other plots. The combination richer in potash in these experiments has shown itself substantially equal to the other combination for the production of corn, and superior for the production of hay.

VIII. The experiments for the production of hay, by using in rotation as top-dressing barnyard manure, wood ashes and a mixture of bone meal and potash, have been continued during the past year in the nine-acre field where these experiments have been under progress since 1893. The average yield on the entire area during the past year was at the rate of 5,036 pounds of hay. The yields on the different materials used in top-dressing were at the following rates per acre: —

	Pounds.
Barnyard manure,	5,394
Wood ashes,	4,708
Fine ground bone and potash,	5,160

The average yields to date under the different systems of top-dressing have been at the following rates per acre: —

	Pounds.
Barnyard manure,	6,373
Wood ashes,	5,805
Fine ground bone and potash,	6,164

The average yield of the nine acres, from 1893 to 1909 inclusive, has been at the rate of 6,150 pounds per acre. The average of the past year, it will be seen, is materially below the long-time average, a fact undoubtedly due to the deficiency of summer rainfall, previously referred to.

IX. In the experiments comparing winter application of manure with spring application of an equal quantity, put into large heaps in the field in the winter and spread in the spring, the crop this year has been hay, mixed timothy, red top and clovers. The two systems of applying manure are under comparison on five pairs of plots, and the experiment has been in progress since 1899. The average crops of the past season were at the following rates per acre: —

	Pounds.
Winter application of manure: —	
Hay,	7,045.0
Rowen,	460.6
Spring application of manure: —	
Hay,	6,482.0
Rowen,	659.2

It will be noted that the winter application has given a larger crop of hay, but that the manure applied in the spring has given a heavier yield of rowen. If we combine the hay and rowen crops, the average yields have been at the following rates per acre: —

	Pounds.
Winter application of manure,	7,505.6
Spring application of manure,	7,141.2

The field in which these experiments are located slopes considerably in a direction running lengthwise with the plots. The superiority of the results obtained where the manure is applied in winter becomes more strikingly evident when it is remembered that by following this system the labor cost is materially less than under the other, since when the manure is applied in the spring it must be handled twice.

X. The leading feature of the poultry experiments during the past year has been the continuation of the experiments comparing the dry with the moist-mash system of feeding. We have carried through six experiments, three during the winter and three during the summer, using in these experiments six different flocks of fowls. The results have been similar to those obtained last year. In the majority of the experiments the fowls receiving the moist mash have produced a greater number of eggs. The moist-mash feed has seemed to be superior to the dry feed in four out of the six experiments, and the number of eggs in most of these experiments has been materially greater than the number produced under the dry system of feeding. In the two experiments in which the dry system gave the greater number of eggs, the differences were relatively small. Averaging the six experiments, the results are as follows: —

Number of Eggs daily per 100 Hens.

Moist mash,	36.3
Dry feeds,	34.5

REPORT OF THE CHEMIST.

JOSEPH B. LINDSEY.

DEPARTMENT OF PLANT AND ANIMAL CHEMISTRY.

Research section: EDWARD B. HOLLAND, ROBERT D. MACLAURIN.[1]
Fertilizer section: HENRI D. HASKINS in charge.
Feed and dairy section: PHILIP H. SMITH in charge.
Assistant chemists: LEWELL S. WALKER, JAMES C. REED, PHILIP V. GOLDSMITH,[2] C. D. KENNEDY.[3]
Assistant in animal nutrition: ROY F. GASKILL.
Inspector: JAMES T. HOWARD.[4]
Clerks and stenographers: HARRIET M. COBB, ALICE M. HOWARD.

In the following pages is given a brief outline of the work carried on by the department for the year ending Dec. 1, 1909.

1. CORRESPONDENCE.

The number of letters sent out during the year ending December 1, on the basis of stamps used, has been 5,641, some 841 more than in the preceding year. Comparatively few stamps are used for packages. The correspondence divides itself principally into (*a*) answering letters of inquiry, (*b*) the execution of the fertilizer and feed laws, (*c*) testing of cows, and (*d*) in the ordering of supplies.

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[1] Resigned Sept. 1, 1909.
[2] Resigned Dec. 1, 1909.
[3] From October, 1909.
[4] From April 1, 1909.

2. Numerical Summary of Work in the Chemical Laboratory.

From Dec. 1, 1908, to Dec. 1, 1909, there have been received and examined 99 samples of water, 389 of milk, 2,933 of cream, 98 of feed stuffs, 234 of fertilizers and fertilizer materials, 42 of soils and 45 miscellaneous. In connection with experiments made by this and other departments of the station, there have been examined 191 samples of milk, 157 of cattle feeds, 58 of fertilizers, 26 of soils and 534 of agricultural plants. There have also been collected and examined 1,042 samples of fertilizer in accordance with the requirements of the fertilizer law, and 946 samples of cattle feeds in accordance with the requirements of the feed law. The total for the year has been 6,794. This summary does not include work done by the research division.

In addition to the above, 25 candidates have been examined and given certificates to operate Babcock machines, and 4,071 pieces of Babcock glassware have been tested for accuracy of graduation, of which 43, or 1.06 per cent., were inaccurate.

3. Résumé of Work of the Research Section.

The research work was carried on jointly by Mr. E. B. Holland and Dr. R. D. MacLaurin. Mr. Holland has given attention particularly to a study of methods for the determination of insoluble acids in butter fats, and has co-operated with the entomological department relative to the burning of foliage by insecticides. Quite satisfactory progress has been made in both of these lines of work, but they are not sufficiently advanced to warrant any detailed publication. A paper on the stability of butter fat, prepared by Mr. Holland, appears elsewhere in this report.

Work on the constitution of fats and the chemistry of fat formation has been suspended by the resignation of Dr. MacLaurin. Dr. MacLaurin devoted substantially a year to the study of this subject, and has signified to the writer his intention of preparing his work for publication.

4. Work in Animal Nutrition.

Work to note the effect of molasses on the digestibility of the ration with which it is fed has been sufficiently advanced to warrant a paper on the subject, which appears elsewhere in this report.

Experiments on the most suitable varieties of corn for the silo have been in progress for a number of years. The results show that such varieties as the Leaming, Pride of the North, Rustler White Dent, Longfellow and Sanford White are more suitable for this latitude than Early Mastodon, Improved White Cap, Brewer's Dent, Wing's White Cap and Eureka. We have noted the degree of maturity by September 15, the yield of dry matter, the proportion of dry matter in stocks, ears, husks and leaves, as well as the degree of digestibility of most of the several varieties. The excess in yield of green material from the latter varieties consists largely of water. In case the coarse dents are field cured, the stalks will not cure out well, and as late as the middle of November contain a much larger amount of water than the smaller varieties. The detailed report of this experiment will probably be ready for publication in another year.

Digestion tests with alfalfa and red clover at the same stages of growth have been completed, but a large amount of laboratory work in connection with the samples still remains to be done before the final results can be obtained.

5. Résumé of Work of the Fertilizer Section.

Mr. H. D. Haskins, in charge, presents the following report: —

The activities of the fertilizer division have been confined chiefly to the fertilizer control work and the examination of fertilizers, soils, refuse by-products, etc., forwarded by farmers and others interested in agriculture. The results of the year's work would indicate that a larger number of private formulas and home-mixed fertilizers had been used by the Massachusetts farmers than ever before. The work of the collection and inspection of licensed fertilizers has also increased during the year. A larger number of fertilizers was licensed this year than during the past season, and the collection and analysis of samples reach the highest number ever attained during the history of fertilizer inspection work in Massachusetts.

(*a*) *Fertilizers licensed.*

During the year 431 distinct brands of fertilizers and agricultural chemicals have been licensed in Massachusetts. Licenses have been secured during the year by 78 manufacturers, importers and dealers, counting each branch of the American Agricultural Chemical Company as a separate company. Two more licenses were issued and 22 more brands were licensed than for 1908. The brands licensed this year may be classed as follows: —

Complete fertilizers,	306
Fertilizers furnishing potash and phosphoric acid,	9
Ground bone, tankage and dry ground fish,	51
Agricultural chemicals and organic compounds furnishing nitrogen,	65
Total,	431

(*b*) *Fertilizers collected.*

An effort was made during the season to cover a larger territory than heretofore, and to procure, so far as possible, representatives of every brand of goods sold in the State. As a general rule, fertilizers cannot be found plentifully in the open markets in Massachusetts until after April 1. Some of the fertilizer is used on early crops by the 15th or 20th of April, and by May 1 considerable of the fertilizer is in the ground. Our collecting season being relatively short, an extra man was delegated to gather samples during that portion of the season when the fertilizer was found most plentiful. The samples were in all cases taken by an authorized agent from the experiment station. Mr. James T. Howard, the assistant usually delegated to this work, assisted by Mr. C. W. Gaskill, covered the eastern portion of the State, while Mr. E. C. Hall looked after the collection in the Connecticut Valley and the central portion of the State. Samples were taken from over 280 different agents, and over 110 different towns were visited.

The total number of samples collected was 1,042, representing 458 distinct brands, — being 418 more samples than during the preceding year. Wherever possible an analysis has been made of a composite made up of equal weights of the same brand collected in various parts of the State. Samples have been taken with the usual care and discrimination, the collecting agents being instructed to sample at least 10 per cent. of the number of packages of each brand, and never less than five bags, without making a special note of the fact on the guarantee slip which is sent to the laboratory with each sample taken.

(c) *Fertilizers analyzed.*

The following analyses have been made in connection with the inspection of licensed fertilizers: —

Complete fertilizers,	384
Ground bone, tankage and fish,	61
Materials furnishing phosphoric acid, potash and lime, such as ashes,	16
Nitrogen compounds, such as nitrate of soda, sulfate of ammonia, blood, castor pomace, cottonseed meal and linseed meal,	68
Potash compounds,	34
Phosphoric acid compounds,	17

In addition to the above, 33 samples of fertilizer have been analyzed that were not licensed but which were goods manufactured for private use. These goods were sampled officially by our collecting agents from stock in the possession of the consumer. This makes a total of 613 analyses which have been made during the season of 1909.

In some instances, where the results of analysis of a composite sample showed a brand to be seriously deficient in plant food, a new sample has been prepared for analysis from each original sample taken, and separate analyses have been made. This was done to ascertain if the shortage was general, or confined to one or more lots of the same brand. Thirty-five such complete analyses were made during the season from 13 composite samples; 172 more analyses have been made than during the previous year.

(*d*) *Trade Values of Fertilizing Ingredients.*

	Cents per Pound.	
	1909.	1908.
Nitrogen: —		
In ammonia salts,	17	17½
In nitrates,	16½	18½
Organic nitrogen in dry and fine ground fish, meat, blood and in high-grade mixed fertilizers,	19	20½
Organic nitrogen in fine bone and tankage,[1]	19	20½
Organic nitrogen in coarse bone and tankage,[1]	14	15
Phosphoric acid: —		
Soluble in water,	4	5
Soluble in ammonium citrate (reverted phosphoric acid),	3½	4½
In fine ground bone and tankage,[1]	3½	4
In coarse bone and tankage,[1]	3	3
In cottonseed meal, linseed meal, castor pomace and ashes,	3	4
Insoluble (in neutral citrate of ammonia solution) in mixed fertilizers,	2	2
Potash: —		
As sulphate free from chlorides,	5	5
As carbonate,	8	8
As muriate (chloride),	4¼	4¼

The above schedule of trade values was adopted at a meeting of the station directors and chemists from the New England and New Jersey experiment stations, which was held in March, 1909. They represent the average cash pound cost, at retail, of the three essential elements of plant food in their various forms, as furnished by chemicals and unmixed raw materials, in the large markets during the six months preceding March 1, 1909. The trade values for nitrogen and phosphoric acid are somewhat lower than for the previous year.

The following table shows the average comparative commercial values, the retail cash prices and the percentages of difference of the licensed complete fertilizers analyzed in Massachusetts during the season of 1908 and 1909: —

Year.	Commercial Values.	Retail Cash Prices.	Difference.	Percentages of Difference.
1908,	$25 81	$36 20	$10 39	40.25
1909,	22 19	34 62	12 43	56.01

It must be remembered that the "commercial values" represent the retail price of the raw or unmixed materials, and that

[1] Fine and medium bone are separated by a sieve having circular openings one-fiftieth of an inch in diameter, the valuation of the bone being based upon the degree of fineness.

the manufacturer cannot sell mixed fertilizers at these figures. He must obtain an advance sufficient to cover costs of manufacture, bagging, agencies, credits, etc. The above differences do not represent his profits. These are much smaller, and are probably not excessive in the case of reliable firms. It is probable, however, that the cash buyer of high-grade unmixed goods can secure needed plant food in that form at a cost considerably lower than in licensed complete fertilizers, and that by intelligent selection he can procure materials from which can be made home mixtures at least equally effective with such fertilizers.

(*e*) *Summary of Analyses and Guarantees.*

Manufacturer.	Number of Brands Analyzed.	Number with All Three Elements equal to Guarantee.	Number equal to Guarantee in Commercial Value.	Number with One Element below Guarantee.	Number with Two Elements below Guarantee.	Number with Three Elements below Guarantee.
W. H. Abbott,	3	1	2	1	2	–
American Agricultural Chemical Company,	69	37	65	23	9	–
Armour Fertilizer Works,	10	4	6	4	2	–
Baltimore Pulverizing Company,	2	–	2	2	–	–
Beach Soap Company,	4	3	4	1	–	–
Berkshire Fertilizer Company,	6	4	6	2	–	–
Bowker Fertilizer Company,	34	19	32	15	–	–
Joseph Breck & Son,	3	1	3	2	–	–
Buffalo Fertilizer Company,	9	4	7	4	1	–
Coe-Mortimer Company,	9	3	6	4	2	–
Eastern Chemical Company,	1	–	1	1	–	–
Essex Fertilizer Company,	11	8	10	3	–	–
R. & J. Farquhar & Co.,	5	2	5	3	–	–
Hubbard Fertilizer Company,	3	2	3	1	–	–
Jordan Marsh Company,	1	–	–	–	1	–
Listers Agricultural Chemical Works,	7	7	7	–	–	–
James E. McGovern,	1	–	–	–	1	–
Mapes Formula and Peruvian Guano Company,	17	11	17	5	1	–
National Fertilizer Company,	12	6	12	6	–	–
Natural Guano Company,	1	–	1	–	1	–
New England Fertilizer Company,	6	3	5	2	1	–
Olds & Whipple,	6	5	6	1	–	–
Parmenter & Polsey,	6	3	6	3	–	–
R. T. Prentiss,	3	–	–	1	1	1
Pulverized Manure Company,	3	–	–	–	2	1
W. W. Rawson & Co.,	2	1	1	–	1	–
Rogers Manufacturing Company,	9	8	9	1	–	–
Rogers & Hubbard Company,	8	5	8	3	–	–
Ross Brothers Company,	3	1	2	1	1	–
N. Roy & Son,	1	–	1	1	–	–
Sanderson Fertilizer and Chemical Company,	7	1	5	6	–	–
M. L. Shoemaker & Co., Ltd.,	2	1	2	1	–	–
Swift's Lowell Fertilizer Company,	18	10	15	5	3	–
Whitman & Pratt Rendering Company,	5	3	5	2	–	–
Wilcox Fertilizer Works,	6	6	6	–	–	–
A. H. Wood & Co.,	3	–	–	2	1	–

The above table shows: —

1. That 296 distinct brands of complete licensed fertilizers were collected and analyzed.

2. That 138 brands (46.6 per cent. of the whole number analyzed) fell below the manufacturer's guarantee in one or more elements.

3. That 106 brands were deficient in one element.

4. That 30 brands were deficient in two elements.

5. That 2 brands were deficient in all three elements. In this connection it might be added that 80 brands were found deficient in nitrogen, 63 in potash and 28 in phosphoric acid.

6. That 45 out of the 296 brands analyzed (over 15 per cent. of the total number) showed a commercial shortage. The term "commercial shortage" means that the brands in question did not show the quantity and value of plant food guaranteed, although the excess of any element of plant food was figured in full value to offset the deficiencies.

7. That certain manufacturers are either extremely careless in mixing or else they do not allow a sufficient margin for variation in the composition of crude stock. In other words, they try to have their goods run too close to the minimum guarantee.

(*f*) *Commercial Shortages.*

The following table has been prepared to show the commercial shortages in the mixed fertilizers for the season of 1909, also to furnish a comparison with the previous year: —

Commercial Shortages.

COST.	NUMBER OF BRANDS.	
	1909.	1908.
Over $4 per ton,	4	–
Between $3 and $4 per ton,	2	3
Between $2 and $3 per ton,	5	1
Between $1 and $2 per ton,	14	7
Under $1, not less than 25 cents,	35	Not given.

The season of 1909 shows the largest number of deficiencies and commercial shortages which has probably ever occurred in this State. The largest number occurring are below $1 per ton, and yet many of the deficiencies are very serious, running 1 per cent. or over below the minimum guarantee. In the table of shortages, in all cases where an excess of plant food has occurred the commercial value of the excess has been used to offset the commercial shortage resulting from a deficiency in some of the other elements. This practice is certainly extremely fair to the manufacturer. We should not lose sight of the fact, however, that serious deficiencies or excesses change the essential character of a fertilizer. A prosecution in every case this year must, from necessity, have contained a certain element of unfairness, as some of the cases of the most serious deficiencies occurred where the licensee was not the manufacturer, and was, therefore, not directly responsible for the composition of the goods, which were manufactured by parties outside of the State. Therefore no prosecutions have been made for shortages. It seemed wise, after a careful review of the situation, to take up the matter with each manufacturer separately, and endeavor to secure an adjustment that would be as favorable as possible to the consumer. It is obviously not possible, however, to follow such a method year after year. *All manufacturers whose goods have fallen seriously below their guarantees have been advised, and all others are hereby informed, that such conditions cannot continue to exist, and that another season it will be necessary to prosecute violators of the statute.*

(*g*) *Grades of Fertilizer.*

The 323 brands of complete fertilizers may be divided into three groups: —

Low-grade fertilizers, having a commercial value of $18 or less per ton,	83
Medium-grade fertilizers, having a commercial value of between $18 and $24 per ton,	122
High-grade fertilizers, having a commercial value of over $24 per ton,	118

The following table has been compiled for the purpose of making a study of the three grades of goods: —

Grade of Fertilizer.	Number of Brands.	Per Cent. of Whole.	Average Composition.				Average Valuation.	Average Cost.	Excess of Selling Price over Valuation.	Percentage Difference.
			Per Cent. Nitrogen.	Per Cent. Available Phosphoric Acid.	Per Cent. Potash.	Pounds Available Plant Food in 100 pounds of Fertilizer.				
High,	118	36.53	3.94	7.62	8.00	19.56	$27 63	$39 05	$11 42	41.33
Medium,	122	37.77	2.61	8.10	5.34	16.05	20 69	33 85	13 16	63.61
Low,	83	25.70	1.80	7.35	3.06	12.21	15 32	29 51	14 19	92.62

The above table shows: —

1. That the per cent. of nitrogen and potash is much higher in the high-grade goods than in the medium or low grade.

2. That with about a 32 per cent. advance in price over the low-grade fertilizers, the high-grade furnished more than 60 per cent. increase in available plant food.

3. With about 32 per cent. advance in price over the low-grade goods, the high-grade furnished over 80 per cent. increase in commercial value.

4. A ton of the average high-grade fertilizer furnishes about 43 pounds more of nitrogen, 5½ pounds more of available phosphoric acid and 99 pounds more of actual potash than does a ton of the low-grade goods.

5. The average high-grade fertilizer costs 15½ per cent. more than the medium-grade article; it furnishes about 22 per cent. more plant food and has about 35.5 per cent. greater commercial value.

6. The medium-grade fertilizers cost about 15 per cent. more than the low-grade and furnish over 35 per cent. greater commercial value.

7. The percentage of difference between cost and valuation in low-grade goods is more than double that for high-grade fertilizers.

Table showing the Pound Cost of Nitrogen, Potash and the Various Forms of Phosphoric Acid in the Three Grades of Fertilizer.

	Low-grade Fertilizer (Cents).	Medium-grade Fertilizer (Cents).	High-grade Fertilizer (Cents).
Nitrogen,	36.60	31.08	26.85
Potash (as muriate),	9.63	8.18	7.07
Soluble phosphoric acid,	7.71	6.54	5.65
Reverted phosphoric acid,	6.74	5.73	4.95
Insoluble phosphoric acid,	3.85	3.27	2.83

The above table shows: —

1. That nitrogen has cost 9.75 cents more per pound, available phosphoric acid about 2 cents more per pound and potash 2.56 cents more per pound in the average low-grade fertilizer than in the average high-grade goods.

2. That nitrogen has cost 4.23 cents, the available phosphoric acid over ¾ of a cent and the potash 1.11 cents more per pound in the average medium-grade fertilizer than in the average high-grade goods.

3. That every conclusion which can be drawn from the above table emphasizes the fact that the farmer cannot afford to purchase low-grade fertilizers.

(*h*) *Unmixed Fertilizers.*

Ground Bones. — Twenty-nine samples of ground bone have been analyzed during the inspection of 1909. Eleven of the brands have been found deficient in phosphoric acid and 8 in nitrogen; 8 brands had a commercial shortage ranging from a few cents to $2.95 per ton. The average retail cash price for bone has been $30.39 per ton, the average valuation $26.09 and the percentage difference 16.57.

Tankage. — Nine samples of tankage have been analyzed and show the usual variations in composition; only 1, however, has shown a serious shortage in nitrogen, and 4 tested low in phosphoric acid. There were no commercial shortages. The average retail cash price was $30.18, the average valuation $29.86 and the percentage difference 1.07. The average cost of nitrogen per pound in this material has been 17.1 cents in fine tankage and 13 cents in coarse tankage.

Dissolved Bone. — Three samples of dissolved bone have been analyzed, only 1 of which was found deficient in plant food. No commercial shortages were found. The average retail cash price was $26.67, the average valuation $20.69 and the percentage difference 28.90.

Dry Ground Fish. — Twenty samples of dry ground fish have been examined, of which 9 were found deficient in nitrogen and only 1 in phosphoric acid. Six brands showed a commercial shortage ranging from a few cents to $1.89 per ton. The average retail cash price was $38.96, the average valuation $36.13 and the percentage difference 7.83. Nitrogen from dry fish has cost, on the average, 23.88 cents per pound.

Wood Ashes. — Thirteen samples of ashes have been analyzed, of which 3 were found deficient in phosphoric acid and 6 in potash. Six of these samples showed a commercial shortage ranging from 32 cents to $1.10 per ton.

(1) Nitrogen Compounds.

Sulfate of Ammonia. — Three samples have been analyzed and found well up to the guarantee. The average cost of nitrogen per pound in this form has been 17.53 cents.

Nitrate of Soda. — Thirteen samples have been analyzed, only 2 being found deficient in nitrogen. The average cost of nitrogen per pound in form of nitrate of soda has been 17.11 cents.

Dried Blood. — Two samples of this material were examined and found deficient in nitrogen; each contained sufficient phosphoric acid, however, so that there was no commercial shortage. The average cost of nitrogen from blood has been 25.57 cents per pound.

Castor Pomace. — Four samples of castor pomace have been analyzed, 1 sample only being found deficient in nitrogen, and this equivalent to $2.36 per ton. The average cost of nitrogen in this form has been 23.67 cents per pound.

Linseed Meal. — Three samples of flax meal have been tested and the nitrogen guarantee has been maintained in each instance. The nitrogen from this source has cost, on the average, 26.47 cents per pound.

Cottonseed Meal. — Forty-three samples of cottonseed meal have been examined. This has been the product from six companies which have licensed this material to be sold as a fertilizer in Massachusetts during the past year. This material, like the castor pomace and linseed meal, is bought largely as a nitrogen source for tobacco. Seventeen out of the 43 samples analyzed show a nitrogen shortage ranging from a few cents to $2.39 per ton. Nitrogen from cottonseed meal has cost, on the average, 23.61 cents per pound.

(2) *Potash Compounds.*

Carbonate of Potash. — Three samples have been analyzed and all of them were found to be of good quality. Potash in this form has cost, on the average, 7.68 cents per pound.

High-grade Sulfate of Potash. — Nine samples have been analyzed and the potash guarantee was maintained in all but 3 of them. The pound of potash has cost in this form, on the average, 5.03 cents.

Potash-magnesia Sulfate. — Six samples have been analyzed and in every case the potash guarantee has been maintained. The pound of actual potash has cost in this form 5.41 cents.

Muriate of Potash. — Thirteen samples have been examined and only 2 samples have shown a potash shortage, amounting to a few cents per ton in value. The pound of actual potash in form of muriate has cost, on the average, 4.18 cents.

Kainit. — Three samples have been analyzed, all testing over the minimum guarantee in potash. The average pound cost of potash from kainit has been 6.13 cents.

(3) *Phosphoric Acid Compounds.*

Dissolved Bone Black. — Three samples have been examined and all were found of good quality. The pound of available phosphoric acid from this source has cost, on the average, 7.41 cents.

Acid Phosphate. — Seven samples have been analyzed and the available phosphoric acid guarantee was maintained in all but 1 instance. The pound of available phosphoric acid from this source has cost, on the average, 5.69 cents.

Basic Slag Phosphate. — Six samples have been examined and the available phosphoric acid in all but 1 sample has run somewhat under the amount guaranteed. There has been a commercial shortage in only one instance, however, as the deficiency was made up by an excess of insoluble phosphoric acid. The pound of available phosphoric acid (by Wagner's method) from slag has cost, on the average, 5.79 cents.

(*i*) *Miscellaneous Fertilizers, Soils and By-products for Free Analysis.*

As in the past, free analyses have been made for farmers and others interested in agriculture so far as our time and facilities would warrant. Work of this nature, however, has been done when it would not conflict with the official inspection of commercial fertilizers. Including the materials which have been tested for the various departments of the experiment station, 385 analyses have been made. They may be grouped as follows: 292 fertilizers and by-products used as fertilizers, 68 soils and 25 samples of miscellaneous materials. Information has been furnished each applicant at the time the results of analyses were reported as to the best method of using fertilizer materials, also as to their average commercial value. Information has also been furnished with soil analyses as to the best method of treating the soil, also as regards the fertilization of the same. Both the fertilizer materials and soil samples have been taken according to instructions furnished from this office, and are therefore in all cases representative samples. These analyses do not appear in our fertilizer bulletin.

The fertilizer section has, as in past years, been active in co-operative work with the Association of Official Agricultural Chemists, and also with the fertilizer branch of the American Chemical Society.

6. Résumé of Work of the Feed and Dairy Section.

Mr. P. H. Smith, in charge, submits the following report: —

(a) *The Feed Law.*

During the past year 946 samples of feed stuffs offered for sale in the Massachusetts markets were collected by the official inspector. These have been examined, and the results are being brought together for publication in bulletin form.

Practically no misrepresentation was detected, although in a number of instances feed stuffs lacked the guarantee and other information required by the statute. Wherever dealers appeared to be particularly careless in this respect the matter was put into the hands of an attorney for settlement, but thus far in every case a satisfactory agreement has been made without resorting to the courts. In the future it is the intention to prosecute where dealers cannot be brought by less drastic means to comply with the law. The requirements of the Massachusetts law are simple and explicit, and afford protection to the reputable dealer as well as to the consumer, therefore the continued evasion of the law by a few dealers is inexcusable and should not be tolerated.

The extent to which the national pure food law aids in preventing adulteration and misrepresentation where feeds enter into interstate commerce is perhaps not known and appreciated as it should be. State officials and others in close touch with the work can see that its effects are far reaching and of great assistance to those engaged in local control work.

Cottonseed meal, usually one of the cheapest sources of protein for the Massachusetts dairyman, has for the past season been quite satisfactory in quality. The results thus far obtained for new meal indicate that, on account of the short cotton crop of the present season, conditions will be much the same as for the season of 1906–07. In spite of the excessively high price many dealers have sold short, and considerable slightly inferior meal is being offered. This may be accounted for in part by the poor quality of the seed, but it is felt, in some instances at least, that hulls and linters are intentionally added.

(1) *Low-grade By-products should be sold under their True Names.*

On account of our increasing population and prevailing high prices, it is becoming more and more necessary to utilize all by-products having any substantial food value in the feeding of our domestic animals. While screenings, weed seeds, oat hulls, corn cobs, cottonseed hulls and other low-grade material may contain some nutriment, the foregoing statement should not be taken to indicate that a compounded feed containing one or more of these materials, together with some high-grade concentrate, is just as valuable as the high-grade concentrate itself. Where such a mixture is offered at its face value, and no misrepresentation attempted, it is certainly a legitimate article of trade, and should be so recognized. The writer firmly believes, however, that, in order that the consumer may purchase intelligently, the ingredients going to make up a compounded feed should be stated on each package, but no legislation absolutely prohibiting the sale of low-grade material should be enacted unless it can be shown that certain kinds of material are poisonous or injurious to the animal.

The molasses feeds, of which there is an increasing number, form an excellent outlet for certain kinds of low-grade material, — especially screenings, — the molasses rendering them more palatable. Most of the manufacturers now grind the grain screenings before using them as a constituent of these feeds.

There are various feeds now offered which contain more or less ground alfalfa. It is believed that feeders cannot afford to pay grain prices for alfalfa hay, even when fine ground; it is decidedly more economical to purchase the high-grade concentrates unmixed, and to depend upon home-grown English hay, alfalfa, clover hay and corn silage as sources of roughage.

(2) *Protein v. Carbohydrates.*

Many manufacturers claim that the experiment stations place too much emphasis upon the value of protein and too little emphasis upon the value of carbohydrates. This station has never questioned the value and necessity of liberal amounts of carbohydrates in the ration. The question is rather an economic one, especially for the New England feeder, who, under our climatic conditions, can easily raise a sufficient quantity of carbohydrates and must depend largely upon *purchased protein* to balance or round out the ration, particularly in the feeding of dairy animals.

(3) Weight of Feed Stuffs.

Up to this time we have paid but little attention to the weight of feed stuffs. Data recently brought together show that while the feed law states *explicitly* that the *net weight* of each package should be stated, the practice has been, except in a few instances, to state gross weight as net. When feed stuffs sold for $15 a ton and less, the difference in value between net and gross weight of sacked feeds amounted to comparatively little, but at the present time the "value difference" is much greater. In a few instances what appear to be a deliberate attempt to give short weight was noted, and consumers should be on their guard against such deception.

(4) Uniform Feed Law.

It was the writer's pleasure to attend, during September, a conference between a committee of the American Feed Manufacturers' Association and State control officials, held at Washington, in the interests of a uniform feed stuffs law. The decision of the conference was that such a law should be as simple as possible, and that a buyer of any feed stuffs should be informed of the following points: —

1. The number of net pounds in the package.
2. Name, brand or trademark.
3. Name and principal address of the manufacturer or jobber responsible for placing the commodity on the market.
4. Its chemical analysis expressed in the following terms: (*a*) minimum percentage of crude protein, (*b*) minimum percentage of crude fat, and (*c*) maximum percentage of crude fiber.
5. If a compound or mixed feed, the specific name of each ingredient therein.

The Massachusetts law does not require a guarantee of fiber or a statement of ingredients in a compounded feed, and it is felt that if the present law could be amended to contain these statements it would be materially strengthened.

(*b*) *The Dairy Law.*

The work required by this act is divided into three natural subdivisions: (1) the examination of candidates, (2) the testing of glassware, and (3) the inspection of machines.

(*1*) *Examination of Candidates.*

During the past year 25 candidates have been examined for proficiency in Babcock testing. Of these, 14 were students at the ten weeks' winter course and 3 were students in the regular college course; the other 8 held positions in different parts of the State. All candidates were at least fairly proficient and capable of doing good work. At the last session of the Legislature, section 4 of the dairy law (chapter 202 of the Acts of 1901) was so amended as to give the director of the experiment station power to revoke the certificate of an operator providing it is found that he is not doing satisfactory work. Following is the section as amended: —

SECTION 4.[1] No person shall, either by himself or in the employ of any other person, firm or corporation, manipulate the Babcock test or any other test, whether mechanical or chemical, for the purpose of measuring the butter fat contained in milk or cream as a basis for determining the value of such milk or cream, or of butter or cheese made from the same, without first obtaining a certificate from the director of the Massachusetts[2] agricultural experiment station that he or she is competent to perform such work. Rules governing applications for such certificates and the granting of the same shall be established by the said director. The fee for issuing the said certificate shall in no case exceed two dollars, shall be paid by the applicant to the said director, and shall be used in meeting the expenses incurred under this act. If the duly authorized inspector finds an operator who, after receiving his certificate of competency, is not, in the judgment of the inspector, correctly manipulating the Babcock or other test used as a basis for determining the value of milk and cream, or who is using dirty, untested or otherwise unsatisfactory glassware, he shall immediately report the case in writing to the director of the station. The director shall at once notify said operator in writing and give him

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1 See chapter 425, Acts of 1909.

2 Massachusetts substituted for Hatch. See chapter 66, Acts of 1907.

not less than thirty days to make the necessary improvements. At the expiration of that time the director may order a second inspection, the cost of which shall be borne by the operator or by the person, firm or corporation employing him, and if the required improvement has not been made, the director is empowered to notify in writing said operator, or the person, firm or corporation employing him, that his certificate of competency is revoked. In case of any subsequent violation the said director may revoke the certificate of competency without giving the notice aforesaid.

(2) *Testing Glassware.*

During the past year 4,071 pieces of glassware were examined, of which 43 pieces, or 1.06 per cent., were inaccurate. Following is a summary of the work for the nine years that the law has been in force: —

Year.	Number of Pieces tested.	Number of Pieces Condemned.	Percentage Condemned.
1901,	5,041	291	5.77
1902,	2,344	56	2.40
1903,	2,240	57	2.54
1904,	2,026	200	9.87
1905,	1,665	197	11.83
1906,	2,457	763	31.05
1907,	3,082	204	6.62
1908,	2,713	33	1.22
1909,	4,071	43	1.06
Totals,	25,639	1,844	7.19[1]

The passage of this law has prevented 1,844 pieces of inaccurately graduated glassware, representing 7.19 per cent., of the entire number tested, from coming into use.

(3) *Inspection of Babcock Machines.*

In 1901, at the time of the first annual inspection, there were in Massachusetts 40 creameries and milk depots using the Babcock test as a basis for fixing the value of milk and cream. Owing to the increasing demand for milk, many creameries have either suspended operations or have been bought up by

[1] Average.

the large Boston milk companies, so that at the present inspection (November, 1909) but 29 places were visited, of which 16 were creameries, 11 milk depots, 1 city milk inspector and 1 chemical laboratory. Ten of the creameries were co-operative and 6 proprietary. The 11 milk depots were in every case proprietary. Twenty-nine machines were inspected, of which 2 were condemned, but on second inspection a few weeks later they were found to have been put in good condition. Those in use are 11 Facile, 8 Agos, 6 Electrical, 3 Wizard and 1 Twentieth Century. The glassware, as a whole, was clean, and so far as noted was Massachusetts tested. It is believed, on account of worn bearings and carelessness in keeping them clean and well oiled, that an excess of steam is necessary in many cases to give the required speed. Care should be taken to see that steam machines do not overheat the tests, which should be read between 120° and 140° F.

The creameries and milk depots which pay by the test are as follows: —

Creameries.

Location.	Name.	President or Manager.
1. Amherst,	Amherst,	W. A. Pease, manager.
2. Ashfield,	Ashfield Co-operative,	Wm. Hunter, manager.
3. Belchertown,	Belchertown Co-operative,	G. B. Jackson, manager.
4. Brimfield,	Crystal Brook,	F. N. Lawrence, proprietor.
5. Cheshire,	Greylock Co-operative,	Carl Williams, manager.
6. Cummington,	Cummington Co-operative,	W. E. Partridge, manager.
7. Egremont,	Egremont Co-operative,	E. A. Tyrrell, manager.
8. Easthampton,	Hampton Co-operative,	W. S. Wilcox, manager.
9. Heath,	Cold Spring,	F. E. Stetson, manager.
10. Hinsdale,	Hinsdale Creamery Company.	W. O. Solomon, proprietor.
11. Monterey,	Berkshire Co-operative,	F. A. Campbell, manager.
12. New Salem,	New Salem Co-operative,	W. A. Moore, president.
13. North Brookfield,	North Brookfield,	H. A. Richardson, proprietor.
14. Northfield,	Northfield Co-operative,	C. C. Stearns, manager.
15. Shelburne,	Shelburne Co-operative,	Ira Barnard, manager.
16. Wyben Springs,	Wyben Springs Co-operative.	C. H. Kelso, manager.

Milk Depots.

Location.	Name.	President or Manager.
1. Boston,	D. W. Whiting & Sons,	Geo. Whiting, manager.
2. Boston,	H. P. Hood & Sons,	W. N. Brown, manager.
3. Boston,	Boston Dairy Company,	W. A. Graustein, president.
4. Boston,	Walker-Gordon Laboratory,	M. B. Small, manager.
5. Boston,	Oak Grove Farm,	Alden Brothers, proprietors.
6. Cambridge,	C. Brigham Company,	J. R. Blair, manager.
7. Cheshire,	Ormsby Farms,	W. E. Penniman, manager.
8. Dorchester,	Elm Farm Milk Company,	J. H. Knapp, manager.
9. Sheffield,	Willow Brook Dairy,	G. W. Patterson, manager.
10. Southboro,	Deerfoot Farm Dairy,	S. H. Howes, manager.
11. Springfield,	Tait Brothers,	Tait Brothers, proprietors.
12. Springfield,	Emerson Laboratory,	H. C. Emerson, proprietor.
13. Springfield,	Milk inspector,	Stephen C. Downs.

Attention is called to the article on the "Babcock Test," published in Circular No. 24 of this station, and to the article on "Reading the Babcock Test," printed elsewhere in this report.

(*c*) *Milk, Cream and Feeds sent for Free Examination.*

The experiment station will analyze samples of milk, cream and feeds sent for examination in so far as the time and resources at its command permit, and in addition will furnish such information as is likely to prove of value in interpreting the results of such analysis. Under the dairy law the station has the right to charge the cost of the analyses of milk and cream; charges, however, are not made unless the number of analyses required is considerable. Only in exceptional cases should material intended for free chemical examination be sent except by previous arrangement. Upon application full instructions for sampling and directions for shipping will be furnished, which will often obviate the necessity of sending another sample in place of the one improperly taken.

(d) *Analysis of Drinking Water.*

Since the establishment of the station in 1882, sanitary analyses of drinking water have been carried out for parties within the State. Beginning Jan. 1, 1903, free analyses were discontinued, and a charge of $3 a sample made. The reason for this change was the fact that many parties abused the privilege, and also because work of this character interfered with legitimate experiment station work. The above charge must be paid when the sample of water is sent. During the year 91 samples have been tested and the results promptly reported.

In order to secure an analysis application must first be made, whereupon a suitably encased glass jar, together with full instructions for collecting and forwarding the sample, will be forwarded by express. An analysis of water sent in shippers' jars will not be undertaken, neither will bacteriological nor mineral analyses be made. The object in offering to make an examination of water is to enable the citizens of the State, depending upon wells and springs, to ascertain at a minimum expense whether their supply is free from such objectionable matter as is likely to gain entrance from sink, barn or privy. Such an examination is referred to as a sanitary analysis.

Lead pipe should never be employed for carrying drinking water; in case it is in use it should be removed at once, and galvanized iron or iron coated with asphaltum substituted. *Lead is a poison* and after it has entered the system it is eliminated only with the greatest difficulty.

(e) *Miscellaneous.*

In addition to the work already described, this division has conducted investigations and made other analyses as follows: —

1. It has co-operated with the Official Dairy Instructors and Investigators Association in a study of the Babcock test, the results of which are published elsewhere in this report.

2. It has made an investigation on the use of the Zeiss immersion refractometer in the detection of watered milk, the results of which are likewise published in the present report.

3. It has co-operated with the Association of Official Agri-

cultural Chemists in a study of methods for the determination of the various ingredients in condensed milk.

4. It has co-operated with the Association of Official Agricultural Chemists in a study of methods for the determination of total nitrogen.

5. In connection with the experimental work of this and other departments of the experiment station, this division has made partial analyses of 191 samples of milk, 157 samples of cattle feeds and 520 samples of agricultural plants.

(*f*) *Testing of Pure-bred Cows.*

The work of testing cows for the various cattle associations has increased considerably during the past year. At the present time two men are kept on the road a greater part of the time on work in connection with the Jersey, Guernsey and Ayrshire tests. The rules of the above associations require the presence of a supervisor once each month at the farms where animals are on test. The milk yields noted by the supervisors at their monthly visits are used in checking up the records reported by the owners to the several cattle clubs. The Babcock tests obtained at that time are likewise reported and used as a basis for computing the butter-fat yield for that month.

The Holstein-Friesian tests are of much shorter duration, usually seven or thirty days, and require the presence of a supervisor during the entire test. These tests give rather irregular employment to a number of men during the winter months. On account of the uncertainty of the work such men are difficult to obtain, but thus far it has not been necessary for the experiment station to refuse an application.

During the past year 1 seven-day and 33 yearly Guernsey, 5 seven-day and 66 yearly Jersey, and 8 yearly Ayrshire tests have been completed. For the Holstein-Friesian association 77 seven-day, 3 fourteen-day, 8 thirty-day and 1 sixty-day tests have been completed. There are now on test for yearly records 80 Jerseys, 29 Guernseys, 9 Ayrshires and 1 Holstein.

REPORT OF THE BOTANISTS.

G. E. STONE; G. H. CHAPMAN, ASSISTANT.

The routine work of the botanist for the past year has been similar to that of other years. Correspondence relating to various diseases and special problems has occupied much time, and investigations of various problems have been taken up.

In carrying out the details connected with the routine work and investigations we have had the assistance of Mr. G. H. Chapman, and in the keeping of records, seed testing and correspondence, Miss J. V. Crocker has been of much assistance. Mr. R. D. Whitmarsh, who is pursuing graduate studies at the college, has aided materially in the diagnosis of diseases and in other ways about the laboratory.

Diseases More or Less Common to Crops during the Year.

The season of 1909 was exceptionally dry, like that of 1908, and vegetation suffered materially. Some rain fell in the early spring months, but the average precipitation was below the normal. The summer was remarkably free from thunderstorms. The growing season opened later than usual and vegetation was a week or two behind throughout the whole season, some crops not maturing as well as in other seasons.

Little or no winter injury was observed to vegetation, but late frosts in the spring affected asparagus in some localities. The injury was in some respects similar to a trouble which has been previously reported on as being associated with a fungus (*Fusarium*).

Some cases were noted of defoliation of apple trees by frost blisters, caused by the effects of late spring frosts.

Besides the usual number of fungous diseases commonly met with, the following may be mentioned as being more or less abundant, and worthy of note for other reasons.

The past season has been a favorable one for rusts in general. Apple rust (*Puccinia*), which is seldom present, was more or less abundant, as in the season of 1908, and affected both foliage and fruit. Certain varieties seemed to be more susceptible than others. Some bad cases of bean rust (*Uromyces*) were noted here and there. This rust, like the one on the apple, is seldom troublesome with us. Hawthorns were affected more severely than usual with rust, resulting in some damage to nursery stock. The wild species of hawthorn is seldom immune to rust, but there is usually no complaint of nursery stock rusting. Quince rust (*Gymnosporangium*), which is always to be found, was more abundant than usual. Some severe cases of rust (*Phragmidium*) were also noted on the rose, and powdery mildew (*Sphærotheca*) was quite prevalent.

Peach leaf curl (*Exoascus*) was occasionally observed, but was not troublesome.

A bacterial wilt of the eggplant, which is more common in the south, was reported once or twice.

One severe case of beet scab (*Oöspora*) was also observed. In this particular case the soil had been limed, which substantiates the fact that liming the soil increases scab materially. While with us the beet is not so susceptible to scab as the potato, care should be taken not to plant beets where scab is abundant, and special precautions should be taken in applying lime to the soil.

Potatoes were generally free from troubles, but some cases of *Rhizoctonia* were observed; also a bacterial rot of the tuber.

Dropsical swelling of pear twigs, a more or less unusual trouble, was reported at different times, and the Baldwin fruit spot, which appears to be more common in dry than wet seasons, has been quite prevalent.

The leaf spot of apple (*Phyllosticta*) was very abundant early in the season and caused considerable defoliation.

More or less severe injury has resulted to peach and plum trees the last year or two from what is known as "gummosis." This disease is apparently caused, at least in many cases, by leaving the old "mummied" fruit affected with Monilia on the trees over winter. These "mummied" plums, contaminated with fungi, come in contact with the branches and cause "gummosis." This trouble is now being studied in the laboratory and field.

The blossem-end rot of tomatoes, a dry-season disease, was quite common, causing considerable injury. A liberal supply of soil moisture during the period of setting fruit is the best remedy for this trouble.

The downy mildew of the cucumber and melon (*Plasmopara*) occurred as usual during August and September, affecting both out-of-door crops and those under glass, while *Anthracnose* (*Colletotrichum*) was not so destructive as in some seasons.

The leaf spot caused by *Alternaria* was quite general on the foliage and fruit of the muskmelon and watermelon, but a large field of rust-resistant melons was found on September 7 to be absolutely free from any blight. Since spraying melons for blight has proved to be of little value, it is desirable to use types which are immune to the blight. The best method of growing melons in this climate consists in selecting an early, sandy soil, with warm exposure. The soil should be thoroughly tilled, and the plants set out early, blight-resisting varieties being used. A location as free as possible from frequent dews should be selected, and manure in the hills is superior to fertilizers, since it gives the plant better soil conditions. It is best to start the plants early in pots or strawberry boxes under glass, and transplant to the open field. Native muskmelons are far superior to the half-matured imported product, and a ready market awaits the successful grower.

Shade-tree Troubles.

The rainfall during the early spring months revived vegetation in general from the effects of the severe drought of the preceding season. This stimulated trees and shrubs to assume a healthy appearance and produce a good crop of foliage. The succeeding months, however, were very dry, and considerable defoliation of shade and fruit trees occurred in June and July. The long period of drought resulted in a premature coloration of the foliage, and consequent early defoliation.

Occasional high winds, with lack of soil moisture, caused sun scorch, particularly to maples. Some of the defoliation, particularly that of the elm, was caused by squirrels, and some was due to a natural shedding of the twigs. *Dothidella ulmi,* a leaf-spot fungus occasionally found on elms, was unusually abundant rather early in the season, and this was also responsible for much loss of foliage.

The Italian poplar was more severely affected with the rust (*Melampsora*) than usual, and the twigs and leaves of the ash suffered from a similar fungus to an unusual extent. Horse-chestnut foliage was badly affected with a leaf spot (*Phyllosticta*), and a black spot (*Rhytisma*) more or less common every year on the white maple was unusually abundant. It was more common on the white maple than usual, and the leaves of the red maple were literally covered with it.

Ivy (*Ampelopsis*) was affected with a leaf spot. In some localities quite a few maple trees were killed by sun scald, while others were scalded only on their southern exposure. Following this outbreak of sun scald, *Nectria,* a fungus of saprophytic habit, developed freely.

REPORT OF THE ENTOMOLOGISTS.

C. H. FERNALD; H. T. FERNALD; J. N. SUMMERS.

The work of the department of entomology during the year 1909 has differed little from that of preceding years. Correspondence, as usual, has required much time, and many inquiries involve considerable investigation where some of the less familiar insects are concerned. This has been particularly true during the past season, the number of insects concerned having been larger than usual, though serious injury from their attacks has been rather conspicuously absent.

Experimental work in some subjects has been continued from previous years, while in others it has been temporarily suspended. The construction of the new entomological building has necessitated giving up the use of the present greenhouse, as this was liable to removal to its new site at any time, and when this should occur any experiments under glass would necessarily come to an end. For this reason further tests of the resistance of muskmelons to fumigation have been discontinued for the present, but it should be possible to resume them another year. Studies on the number and relative importance of the different broods of the codling moth have been continued, but the orchard in which these have been made thus far has now been taken for other uses, and has been so treated that it is no longer available for this purpose. Unless another orchard, under conditions suitable for the work, can be obtained, this line of investigation will, therefore, have to be dropped, although in order to reach satisfactory results it should be continued for at least four or five years more.

Experiments on methods for the control of the cabbage maggot have been repeated again, but without satisfactory results, the maggots, though more abundant than during the two years preceding, being still too scarce to give results which could be considered entirely trustworthy.

Observation of the dates of appearance of the young of our common scales have been continued, adding the records of another year to those already in hand. This work will also need to be continued for a number of years in order to provide data of sufficient value for general use.

The experiments for the control of the onion thrips have proceeded far enough to show that spraying the onions after this insect has appeared on them is, at best, only a partial remedy. One of the results of the work of this pest is to curl the leaves of the onion, and the insects at once gather on the inner side of the curled surface, so that many of them cannot be reached by the spray, though those which are reached in this way are destroyed. A study of the life history of these insects shows that they pass the winter at the top of the ground in protected places, such as are furnished by dead grass around the onion fields, in rubbish heaps and similar places; and a few attempts to destroy them by burning over the grass and rubbish around the fields have been followed by a reduction in the abundance of the insect the next spring. This method of control has not as yet been tested long enough to prove that the result was actually due to the treatment rather than to merely natural causes, but, in any case, it seems to be the most promising way we have yet found to check this insect, and it should be repeated until its value has been fully determined.

Perhaps the most important entomological event of the year at the station was the discovery of an egg parasite of the common asparagus beetle, which was found actively at work about the first of June. Observations on this insect, its habits and life history, have been published as Circular No. 23 of the station, and also in the "Journal of Economic Entomology."

The control of wire worms, attacking seed corn in the ground soon after it has been planted, is important, as these pests, when abundant, often necessitate the replanting of many acres. Experiments to prevent the attacks of this insect have been carried on by Mr. Ralph H. Whitcomb of Amherst, and his ingenuity has discovered that when the corn, when planted, has been covered with tar as a repellant for crows, as is quite generally done in this locality, and then treated with a mixture of Paris green and dust until a greenish color is perceptible, it will not be eaten by wire worms. These experiments will be repeated the coming year.

Within the last twenty years Massachusetts has been invaded by several injurious insects which naturally belong farther south. Among these may be mentioned the elm-leaf beetle, San José scale, common asparagus beetle and the twelve-spotted asparagus beetle. How far north these pests can spread and be injurious is as yet unknown, but it is certain that there are limits to this spread, and for at least some of those named it seems quite certain that these limits may probably be found within this State. It is not a particular degree of latitude which marks the barrier to their further spread northward, but rather climatic conditions, and these are modified by elevation. In other words, the limiting lines of distribution appear to be isothermal in their nature, though their exact character is as yet unsettled. It may be the average winter temperature, the minimum winter temperature or some other factor which settles whether an insect shall be a pest at any given place near its northern limit. In any case, the determination of this cause, and the resulting conclusion that an insect will or will not become injurious at a given place, will be of much importance. As an example of this it may be stated that such evidence as is now available, though as yet too little to be conclusive, suggests the belief that in Massachusetts the elm-leaf beetle will not be likely to be of much importance in those parts of the State which are more than a thousand feet above sea level, except, perhaps, near the southern edge of the State, where the altitude is to some extent offset by the more southern latitude. To work out problems of this nature fuller meteorological data are needed, as well as more observations of the distribution of the insects themselves, and studies of this kind have been in progress for several years, and will be continued.

Parasitism as one of nature's methods for the control of injurious forms has long been recognized. It has been utilized in numerous cases by man, who has conveyed parasites from one country to another to attack their hosts, which have already been by accident thus transferred. Perhaps the most gigantic experiment of this kind is that now being conducted by the Bureau of Entomology of the United States Department of Agriculture and those in charge of the gypsy moth work in Massachusetts, in importing from the old world the parasitic and other enemies of the gypsy and brown-tail moths, in the hope that they may become established in this country and bring these pests under control.

No one seems to know, however, how effective parasites really are; conceding their importance, we have only the most general statements on the subject, and almost the only paper giving more than these is a short one by Dr. L. O. Howard, entitled "A Study of Insect Parasitism."

It would seem most desirable to substitute statistics for guess-work on a subject so important as this, and therefore the scope of parasitism by the insects of a restricted group, the conditions favoring and checking it, and all the factors entering into the problem have been taken up for prolonged study, and it is hoped that tangible results may in time replace the vague generalizations on this subject which, thus far, are all that have been available.

Investigations on spraying have been continued since the last report, but with disappointing results. As was stated last year, the first step was to obtain pure spraying materials, and it was supposed that these were available, as reliable manufacturers offered them as such. To be certain, however, these were analyzed, and the results showed that the materials were not as pure as was necessary for the purpose, making it necessary to make these materials at the station. This has held up the work to some extent, for while considerable time was spent in applying the materials to various plants, and watching the results, the later discovery of the unreliability of the materials used has made valueless the experimental work done with them. New spraying materials made here must, therefore, be obtained to use in these experiments, in order to obtain the results needed as a basis for the study of the commercial materials which is to follow, and at present the work is at a standstill till these materials can be prepared. It is expected, however, that they will be available for use during the coming summer.

THOMAS SLAG. A SHORT HISTORICAL REVIEW.

BY J. B. LINDSEY.

Thomas slag, or basic phosphatic slag, is a by-product in the modern method of steel manufacture from ores containing noticeable quantities of phosphorus. The process of removing the phosphorus from the ore was discovered by the English engineers Gilchrist and Thomas, and, briefly stated, consists in adding to the so-called converter containing the molten ore a definite quantity of freshly burnt lime, which, after a powerful reaction, is found to be united with the phosphorus, and swims upon the surface of the molten steel in the form of a slag.

Composition of the Slag.

The composition of the Thomas or Belgian slag varies according to the character of the ore and the success of the process for removing the impurities. The following figures show such variations:[1] —

	Per Cent.
Phosphoric acid,	11–23
Silicic acid,	3–13
Calcium oxide (lime),	38–59
Ferrous and ferric oxides,	6–25
Protoxide of manganese,	1–6
Alumina,	.2–3.7
Magnesia,	2–8
Sulphur,	.2–1.4

More or less metallic iron is enclosed in the coarse slag which is generally thoroughly removed from the ground material by the magnet.

[1] Agricultur Chemie von Adolf Mayer, II Band, 2te Abtl., 6 Auflage pp. 138, 139.

Manurial Value of Slag recognized.

The manurial value of the slag was not recognized for a long time; finally experiments revealed that a considerable portion of its phosphoric acid was soluble in dilute citric and carbonic acids, which led to successful field experiments. The only preparation of the slag for fertilizing purposes, when its value was first recognized, consisted in having it finely ground in especially prepared mills, so that 75 per cent. would pass through a sieve with perforations of .17 millimeter diameter. This requirement was suggested by M. Fleischer, who used the slag with much success in improving the condition of marsh and meadow lands.

Methods for determining Availability and Adulteration.

Previous to 1890, by means of pot experiments as well as by laboratory investigations, Wagner demonstrated that the phosphoric acid in different slags of the same degree of fineness varied in its availability from 30 to 90 or more per cent., and, further, that many brands were adulterated with Belgian or other insoluble mineral phosphates.

The previous method, therefore, of determining the value of a slag by the percentage of total phosphoric acid present and the degree of fineness, was of secondary importance.

In order to detect adulteration with mineral phosphates, Wagner originally used a dilute solution of citrate of ammonia and free citric acids.[1] The phosphoric acid in all of the mineral phosphates was sparingly soluble in such a reagent, while an unadulterated high-grade slag gave up 80 to 90 parts of its phosphoric acid. Further investigations on various soils with many brands of slag made it clear that the results obtained from pot experiments corresponded quite well with those secured by means of the citric acid solution. This may be illustrated as follows:—

[1] Chemiker Zeitung No. 63, 1895; also Düngungsfragen Heft I., p. 16, von P. Wagner, 1896.

Brand of Slag.	Phosphoric Acid available in Citric Acid Solution.	Phosphoric Acid available in Pot Experiments.
1,	100	100
2,	85	80
3,	81	72
4,	72	72
5,	73	66
6,	76	63
7,	39	40
8,	48	38
9,	42	38
10,	45	31
11,	38	30

Results similar to the above were secured by Maercker,[1] who stated that "the results removed all doubt that the citrate solubility and plant experiments were so nearly proportioned that one had the same right to value the slag according to its content of phosphoric acid soluble in citrate solution as to value a superphosphate by its content of water soluble phosphoric acid."

As a result of these investigations, the union of German experiment stations, at its meeting at Kiel in September, 1896, adopted the method of determining the relative value of the slag according[2] to its phosphoric acid solubility in a 2 per cent. citric acid solution, and did away with the previous standard of total phosphoric acid and fineness.

Wagner as well as Maercker repeatedly called attention to the fact that experiments both in the laboratory and with plants gave positive evidence that those slags of *like phosphoric acid content* which were *richest in silicic acid* gave the best results. G. Hoyermann, working independently, came to similar conclusions. At the present time, according to Wagner, practically all of the iron works treat the molten slag as it flows from the converter with hot quartz sand, with the result that the avail-

[1] Landw. Presse 1895, No. 82.

[2] Method slightly modified from the original. Present method described in Konig's Untersuchung landwirtschaftlich und gewerblich wichtiger Stoffe. Dritte Auflage, pp. 173, 174.

ability of the phosphoric acid is improved from 10 to 30 per cent.[1]

Chemical Combination of Phosphoric Acid in Slag.

The form in which the phosphoric acid exists in the slag has never been fully explained. It was formerly supposed that it was combined with lime as a tetra-calcium phosphate, and that this latter compound, being less stable than tri-calcium phosphate, under the influence of dilute acids became easily available to the plants by being decomposed into the calcium salt of the dissolving acid and bi-calcium phosphate. The tetra-lime phosphate, however, has never been made artificially,[2] although it has been recognized by the aid of the microscope in the slag, and exists as a mineral under the name of isoklas.

More recent investigations having shown, as already indicated, that those slags richest in silicic acid of like phosphoric acid content gave the best results, the conclusion followed that a part of the lime must be in the form of lime silicate. It is now generally held, especially by Wagner,[3] that the phosphoric acid is combined in the slag as a double salt of tri-calcium phosphate and calcium silicate, and that in this form the roots are able to utilize it. It is also believed probable that some of the phosphoric acid is more or less united with iron as a basic iron phosphate.

The Use of Phosphatic Slag.

Basic slag has been shown to work especially well upon sour marsh and meadow lands, upon porous, well-aired soils rich in humus, as well as upon sandy soils deficient in lime.

When a rapid development of the crop is not desired, the slag may be used exclusively in place of acid phosphate. On the other hand, in cases when it is feared that the crop will not mature early enough, upon heavy, cold land and in high altitudes, where the season is short, acid phosphate should be given the preference.

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[1] Already cited, p. 28; also, Anwendung Künstlicher Düngemittel, vierte Auflage von Wagner, pp 74, 75.

[2] Hilgenstock: Jahresber. Chem. Technologie, 1887, p. 282, after Adolf Mayer, already cited.

[3] Wagner, already cited.

The phosphoric acid in slag is comparable in its quickness of action to nitrogen in barnyard manure, tankage and green crops; and the phosphoric acid in acid phosphate to the action of nitrogen in nitrate of soda. A combination of slag and sulfate of potash (500 pounds slag and 150 pounds potash) has been found to work especially well upon grass land, and to be very favorable to the development of clover.

Quantity of Slag per Acre.

If the soil is particularly deficient in phosphoric acid, one can use as high as from 800 to 900 pounds of slag to the acre, plowed in and supplemented with 200 pounds of acid phosphate in the hill or drill.

If, on the contrary, the soil is naturally rich in phosphoric acid, or has been made so by large additions of slag for a series of years (1,000 or more pounds yearly), then it is necessary only to replace from year to year the amount removed by the crop. In such cases Maercker states that one part of phosphoric acid in basic slag is as valuable as an equal amount in acid phosphate.

EFFECT OF PORTO RICO MOLASSES ON DIGESTIBILITY OF HAY AND OF HAY AND CONCENTRATES.

BY J. B. LINDSEY AND P. H. SMITH.

I. INTRODUCTION.

In New England, cane molasses brought in tank steamers from Porto Rico has been freely offered for a number of years at from 12 to 15 cents a gallon of 12 pounds in barrel lots. The material is dark in color but quite satisfactory in quality. It has been found to contain from 20 to 28 per cent. of water (average 24 per cent.), about 3 per cent. of protein (largely as amids), 6 to 7 per cent. of ash, and the balance of sugars and allied substances. The following analyses made at this station represent the composition of three different samples of Porto Rico molasses: —

		1904. Sample.		1905. Sample.		1906. Sample.	
Water,			24.40		28.50		24.98
Ash,			7.13		6.04		5.57
Crude Protein,	Albuminoids,	1.24	3.17	.96	2.82	-	2.19
	Amids,	1.93		1.86		-	
Extract Matter,	Cane sugar,	29.72	65.30	36.26	62.64	37.86	67.26
	Invert sugar.	25.03		19.38		20.48	
	Undetermined,	10.55		7.00		8.92	
			100.00		100.00		100.00

It may be remarked that two analyses of the ash have shown traces of phosphoric acid and 3.66 and 4.84 per cent. of potash, the latter being by far the most predominant ash constituent. Beet molasses has been shown to contain rather more ash than cane molasses.

It can be assumed with safety that molasses, being soluble in water, is easily digested and assimilated when fed in reasonable amounts. If fed in excess it is likely to affect adversely the heart and kidneys, and to appear undigested in the urine.[1] It is a well-known fact that the addition of starch, sugar and similar substances causes a distinct depression in the digestibility of the material with which they are fed.[2] Various reasons have been advanced to account for this depression, which has as yet not been definitely proved. In case of beet molasses, Kellner [3] has shown an average digestion depression of 9 per cent., and he states that the value of beet molasses for cattle and sheep consists in its 55 per cent. of digestible carbohydrates (1,100 pounds to the ton).

Lehmann,[4] as a result of three digestion experiments (nine single trials) with sheep, obtained an average digestion depression of 11 per cent., which he deducts from the 71 per cent. of total organic matter in beet molasses, thus securing 60 per cent., or 1,200 pounds, of digestible organic matter to the ton.

Grandeau and Aleken have shown that molasses when fed to horses also causes a noticeable digestion depression. Alquier and Drouineau, in reviewing the work of both French and German investigators, state that in case of horses the addition of 3 pounds of molasses per 1,000 pounds live weight caused a depression of 4.5 per cent., while with ruminants the feeding of 4 pounds of molasses per 1,000 pounds live weight produced an average depression of only 3 per cent. in the digestibility of the foods with which it was fed.[5]

Patterson [6] reported, in case of two steers, when molasses constituted some 12 per cent. of the total dry matter of the ration, an improvement of 24 per cent. in the digestibility of the hay. Molasses fed to four steers in combination with hay and grain, and comprising 14 per cent. of the total dry matter of the ration, improved the condition of the hay and grain ration 14.5 per cent. (coefficients of digestibility of the dry matter of the hay

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1 Kellner, Arbeiten der D. Landw. Ges. 152 Heft., 1909, p. 16.

2 Kellner, Die Ernahrung Landw. Nutzthiere, fünfte Auflage 1909, pp. 50, 51. Numerous references are cited by Kellner.

3 Landw. Verssuchs. 53 Bd., pp. 220 and 233, 234, 304 and 342, 343; 55 Bd., p. 384.

4 Landw. Jahrbücher, Vol. XXV., Ergänzungsband II., 1896.

5 Ann. Sci. Agron., 2 série, 1904, Tome 1, pp. 249-254.

6 Molasses Feeds, Bulletin 117, Maryland Experiment Station.

and grain without molasses, 55.1 per cent.; with molasses, 63.1 per cent.). Patterson's results are quite the opposite of all previous work along this line.

II. EXPERIMENTS AT THE MASSACHUSETTS EXPERIMENT STATION.

Experiments relative to the effect of Porto Rico molasses on digestibility have been in progress at intervals at this station since 1905. Different amounts of molasses have been added to a basal ration of hay, of hay and corn meal, and particularly of hay and gluten feed. The experiments made during the winter of 1905 and 1906 have been published in detail.[1] The numerous other experiments are here reported for the first time.

Sheep were employed in all cases; in Series XI. and XII. grade Southdown wethers were used, and in Series XIII. and XIV. one and two year old Shropshires were employed.

The hay was cut in 2-inch lengths before being fed, and was largely Kentucky blue grass, with an admixture of some clover and sweet vernal grass. The gluten feed represented the dried residue of Indian corn (Zea mais) in the manufacture of corn-starch, and consisted of the hulls and glutinous part of the corn, together with that portion of the starch and broken germs which could be removed by mechanical means. It was free from any indication of decomposition. The corn meal consisted of the ground corn kernels.

The sheep were fed twice daily, — about 7 o'clock in the morning and 5 in the afternoon. The molasses was mixed with about its weight of water and sprinkled over the hay, or was mixed with the grain and eaten without the addition of water. The food was given in galvanized-iron pans which fitted closely into the wooden stalls in which the sheep were confined.[2] Particles of cut hay that were thrown out of the box were carefully brushed up and returned. Any waste remaining at the end of the period was preserved and analyzed. Water in galvanized-iron boxes was always before the sheep. The fæces were collected twice daily, preserved in wide-mouth glass-

[1] Nineteenth report of the Hatch Experiment Station, pp. 126-149.

[2] Illustrated in eleventh report of the Massachusetts State Experiment Station, 1893, p. 148.

stoppered bottles and taken to the laboratory every twenty-four hours. The daily sample was poured upon a newspaper, well mixed and an aliquot part (usually 1/10) weighed into a crystallization dish and dried at 60° C. After this drying was completed the samples were allowed to stand at ordinary temperature for a number of days, and were reweighed, mixed, ground, placed in glass-stoppered bottles and eventually analyzed. Nitrogen was determined in the dry sample but not in the fresh fæces, as is frequently done at the present time. The entire period lasted fourteen days, seven of which were preliminary, the fæces being collected during the last seven. The sheep were kept in roomy stalls during the first three days, and then harnessed and placed in the digestion stalls for the last eleven days of the trial.

The results of the different experiments are first presented, together with a discussion of the same. The full data follows the discussion.

A. Hay and Molasses.

Summary of Results.

Series XII., Period III.

[800 grams hay, 100 grams molasses and 10 grams of salt.]

(*a*) *Coefficients for Molasses.*

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Old Sheep II., ...	69.05	–	–	87.26
Old Sheep III., ...	100.99	41.31	80.29	101.58

From the above coefficients it would appear that Sheep II. digested only 69 per cent. of the total dry matter of the molasses, while Sheep III. digested the entire amount fed. It can, however, be safely assumed that molasses, being quite soluble in water, is easily digested and entirely resorbed in the digestion tract. Only minute traces of reducing substances have been recognized in the fæces.

(*b*) *Depression noted* (*Grams*).

Old Sheep II.

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 800 grams hay when fed alone,	476.72	23.31	53.52	179.27	208.31	10.67
Digested of 800 grams hay plus 100 grams molasses,	527.44	23.17	51.88	177.82	265.30	9.27
Minus 100 grams molasses fed, assumed to be all digested,	73.45	5.35	2.79	-	65.31	-
Remains for 800 grams hay digested when fed with molasses,	453.99	17.82	49.09	177.82	199.99	9.27
Difference or depression,	—22.73	—5.49	—4.43	—1.45	—8.32	—1.40

Old Sheep III.

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 800 grams hay when fed alone,	476.72	23.31	53.52	179.27	208.31	10.67
Digested of 800 grams hay plus 100 grams molasses,	550.90	25.52	55.76	184.40	274.65	10.56
Minus 100 grams molasses fed, assumed to be all digested,	73.45	5.35	2.79	-	65.31	-
Remains for 800 grams hay digested when fed with molasses,	477.45	20.17	52.97	184.40	209.34	10.56
Difference or depression,	+.73	—2.14	—.55	+5.13	+1.03	—.11

When the hay was fed by itself the nutritive ratio of the digestible ingredients was 1:7.7, and when fed with molasses, 1:9; molasses constituted 9.5 per cent. of the dry matter of the hay-molasses ration. In case of Sheep II. the 100 grams of molasses created a very marked depression in the digestibility of the several ingredients of the hay, namely, 21.09 (22.73) grams of dry matter, equal to 4.7 per cent. In case of Sheep III. there appears to have been a very slight gain in the digestibility of the hay.

Series XIII., Period I.

[600 grams hay, 100 grams Porto Rico molasses, 10 grams salt.]

(*a*) *Coefficients for Molasses.*

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Sheep I,	99.77	48.08	52.40	102.01
Sheep II,	96.34	47.36	23.65	100.66
Average,	98.06	47.70	38.03	101.34

(*b*) *Depression noted* (*Grams*).

Sheep I.

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 600 grams hay when fed alone,	354.34	18.07	40.41	110.27	178.99	6.54
Digested of 600 grams hay plus 100 grams molasses,	427.10	20.89	42.16	113.00	243.99	7.05
Minus 100 grams molasses, all digested,	72.93	5.87	3.34	-	63.72	-
Remains for 600 grams hay digested when fed with molasses,	354.17	15.02	38.82	113.00	180.27	7.05
Difference,	—.17	—3.05	—1.59	+2.73	+1.28	+.51

Sheep II.

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 600 grams hay when fed alone,	354.54	18.07	40.41	110.27	178.99	6.54
Digested of 600 grams hay plus 100 grams molasses,	424.60	20.85	41.20	112.62	243.13	6.79
Minus 100 grams molasses, all digested,	72.93	5.87	3.34	-	63.72	-
Remains for 600 grams hay digested when fed with molasses,	351.76	14.98	37.86	112.62	179.41	6.79
Difference,	—2.67	—3.09	—2.55	+2.35	+.42	+.25

The nutritive ratio of the hay when fed by itself was 1: 7.5, and of the molasses-hay ration, 1: 8.6; the dry matter of the molasses constituted some 12 per cent. of the dry matter of the hay-molasses ration. A slight depression only is noted, being rather more pronounced in case of Sheep II. The depression falls upon the ash and protein. An apparent slight improvement in digestibility is noted in case of the fiber and extract matter. Sheep I. gained 3 pounds in live weight, and Sheep II. maintained equilibrium.

SERIES XI., PERIOD III.[1]

[800 grams hay, 150 grams molasses and 10 grams salt.]

(*a*) *Coefficients for Molasses.*

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Paige Sheep IV.,	107.09	92.16	40.43	102.76
Paige Sheep V.,	90.93	80.02	10.17	95.80

[1] Already published in nineteenth report of this station, p. 145.

The coefficients indicate that in one case the molasses depressed the digestibility of the hay and in one case it actually improved it.

(*b*) *Depression noted* (*Grams*).

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Paige Sheep IV., ...	+7.60	—.71	—2.52	+8.03	+2.60	+.42
Paige Sheep V., ...	—9.73	—1.81	—3.80	—.04	—3.95	+.19

The nutritive ratio of the hay ration was as 1 : 9.9, and of the hay-molasses ration, 1 : 10.7 ; molasses constituted 13.2 per cent. of the dry matter of the total ration. In this case the results are contradictory, in one case increasing and in the other depressing the digestibility of the hay. Each sheep lost 2 pounds in weight during the seven days.

Series XIII., Period III.

[600 grams hay, 200 grams molasses, 10 grams salt.]

(*a*) *Coefficients for Molasses.*

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Sheep I, ...	88.96	59.34	21.57	94.76
Sheep II, ...	74.67	52.41	-	89.72

(*b*) *Depression noted* (*Grams*).

Sheep I.

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 600 grams hay when fed alone,	357.06	18.22	40.72	111.13	180.37	6.60
Digested of 600 grams hay plus 200 grams molasses, ...	486.81	25.24	42.20	111.76	300.89	6.75
Minus 200 grams molasses, assumed to be all digested, ...	145.86	11.83	6.86	-	127.18	-
Remains for 600 grams hay digested when fed with molasses, ...	340.95	13.41	35.34	111.76	173.71	6.75
Difference or depression, ...	—16.11	—4.81	—5.38	+.63	—6.66	+.15

Sheep II.

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 600 grams hay when fed alone,	357.06	18.22	40.72	111.13	180.37	6.60
Digested of 600 grams hay plus 200 grams molasses, ...	465.99	24.42	40.71	100.14	294.48	6.25
Minus 200 grams molasses, assumed to be all digested, ...	145.86	11.83	6.86	-	127.18	-
Remains for 600 grams hay digested when fed with molasses, ...	320.13	12.59	33.85	100.14	167.30	.25
Difference or depression, ...	—36.96	—5.63	—6.87	—10.99	—13.07	—.35

The nutritive ratio of the hay when fed alone was 1:7.5, and of the hay-molasses ration, 1: 10.1; molasses constituted 21.4 per cent. of the dry matter of the hay ration. The digestion depression is very noticeable, especially with Sheep II. The average depression for both sheep was 13.56 grams of dry matter and 10.63 grams of organic matter per 100 grams of molasses. The total average depression was equivalent to 18.2 per cent. of the dry matter of the molasses consumed. The feeding of 200 grams of molasses caused an average loss of 7.4 per cent. in the digestibility of the hay. No particular change was noted in the live weight of either animal.

Series XI., Period IV.[1]

[800 grams hay, 250 grams molasses, 10 grams salt.]

(*a*) *Coefficients for Molasses.*

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Paige Sheep IV., ...	91.89	47.38	-	95.35
Paige Sheep V., ...	88.21	57.54	-	95.30

(*b*) *Depression noted* (*Grams*).

Average, Sheep, IV. and V.

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 800 grams hay when fed alone,	404.56	23.19	32.51	132.44	208.07	8.03
Digested of 800 grams hay plus 250 grams molasses, ...	566.92	31.20	32.04	136.99	358.65	8.06
Minus 250 grams molasses, all digested, .	180.30	15.24	7.10	-	157.96	-
Remains for 800 grams hay digested when fed with molasses, ...	386.62	15.96	24.94	136.99	200.69	8.06
Difference or depression, ...	—17.94	—7.23	—7.57	+4.55	—7.38	+.03

The nutritive ratio of the hay-molasses ration was 1: 11.2, and molasses constituted 20.6 per cent. of the dry matter of the total ration. The results show that 17.94 (17.60) grams less hay were digested when 250 grams of molasses were fed than when the hay was fed by itself; or 100 grams of molasses caused

[1] Already reported, *loco citato*, pp. 146, 147.

a depression in the hay of 7.2 (7.02) grams of dry matter and 4.1 grams of organic matter. The depression was equivalent to 9.9 per cent. of the dry matter of the molasses fed. The total molasses likewise caused a loss of 4.4 per cent. in the digestibility of the dry matter of the hay.

General Summary.

In the table below the results of the several experiments with hay and molasses are brought together for comparison. The results of one experiment by Kellner are also stated.

RATION.	Nutritive Ratio.	Per Cent. Molasses in Dry Matter of Ration.	Depression per 100 Grams Fresh Molasses fed.		Depression equals Per Cent. of Molasses fed (Dry Matter).	Percentage Loss in Digestibility of Hay.	Gain or Loss in Live Weight (Pounds).
			Dry Matter (Grams).	Organic Matter (Grams).			
800 grams hay, . .	-	-	—21.09	—15.60	-	-	—1.0
100 grams molasses, .	1:9.0	9.50	+3.36	+5.50	-	-	±
600 grams hay, . .	-	-	—0.12	+2.93	-	-	+3.0
100 grams molasses, .	1:8.6	12.0	—2.62	+0.47	-	-	±
600 grams hay, . .	-	-	+5.21	+6.90	-	-	—2.0
150 grams molasses, .	1:10.7	13.2	—6.27	—5.07	-	-	—2.0
600 grams hay, . .	-	-	—8.04	—5.63	-	-	—.75
200 grams molasses, .	1:10.1	21.4	—18.45	—15.64	8.2	7.4	+1.25
800 grams hay, . .	-	-	-	-	-	-	+4.50
250 grams molasses, .	1:11.2	20.6	—7.10	—4.10[1]	9.9	4.4	+3.00
800 grams hay,[2] . .	-	-	-	-	-	-	-
100 grams molasses, .	1: 9.3	9.2	-	—14.4	22.4[3]	3.4	-

The nutritive ratio of the different lots of hay varied from 1: 7.5 to 1: 9.9; the addition of different amounts of molasses naturally widened the ratio, variations being noted of from 1: 8.6 to 1: 11.2. So far as one is able to judge, the different ratios were without effect on depression. Our own experiments indicate that when cane molasses constituted from 10 to 13 per cent. of the dry matter of the total ration it was without pronounced effect on the digestibility of the hay. In case of one trial with one sheep the depression was very marked, but in the other five single trials with different sheep the influence was slight, or one trial was contradictory of the other. The same

[1] Average, two sheep.
[2] Kellner's results in Landw. Vers., 55 Bd. S. 384.
[3] Organic matter of molasses fed.

results hardly hold true in case of Kellner's trial with two sheep, in which beet molasses composed 9.2 per cent of the dry matter of the ration. Here one notes a depression of 14.4 grams of organic matter per 100 grams of molasses. The two sheep gave closely agreeing results.

In our own case, when molasses composed some 20 per cent. of a hay-molasses ration the depression was quite noticeable, averaging in case of four single trials with four different sheep 10.14 grams of digestible dry matter and 7.37 grams of digestible organic matter for each 100 grams of molasses fed. These latter trials show a loss or depression equivalent to from 9.9 to 18.2 per cent. of the dry matter of the molasses fed; or, otherwise expressed, the molasses caused a loss of from 4.4 to 7.4 per cent. in the digestibility of the hay. The feeding of 20 per cent. of cane molasses did not cause as great a depression as did the feeding of 9.2 per cent. of beet molasses (Kellner's results). It is doubtful, however, if these varying results are due to the different kinds of molasses.

In experiments of this sort one is obliged to take into account individuality, the effect of food upon different individuals, as well as the condition of the animal at the time of the trial. Positive conclusions cannot be drawn unless the evidence is very pronounced. Why it is that two animals, both apparently in good condition, should give contrary results it is difficult to explain. Thus, in the above table note that molasses appeared to have caused a depression of 21.09 grams dry matter with one sheep and an increase of 3.36 grams with another; also, in another case 100 grams of molasses caused an increase of 5.21 grams and in another case a decrease of 6.27 grams in the digestibility of the hay.

B. Hay, Corn Meal and Molasses.

Two experiments were conducted in each case with two sheep, using 100 and 200 grams of molasses. Unfortunately, in each experiment one of the sheep suffered from indigestion and did not complete the trial.

Summary of Results.

Series XIII., Period VI.

[500 grams hay, 150 grams corn meal, 100 grams molasses, 10 grams salt.]

(a) Coefficients for Molasses.

	Dry Matter.	Ash.	Protein.	Extract Matter.
Sheep III.,	85.20	78.60	19.24	91.29

(b) Depression noted (Grams).

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of hay and corn meal when fed without molasses,	407.18	15.67	42.30	89.07	249.23	10.94
Digested of hay and corn meal plus 100 grams molasses,	469.12	20.37	42.96	87.99	307.01	10.74
Minus 100 grams molasses, all digested,	72.70	5.98	3.43	-	63.69	-
Remains for hay and corn meal digested when fed with molasses,	396.42	14.39	39.53	87.99	243.72	10.79
Difference or depression,	—10.76	—1.28	—2.77	—1.08	—5.51	—.15

The nutritive ratio of the hay and corn-meal ration was 1: 8.6, and of the hay-corn-meal-molasses ration, 1: 9.7; molasses constituted 11 per cent. of the dry matter of the total ration. The depression observed is 10.79 (10.76) grams of dry matter and 9.51 grams of organic matter per 100 grams of molasses.

Series XIII., Period VIII.

[500 grams hay, 150 grams corn meal, 200 grams molasses, 10 grams salt.]

(a) Coefficients for Molasses.

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Sheep II.,	75.26	23.11	60.44	84.90

(*b*) *Depression noted* (*Grams*).

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of hay and corn meal when fed without molasses,	414.44	12.97	21.90	110.60	258.01	10.94
Digested of hay and corn meal plus 200 grams molasses,	423.99	22.83	26.04	98.41	365.67	11.02
Minus 200 grams molasses, all digested,	145.56	11.89	6.85	-	126.21	-
Remains for hay and corn meal digested when fed with molasses,	378.43	10.94	19.19	98.41	238.86	11.02
Difference or depression,	–36.01	–2.03	–2.71	–12.19	–19.15	+.08

Molasses constituted 20 per cent. of the dry matter of the total ration; the nutritive ratio of the hay-corn-meal ration was 1 : 17.9, and of the hay-corn-meal-molasses ration 1 : 18.4.[1] The depression was very noticeable, being 18 grams of dry matter and 17 grams of organic matter per 100 grams of molasses.

C. Hay, Gluten Feed and Molasses.

Numerous experiments were carried out to note the effect of different amounts of molasses upon a combination of hay and gluten feed, the latter being a rich protein concentrate. Hay, gluten feed and molasses is a much more suitable ration than is one composed only of hay and molasses, or of hay, corn meal and molasses.

In calculating the depression caused by the molasses, the digestibility of the hay-gluten-feed ration was first determined. The amount of molasses fed was assumed to be all digested and was deducted from the total amount digested of the hay-gluten-feed-molasses ration, the remainder being the hay and gluten feed digested when fed with the molasses. The difference between the hay-gluten-feed digested when fed without the molasses

[1] A new lot of hay was used in this experiment; it contained only 7.19 per cent. of protein, as against 12.24 per cent. in the hay used to secure the coefficients for the digestibility of the hay and corn meal, and which were applied to the hay-corn-meal and 100 grams molasses ration. The low protein content of the hay accounts for the very wide nutritive ratio of the present hay-corn-meal-molasses ration. The coefficients of the hay-corn-meal ration, applied in case of the present experiment, were those obtained with the hay having the high protein content. Had an experiment been made with the low protein hay-corn-meal ration it is possible the coefficients might have been lower than the ones actually used, in which case a less depression wou'd have been obtained than the one actually found.

and when fed with the molasses shows the depression exerted by the latter. The coefficients of digestibility for the hay and for the hay-gluten-feed rations will be found in a table with the other data.

Summary of Results.

SERIES XIV., PERIOD VI.

[500 grams hay, 150 grams gluten feed, 50 grams molasses, 10 grams salt.]

(a) Coefficients for Molasses.

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Sheep III.,	38.19	-	-	66.08
Sheep IV.,	9.73	-	-	38.47

(b) Depression noted (Grams).

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Sheep III.,	—23.13	—4.10	—4.26	—4.83	—10.90	—.33
Sheep IV.,	—33.78	—3.44	—5.48	—7.26	—19.77	—.26

(c) Average, Sheep III. and IV. (Grams).

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 500 grams English hay and 150 grams gluten feed when fed without molasses,	409.17	16.27	48.74	103.26	232.16	10.16
Digested of hay and gluten feed plus 50 grams molasses,	418.14	15.56	46.55	97.21	248.96	9.87
Minus 50 grams molasses, all digested,	37.42	3.06	2.23	-	32.13	-
Remains for hay and gluten feed digested when fed with molasses,	380.71	12.50	44.32	97.21	216.83	9.87
Difference or depression,	—28.46	—4.32	—4.42	—6.05	—18.49	—.30

The nutritive ratio of the hay-gluten-feed ration was 1:7.3, of the hay-gluten-feed-molasses ration, 1:8. The rather wide ratio of the hay-gluten-feed ration was due to the low protein content of the hay. Molasses constituted only 6 per cent. of the dry matter of the total ration. The average depression was 59.72 (56.92) grams of dry matter and 52.18 (49.32) grams of organic matter per 100 grams of fresh molasses fed, and equaled about 76 per cent. of the dry matter of the molasses fed. The feeding of 50 grams of molasses caused an apparent depression, or loss of 6.9 per cent. in the digestibility of the hay-gluten-feed-ration. The cause of this excessive depression for so small an amount of molasses is not clear. The sheep substantially maintained their weight during the experiment.

Series XIV., Period VII.

[500 grams hay, 150 grams gluten feed, 100 grams molasses, 10 grams salt.]

(a) Coefficients for Molasses.

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Sheep III.,	66.37	19.61	-	86.02
Sheep IV.,	42.92	34.36	-	65.48

(b) Depression noted (Grams).

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Sheep III.,	—25.32	—4.96	—6.08	—6.73	—9.03	+.18
Sheep IV.,	—42.96	—4.01	—5.83	—11.97	—22.29	—.40

(c) Average, Sheep III. and IV. (Grams).

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 500 hay and 150 grams gluten feed when fed without molasses,	411.92	16.36	49.29	103.69	233.77	10.25
Digested of hay and gluten feed plus 100 grams molasses,	453.04	18.04	47.85	94.34	282.69	10.14
Minus 100 grams molasses, assumed to be all digested,	75.26	6.17	4.51	-	64.58	-
Remains for hay and gluten feed digested when fed with molasses,	377.78	11.87	43.34	94.34	218.11	10.14
Difference or depression,	—34.14	—4.49	—5.95	—9.35	—15.66	—.11

The nutritive ratio of the hay-gluten-feed ration was 1 : 7.3, and of the hay-gluten-feed-molasses ration, 1 : 8.6; molasses constituted 11.3 per cent. of the dry matter of the total ration. The average depression found was 35.56 (34.14) grams of dry matter and 31.07 grams of organic matter per 100 grams of molasses, and is equivalent to 47 per cent. of the molasses fed. The feeding of 100 grams of molasses caused a loss of 8.3 per cent. in the digestibility of the hay-gluten-feed ration. Sheep IV. showed considerably more depression than Sheep III.; the former sheep lost ½ pound and the latter gained 2 pounds in weight during the seven days of the trial.

Series XII., Period V.

[600 grams hay, 200 grams gluten feed, 100 grams molasses, 10 grams salt.]

(a) Coefficients for Molasses.

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Paige Sheep IV.,	52.27	51.30	-	70.31
Paige Sheep V.,	48.88	77.53	-	69.70
Average,	50.58	64.42	-	70.01

(b) Depression noted (Grams).

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Paige Sheep IV.,	—37.14	—2.35	—6.91	—7.75	—19.83	—.35
Paige Sheep V.,	—35.39	—1.44	—7.06	—8.16	—19.53	+.76

(c) Average, Sheep IV. and V. (Grams).

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 600 grams hay and 200 grams gluten feed when fed without molasses,	515.72	15.39	82.23	145.12	262.16	10.87
Digested of hay and gluten feed plus 100 grams molasses,	552.83	18.83	78.03	137.16	307.72	11.08
Minus 100 grams molasses, all digested,	73.37	5.34	2.79	-	65.24	-
Remains for hay and gluten feed digested when fed with molasses,	479.46	13.49	75.24	137.16	242.48	11.08
Difference or depression,	—36.26	—1.90	—6.99	—7.96	—19.68	+.21

The nutritive ratio of the hay-gluten-feed ration was 1:5.2, and of the hay-gluten-feed-molasses ration, 1:6; molasses represented 9.4 per cent. of the dry matter of the total ration.

The average depression was 36.32 grams of dry matter and 34.42 grams of organic matter per 100 grams of molasses fed, and equaled 50 per cent. of the dry matter of the molasses fed. The feeding of 100 grams of molasses caused a depression, or loss of 7 per cent. in the digestibility of the hay-gluten-feed ration.

Both sheep were in good condition during the experiment; Sheep IV. showed an apparent gain of 4 pounds and Sheep V. a loss of 3.5 pounds. Such variations would hardly be expected.

SERIES XIV., PERIOD IX.

[500 grams hay, 150 grams gluten feed, 150 grams molasses, 10 grams salt.]

(*a*) *Coefficients for Molasses.*

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Sheep IV., ...	56.63	30.24	-	76.86

(*b*) *Depression noted (Grams).*

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 500 grams hay and 150 grams gluten feed when fed without molasses, .	423.47	16.91	49.53	107.16	241.60	9.90
Digested of hay and gluten feed plus 150 grams molasses, ...	487.01	19.75	44.90	97.32	315.49	9.55
Minus 150 grams molasses, all digested, .	112.20	9.39	6.68	-	96.13	-
Remains for hay and gluten feed digested when fed with molasses, ...	374.81	10.36	38.22	97.32	219.36	9.55
Difference or depression, ...	—48.66	—6.55	—11.31	—9.84	—22.24	—.35

The nutritive ratio of the hay-gluten-feed ration was as 1 : 7.5, and of the hay-gluten-feed-molasses ration, 1 : 9.7; molasses composed 16 per cent. of the dry matter of the ration. The depression noted was 33.52 grams of dry matter and 29.16 grams of organic matter per 100 grams of molasses fed, and is likewise equivalent to practically 45 per cent. of the dry matter of the molasses consumed. The feeding of 150 grams of molasses caused a loss of 11.9 per cent. in the digestibility of the hay-gluten-feed ration. This sheep made a gain of 5 pounds in one week according to our weights.

Series XIV., Period IV.

[500 grams hay, 150 grams gluten feed, 200 grams molasses, 10 grams salt.]

(a) Coefficients for Molasses.

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Sheep III., ...	77.58	47.22	24.19	88.30
Sheep IV., ...	74.18	48.27	1.05	85.21

(b) Depression noted (Grams).

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Sheep III., ...	—33.41	—6.55	—6.52	—6.46	—14.98	—.18
Sheep IV., ...	—38.47	—6.42	—8.51	—6.00	—18.93	—.04

(c) Average, Sheep III. and IV. (Grams).

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 500 grams hay and 150 grams gluten feed when fed without molasses, .	408.00	16.23	48.55	103.02	231.48	10.13
Digested of hay and gluten feed plus 200 grams molasses, ...	521.08	22.16	49.64	96.79	342.53	9.97
Minus 200 grams molasses, all digested, .	149.02	12.41	8.60	-	128.01	-
Remains for hay and gluten feed digested when fed with molasses, ...	372.06	9.75	41.04	96.72	214.52	9.97
Difference or depression, ...	—35.94	—6.48	—7.51	—6.23	—16.96	—.16

The ratio of the hay-gluten-feed-molasses ration was as 1: 9.3, against 1: 7.4 in case of the hay-gluten-feed ration, and 20.4 per cent. of the dry matter of the entire ration consisted of molasses. The depression was 18.67 (17.97) grams of dry matter and 15.43 (14.73) grams of organic matter per 100 grams of molasses, which was equal to 25 per cent. of the dry matter of the molasses fed. The feeding of 200 grams of molasses caused a loss or depression of 7.60 per cent. in the digestibility of the 650 grams of hay-gluten-feed ration. Sheep III. lost 2 pounds and Sheep IV. 3.5 pounds in live weight during the trial.

SERIES XII., PERIOD VII.

[600 grams English hay, 200 grams gluten feed, 200 grams molasses, 10 grams salt.]

(a) Coefficients for Molasses.

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Paige Sheep IV., ...	76.78	76.59	-	85.72
Paige Sheep V., ...	73.71	81.06	-	84.21

(b) Depression noted (Grams).

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Sheep IV., ...	—34.18	—2.51	—7.66	—6.19	—18.70	+.94
Sheep V., ...	—38.70	—2.03	—6.70	—10.55	—20.67	+1.30

(c) Average, Sheep IV. and V. (Grams).

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 600 grams hay and 200 grams gluten feed when fed without molasses, .	517.35	15.43	82.53	145.51	262.94	10.91
Digested of hay and gluten feed plus 200 grams molasses, ...	628.13	23.88	80.94	137.14	374.17	12.03
Minus 200 grams molasses, all digested, .	147.22	10.72	5.59	-	130.91	-
Remains for hay and gluten feed when fed with molasses, ...	480.91	13.16	75.35	137.14	243.26	12.03
Difference or depression, ...	—36.44	—2.27	—7.18	—8.37	—19.68	+1.12

The nutritive ratio of the hay and gluten-feed ration was 1 : 5.2, and with the addition of 200 grams molasses, 1 : 6.7 ; molasses composed 17.2 per cent. of the dry matter of the total ration. The depression observed was 18.2 grams of dry matter and 17.05 grams of organic matter per 100 grams of molasses fed, and is equivalent to 25 per cent. of the dry matter of the molasses fed. The feeding of 200 grams of molasses caused a loss of 7 per cent. in the digestibility of the hay-gluten-feed ration. Both sheep lost in weight during the experiment, Sheep IV. losing 4 pounds and Sheep V. 5 pounds. This is not what would be expected from animals receiving more than a maintenance ration. Sheep IV. passed through the experiment in good condition. Sheep V. began to show signs of indigestion shortly after the beginning of the period proper, and the disturbance became so pronounced that the experiment was discontinued at the end of the sixth day. The results show that he digested a little less than Sheep IV.

This and the trial immediately preceding show similar results; namely, an equal depression and a loss in weight, in spite of the fact that the several animals were receiving more than a maintenance ration.

Series XI., Period VIII.

[600 grams hay, 200 grams gluten feed, 250 grams molasses, 10 grams salt.]

(*a*) *Coefficients for Molasses.*

	Dry Matter.	Ash.	Extract Matter.
Paige Sheep IV.,	76.50	64.12	86.93
Paige Sheep V.,	72.53	65.25	84.80
Average,	74.52	64.59	85.87

(*b*) *Depression noted* (*Grams*).

	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Digested of hay and gluten feed when fed without molasses,	524.97	18.75	81.88	148.40	264.22	11.74
Digested of hay and gluten feed plus molasses,	660.31	29.58	79.47	139.96	399.66	11.61
Minus 250 grams molasses fed, assumed to be all digested,	181.68	16.75	7.16	-	157.77	-
Hay and gluten feed digested when fed with molasses,	478.63	12.83	72.31	139.96	241.89	11.61
Difference or depression,	—46.34	—5.92	—9.57	—8.44	—22.33	—.13

The nutritive ratio of the hay-gluten-feed ration was 1 : 5.3, and of the hay-gluten-feed-molasses ration, 1 : 7.1; molasses constituted 20.2 per cent. of the dry matter of the total ration. The average depression for both sheep was 18.5 grams of dry matter and 16.1 grams of organic matter per 100 grams of molasses, and equals 25.5 per cent. of the dry matter of the molasses fed.

The feeding of 250 grams of molasses caused a loss of 8.8 per cent. in the digestibility of the hay-gluten-feed ration. Each sheep lost 3 pounds in live weight during the seven days.

Series XII., Period XI.

[600 grams English hay, 200 grams gluten feed, 250 grams molasses, 10 grams salt.]

(a) Coefficients for Molasses.

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Young Sheep II., ...	70.10	39.63	-	82.92

(b) Depression noted (Grams).

	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Digested of 600 grams English hay and 200 grams gluten feed when fed without molasses, ...	498.12	15.47	74.29	139.31	256.86	11.84
Digested of hay and gluten feed plus 250 grams molasses, ...	628.12	20.82	71.91	131.24	393.59	10.56
Minus 250 grams molasses, all digested, .	185.45	13.50	7.05	-	164.90	-
Remains for hay and gluten feed digested when fed with molasses, ...	442.67	7.32	64.86	131.24	228.69	10.56
Difference or depression, ...	—55.45	—8.15	—9.43	—8.07	—28.17	—1.28

The ratio of the hay-gluten-feed-molasses ration was as 1 : 7.6, and of the hay-gluten-feed ration 1 : 5.7; molasses constituted 20.4 per cent. of the dry matter of the total ration. The depression observed was 22 (22.2) grams of dry matter and 18.8 (19) grams of organic matter for each 100 grams of molasses fed, and was equivalent to about 30 per cent. of the dry matter of the molasses. The feeding of 250 grams of molasses caused a loss of 11.1 per cent. in the digestibility of the hay and gluten feed. The sheep passed through the trial in good condition, and neither gained nor lost in live weight.

Series XII., Period X.

[600 grams English hay, 200 grams gluten feed, 300 grams molasses, 10 grams salt.]

(a) Coefficients for Molasses.

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Paige Sheep IV., ...	87.09	74.25	-	92.60

(*b*) *Depression noted* (*Grams*).

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 600 grams English hay and 200 grams gluten feed when fed without molasses,	523.59	15.63	83.44	147.41	266.00	11.04
Digested of hay and gluten feed plus 300 grams molasses,	715.92	27.57	82.21	146.52	447.82	11.80
Minus 300 grams molasses, all digested,	220.83	16.08	8.39	-	196.36	-
Remains for hay and gluten feed digested when fed with molasses,	495.09	11.49	73.82	146.52	251.46	11.80
Difference or depression,	—28.50	—4.14	—9.62	—.89	—14.54	+.76

The nutritive ratio of the hay-gluten-feed ration was as 1 : 5.2, and of the hay-gluten-feed-molasses ration, 1 : 7.6 ; molasses constituted some 23.5 per cent. of the dry matter of the total ration. The depression was 9.48 grams of dry matter and 8.1 grams of organic matter for each 100 grams of molasses fed, and was equivalent to 13 per cent. of the dry matter of the molasses. The feeding of 300 grams of molasses caused a loss of 5.4 per cent. in the digestibility of the hay-gluten-feed ration. The sheep kept in good condition during the experiment, but showed an apparent loss in live weight of 8 pounds. This is believed to be an error, although in a general way it confirms the results of previous trials, which indicate that when molasses constitutes more than 15 per cent. of the dry matter of the total ration a loss of live weight results, although more than a maintenance ration is being fed.

General Summary.

Effect of Molasses upon Digestibility of Hay and Gluten Feed.

In the following table an attempt has been made to summarize the principal results of feeding different amounts of molasses upon the digestibility of a ration composed of hay and gluten feed. The results obtained by Lehmann[1] and by Garland[2] are also appended.

[1] *Loco citato.*

[2] Berichte des landw. Institutes der Univ. Halle, XV. Heft, pp. 23-25.

Our Own Results.

RATION.	Nutritive Ratio.	Per Cent. Molasses in Dry Matter of Ration.	Depression per 100 Grams Molasses fed. Dry Matter (Grams).	Depression per 100 Grams Molasses fed. Organic Matter (Grams).	Depression equals Per Cent. of Molasses fed (Dry Matter).	Percentage Loss in Digestibility of Hay and Gluten Feed.	Gain or Loss in Live Weight. (Pounds.)
500 grams hay, 150 grams gluten, 50 grams molasses	1:8.0	6.0	59.72	52.18	76.0	6.9	—1.00, —.50
500 grams hay, 150 grams gluten, 100 grams molasses	1:8.6	11.3	35.56	31.07	47.0	8.3	—.50, +2.00
600 grams hay, 200 grams gluten, 100 grams molasses	1:6.0	9.4	36.32	34.42	50.0	7.0	+4.00, —3.50
500 grams hay, 150 grams gluten, 150 grams molasses	1:9.7	16.0	33.50	29.16	45.0	11.9	+5.00
500 grams hay, 150 grams gluten, 200 grams molasses	1:9.3	20.4	18.67	15.43	25.0	7.6	—2.00, —3.50
600 grams hay, 200 grams gluten, 200 grams molasses	1:6.7	17.2	18.20	17.05	25.0	7.0	—4.00, —5.00
600 grams hay, 200 grams gluten, 250 grams molasses	1:7.1	20.2	18.56	16.1	25.5	8.8	—3.00, —3.00
600 grams hay, 200 grams gluten, 250 grams molasses	1:7.6	20.4	22.0	18.8	30.0	11.1	-
600 grams hay, 200 grams gluten, 300 grams molasses	1:7.6	23.5	9.5	8.1	13.0	5.4	—8.00

Lehmann's Results.

RATION.	Nutritive Ratio.	Per Cent. Molasses in Dry Matter of Ration.	Dry Matter (Grams).	Organic Matter (Grams).	Depression equals Per Cent. of Molasses fed (Dry Matter).	Percentage Loss in Digestibility.	Gain or Loss in Live Weight.
500 grams hay, 300 grams cottonseed meal, 200 grams molasses	1:3.3	18.0[1]	19.75	22.2	28.5[1]	8.2	-
500 grams hay, 300 grams palm-nut cake, 300 grams molasses	1:9.5	24.0[1]	8.8	11.6	15.0[1]	6.1	-
500 grams hay, 300 grams cottonseed meal, 400 grams molasses	1:4.4	32.0[1]	7.0	7.4	9.5[1]	6.0	-

Garland's Results.

RATION.	Nutritive Ratio.	Per Cent. Molasses in Dry Matter of Ration.	Dry Matter (Grams).	Organic Matter (Grams).	Depression equals Per Cent. of Molasses fed (Dry Matter).	Percentage Loss in Digestibility.	Gain or Loss in Live Weight.
476 grams hay and grain, 68 grams molasses	1:5.7	11.0	-	13.8	16.7	3.8	-

[1] Estimated, assuming that the molasses contained 78 per cent. of dry matter, the hay 88 per cent. and the concentrates 92 per cent.

The nutritive ratio of the two hay and gluten-feed rations with which the molasses was fed varied from 1: 5.5 to 1: 7.5, hence the nutrients may be considered satisfactorily proportioned. After the addition of the molasses the rations were widened from 1: 6 to 1: 9.7; most of them could not be considered unduly wide. In two of the three experiments reported by Lehmann the rations were quite narrow, due to the presence of so much cottonseed meal. So far as one is able to judge, the width of the ration did not bear any direct relation to the depression observed. In all of the experiments reported molasses constituted from 6 per cent. to approximately 32 per cent. of the dry matter of the total ration.

It is noted that when molasses made up from 9 to 16 per cent. of the dry matter of the ration, the depression averaged 32.1 grams of organic matter per 100 grams of fresh molasses; when molasses composed about 20 per cent. of the dry matter of the ration, in case of eight single trials, it averaged approximately 15.5 grams of organic matter per 100 grams of molasses. The average of all of our experiments, excepting the first, show a depression of 21.8 grams of organic matter per 100 grams of fresh molasses. Lehmann's experiments show that when beet molasses composed 18 per cent. of the dry matter of the ration, the depression was 22.2 grams of organic matter per 100 grams of molasses. This depression decreased to 7.4 grams of organic matter per 100 grams of molasses when molasses composed some 30 per cent. of the dry matter of the ration.

Results of a similar character are secured when one calculates the depression on the basis of the percentage of the dry matter of the molasses fed. When it composed 9 to 16 per cent. of the dry matter of the total ration, the depression or loss was equivalent to nearly 50 per cent. of the amount fed. When, however, 20 per cent. of the dry matter of the total ration consisted of molasses, the depression equaled only 24 per cent. In case of Lehmann's results, the depression decreased from 28.5 to 9.5 per cent.

The percentage loss in digestibility of the feeds with which the molasses was fed proved to be reasonably constant. The average percentage loss in case of twelve experiments, including nine of our own and three of Lehmann's, was 7.86. In most cases the variations do not depart widely from this average. The smaller amounts of molasses in most cases caused practically as much absolute depression as the larger amounts.

The amount of hay and gluten-feed fed to the different sheep was probably a little less than a maintenance ration; this was intended in order that, when from 100 to 300 grams of molasses were added, the total amount would not be more than the animal could consume.

With molasses composing 6 to 11.3 per cent. of the dry matter of the ration, one notes, on the whole, comparatively little change in the live weight, but when this was increased to some 20 per cent., the live weight of each sheep shows a pronounced decrease in almost every case, although the total ration was certainly in excess of maintenance requirements. The reason for this loss in weight cannot be explained. Occasional qualitative tests for sugar in the fæces were made with negative results. The urine was not collected, but it is believed that sugar would not have thus escaped unassimilated. The loss of digestible material through depression hardly seems sufficient to account for it. A possible explanation lies in the fact that each sheep was given 2,500 grams of water daily, usually considered a liberal allowance. In most of the cases showing a loss in weight the sheep drank the entire amount, but the attendant, contrary to instructions, failed to supply more. It may be that the molasses induced an increased thirst, and required more water for its complete metabolism than was supplied, and the intake of water being relatively less than the outgo caused a temporary loss of weight. In one case, however, where the 2,500 grams of water were entirely consumed, the sheep neither gained nor lost in weight. It is to be regretted, however, that this oversight occurred.

General Conclusions.

(*a*) *Hay and Molasses.*

1. Our own experiments indicate that molasses had relatively little effect in depressing the digestibility of the hay when the amount fed did not exceed 10 to 13 per cent. of the dry matter of the total ration.

2. When molasses composed 20 per cent. of the dry matter of the total ration, the depression averaged 7.37 grams of organic matter per 100 grams of fresh molasses, and the molasses caused substantially a loss of 6 per cent. in the digestibility of the hay.

(*b*) *Hay, Corn Meal and Molasses.*

3. In case of two single trials the depression was from 9.5 to 17 grams of organic matter per 100 grams of molasses.

(*c*) *Hay, Gluten Feed and Molasses.*

4. When relatively small amounts of molasses were fed the depression was higher *per 100 grams of molasses* than when relatively large amounts were fed.

5. When relatively small amounts of molasses were fed the loss expressed in dry matter *as percentage of molasses fed* was higher than when relatively large amounts of molasses were consumed.

6. The feeding of small amounts of molasses have in most cases caused as much depression of the feeds with which they were fed as large amounts, the loss averaging substantially 8 per cent.

Why molasses seemed to exert less depression on the hay than on a ration composed of hay and a concentrate is difficult of explanation.

D. *The Cause of the Depression produced by Molasses.*

Our own numerous experiments, as well as those of other investigators, have shown that molasses exerts a distinct depression upon those feed stuffs with which it is fed. This depression appears to vary, depending upon the character of the feed, the amount of molasses fed and the individuality and condition of the animal. The addition of considerable amounts of sugar and starch have been shown to produce similar results.[1]

The cause or causes of this depression have never been fully demonstrated. Kellner [2] offers a partial explanation substantially as follows: —

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[1] See the numerous experiments of Henneberg and Stohmann, Kühn and Fleischer, E. Wolff, etc., in the Journal für Landw. and in the Landw. Versuchssta.

[2] *Loco citato*, fünfte Auflage, pp. 50, 51.

(*a*) The cause or partial cause of the depression of the proteid matter is due to the increased excretion of metabolic by-products in the fæces. It has been definitely proved that for every 100 grams of digested dry matter there is excreted .4 to .5 of a gram of nitrogen, or 2.5 to 3.1 grams of protein, hence the additional carbohydrates increase the digestible dry matter and cause the excess excretion of metabolic nitrogen, which is calculated as undigested nitrogen.

(*b*) According to Hirschler [1] an increase of the carbohydrates or of lactic acid in the ration checks the action of putrefactive bacteria, *i.e.,* those acting upon the proteid matter, and G. Gothwald [2] has confirmed this for herbivorous animals.

(*c*) It being known that the easily soluble and digestible carbohydrates are large yielders of lactic and butyric acids in the processes of digestion, it seems at least possible that it is these acids, when present in sufficient quantities, which check the further action of the micro-organisms, and prevents their attacking the more difficult digestible carbohydrates, such as the fiber, pentosans, gums, etc.

Alquier and Drouineau [3] state that in case of ruminants the depression is caused because the food remains for a long time in the digestive tract, and is subjected to the action of various micro-organisms. These organisms follow the line of the least resistance, and attack the sugars and other soluble carbohydrates, leaving the cellulose, ligno-cellulose and pentosans, which they would attack and dissolve more freely were the soluble carbohydrates not present in excess; hence the depression falls largely upon these latter compounds.

It is further explained that in case of the horse the action of molasses in causing the depression is not due primarily to the action of micro-organisms for the reason that the food remains so short a time in the intestines, but to the alkaline salts, — potash and soda, — which cause an increased action of the intestines (peristalsis). Grandeau's work is cited, in which, in an average of four trials with four different horses the first fæces appeared sixteen hours after the feeding of molasses, while

[1] Zeitschrift für physiol. Chem. 10 Bd. 1886, p. 306; also 39 Bd. p. 99; Abs. from Kellner.
[2] Journal für Landw. 39 Jahrgang, 1888, p. 325.
[3] Ann. de Sci. Agron. 2 Serie, 1904. Tome I., pp. 252–258.

twenty-seven hours elapsed before the first fæces from a normal ration were excreted.

Observations at this Station.

In order to note the effect of molasses in increasing peristalsis, thereby causing a less complete digestion of the food, a number of observations were made using lampblack as an indicator.

October 21, at 4 P.M., Sheep III., receiving hay, gluten feed, salt and *200 grams of molasses,* was fed in addition 10 grams of lampblack. The first indication in the fæces appeared at 1 P.M. on the following day, — twenty-one hours after feeding. The lampblack could be observed in the fæces until 4 P.M. of October 25, — some four days thereafter.

October 27, at 4 P.M., and October 28, at 7 A.M., Sheep II., receiving a ration of hay, gluten feed and salt, was given in addition a total of 10 grams of lampblack. Indications of the lampblack first appeared at 2 P.M. on the following day, October 28, — twenty hours after the first feeding. At the same time Sheep IV., receiving hay, gluten feed, salt and *200 grams of molasses,* was given in addition 15 grams of lampblack, which first appeared in the fæces at 4 P.M. of the following day, — twenty-two hours later.

November 6, at 5 P.M., and November 7, at 7 A.M., Sheep I., receiving a ration of hay, gluten feed and salt, was fed in addition with 10 grams of lampblack, which first appeared in the fæces at noon on November 7, — nineteen hours later. This lampblack was noticed in the fæces until noon of November 12, nearly six days (one hundred and thirty-nine hours) after the first was given.

November 6, at 5 P.M., and November 7, at 7 A.M., Sheep IV., receiving a ration of hay, gluten feed, salt and *200 grams of molasses,* was given in addition a total of 15 grams of lampblack. It first appeared at 7 A.M., November 7, — fourteen hours later, — and disappeared at 7 A.M., November 12, — one hundred and thirty-four hours later.

November 7, at 4 P.M., and November 8, at 7 A.M., Sheep II., receiving a ration of hay, gluten feed and salt, was given in addition 10 grams of lampblack. The first indication of lampblack was at 7.30 A.M., November 8, — fifteen and a half hours later, — and it had entirely disappeared from the fæces on November 13, at 4 P.M., — six days later.

November 7, at 4 P.M., and November 8, at 7 A.M., Sheep III., receiving hay, gluten feed, salt and *200 grams of molasses*, received in addition a total of 15 grams of lampblack. The first colored fæces were noted November 8, at 2 P.M., — twenty-two hours later, — and the color disappeared November 13, at 4 P.M., — after a lapse of six days.

The above data placed in tabular form are as follows: —

Sheep Number.	Normal Ration. Lampblack appeared (Hours).	Molasses Ration. Lampblack appeared (Hours).	Normal Ration. Lampblack disappeared (Hours).	Molasses Ration. Lampblack disappeared (Hours).
II.,	20.0	-	-	-
I.,	19.0	-	139.0	-
II.,	15.5	-	144.0	-
IV.,	-	22.0	-	-
III.,	-	21.0	-	96
IV.,	-	14.0	-	134
III.,	-	22.0	-	144
Average,	18.2	19.7	141.5	139

It is evident that these results do not show sufficient variation to warrant a conclusion that the molasses exerted any peristaltic action. It is to be admitted that the lampblack did not prove as sharp an indicator as was desired. It is intended to make additional observations of a similar character, using another indicator, and also to continue our inquiry relative to the cause of the depression.

Data of the Experiments.

Composition of Feed Stuffs (Per Cent.).

[Dry Matter.]

Series.	Periods.	Feeds.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
XI.	III., IV.,	English hay,	8.20	8.69	32.14	48.56	2.41
XI.	V., VII., VIII.,	English hay,	6.75	12.23	33.45	44.67	2.90
XI.	VII.,	Gluten feed,	1.67	24.98	7.22	63.34	2.79
XI.	III., IV.,	Porto Rico molasses,	8.45	3.94	–	87.61	–
XI.	VIII.,	Porto Rico molasses,	9.22	3.94	–	86.84	–
XII.	III., IV., V., VII., X., XI., XIV.,	English hay,	6.75	12.23	33.45	44.67	2.90
XII.	IV., V., VII., X., XI., XIV.,	Gluten feed,	1.53	26.22	6.30	63.35	2.60
XII.	III., V., VII., X., XI.,	Porto Rico molasses,	7.28	3.80	–	88.92	–
XIII.	I., II., III., IV., V., VI.,	English hay,	6.46	12.24	29.24	49.49	2.57
XIII.	VII., VIII.,	English hay,	6.43	7.19	34.08	49.82	2.48
XIII.	II., IV., VI., VII., VIII.,	Corn meal,	1.58	10.45	2.10	81.22	4.65
XIII.	I.,	Porto Rico molasses,	8.05	4.58	–	87.37	–
XIII.	III.,	Porto Rico molasses,	8.11	4.70	–	87.19	–
XIII.	VI.,	Porto Rico molasses,	8.23	4.72	–	87.05	–
XIII.	VIII.,	Porto Rico molasses,	8.17	4.71	–	87.12	–
XIV.	XI.,	English hay,	7.13	7.75	32.64	50.01	2.49
XIV.	III., IV., V., VI., VII., IX.,	English hay,	6.82	7.67	30.35	52.79	2.37
XIV.	III., IV., V., VI., VII.,	Gluten feed,	4.12	27.22	7.81	56.54	4.31
XIV.	IV.,	Porto Rico molasses,	8.33	5.77	–	85.90	–
XIV.	VI.,	Porto Rico molasses,	8.18	5.95	–	85.87	–
XIV.	VII.,	Porto Rico molasses,	8.20	5.99	–	85.81	–
XIV.	IX.,	Porto Rico molasses,	8.37	5.95	–	85.68	–

Composition of Fæces (Per Cent.).

[Dry Matter.]

Series.	Periods.	Sheep Number.	Feed or Ration.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
X.	VI.	IV.	English hay,	11.61	9.90	30.66	44.91	2.92
X.	IX.	V.	English hay,	11.23	9.24	31.93	44.49	3.11
XI.	V.	IV.	English hay,	11.18	14.10	24.20	46.24	4.28
XI.	V.	V.	English hay,	10.49	13.17	26.51	45.74	4.09
XI.	VI.	II.	English hay,	10.80	14.70	23.99	46.27	4.24
XI.	VI.	III.	English hay,	10.57	14.03	25.31	45.74	4.35
XI.	VII.	IV.	Hay and gluten feed,	10.55	15.33	22.35	47.20	4.57
XI.	VII.	V.	Hay and gluten feed,	10.63	15.05	22.84	46.84	4.64
XI.	III.	IV.	Hay and molasses,	12.16	10.72	29.32	44.87	2.93
XI.	III.	V.	Hay and molasses,	11.83	10.53	30.33	44.47	2.84
XI.	IV.	IV.	Hay and molasses,	13.66	11.47	27.13	44.86	2.83
XI.	IV.	V.	Hay and molasses,	12.87	11.49	28.95	43.94	2.75
XI.	VIII.	IV.	Hay, gluten feed and molasses,	11.15	16.36	21.26	47.44	3.79
XI.	VIII.	V.	Hay, gluten feed and molasses,	10.82	16.21	22.09	47.15	3.73
XII.	IV.	IV.	Hay and gluten feed,	12.27	15.50	21.65	45.97	4.61
XII.	IV.	V.	Hay and gluten feed,	11.75	15.22	22.83	45.30	4.90
XII.	XIV.	II.Y.	Hay and gluten feed,	9.98	18.48	22.31	45.44	3.79
XII.	III.	II.	Hay and molasses,	11.91	14.82	23.00	45.80	4.47
XII.	III.	III.	Hay and molasses,	12.11	14.64	22.47	46.42	4.36
XII.	V.	IV.	Hay, gluten feed and molasses,	11.31	16.00	21.55	47.13	4.01
XII.	V.	V.	Hay, gluten feed and molasses,	10.57	15.94	22.89	46.79	3.81
XII.	VII.	IV.	Hay, gluten feed and molasses,	11.31	16.42	21.64	47.01	3.62
XII.	VII.	V.	Hay, gluten feed and molasses,	10.88	15.68	23.11	46.94	3.39
XII.	X.	IV.	Hay, gluten feed and molasses,	12.35	17.70	19.83	46.31	3.81
XII.	XI.	II.Y.	Hay, gluten feed and molasses,	11.44	17.38	22.04	45.62	3.52

Composition of Fæces (Per Cent.).

[Dry Matter.]

Series.	Periods.	Sheep Number.	Feed or Ration.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
XIII.	V.	I.	English hay,	9.32	14.24	24.35	48.01	4.08
XIII.	V.	II.	English hay,	9.03	13.59	26.55	46.88	3.95
XIII.	IV.	III.	English hay and corn meal,	8.71	15.09	25.44	46.89	3.87
XIII.	VII.	II.	English hay and corn meal,	10.71	14.60	26.46	44.38	3.85
XIII.	I.	I.	English hay and molasses,	10.88	14.79	23.92	46.68	3.73
XIII.	I.	II.	English hay and molasses,	10.75	15.12	23.80	46.51	3.82
XIII.	III.	I.	English hay and molasses,	10.88	15.52	23.05	46.94	3.61
XIII.	III.	II.	English hay and molasses,	10.21	14.71	26.21	45.38	3.49
XIII.	VI.	III.	Hay, corn meal and molasses,	8.87	15.69	24.52	47.18	3.74
XIII.	VIII.	II.	Hay, corn meal and molasses,	9.81	13.34	27.78	45.95	3.12
XIV.	XI.	I.	English hay,	11.16	10.65	27.78	46.91	3.50
XIV.	XI.	II.	English hay,	10.45	10.17	29.55	46.65	3.18
XIV.	III.	I.	English hay and gluten feed,	11.51	13.51	23.65	47.92	3.41
XIV.	III.	II.	English hay and gluten feed,	11.46	12.89	25.07	47.15	3.43
XIV.	V.	III.	English hay and gluten feed,	10.89	13.12	25.28	47.19	3.52
XIV.	V.	IV.	English hay and gluten feed,	11.85	13.31	24.34	46.68	3.82
XIV.	IV.	III.	Hay, gluten feed and molasses,	12.16	14.01	24.20	46.63	3.00
XIV.	IV.	IV.	Hay, gluten feed and molasses,	12.84	14.84	22.54	46.61	3.17
XIV.	VI.	III.	Hay, gluten feed and molasses,	11.58	13.62	24.60	46.98	3.22
XIV.	VI.	IV.	Hay, gluten feed and molasses,	11.63	13.21	23.70	48.15	3.31
XIV.	VII.	III.	Hay, gluten feed and molasses,	11.85	14.38	25.18	45.63	2.96
XIV.	VII.	IV.	Hay, gluten feed and molasses,	11.38	13.27	24.88	47.23	3.24
XIV.	IX.	IV.	Hay, gluten feed and molasses,	12.37	15.25	23.19	46.18	3.01

Dry Matter Determinations made at Time of weighing out the Different Foods, and Dry Matter in Air-dry Fæces (Per Cent.).

Series.	Period.	Sheep Number.	English Hay.	Gluten Feed.	Molasses.	Fæces.
X.,	VI.	IV.	88.35	–	–	93.35
X.,	IX.	V.	89.77	–	–	95.08
XI.,	V.	IV.	88.65	–	–	92.22
XI.,	V.	V.	88.65	–	–	92.14
XI.,	VI.	II.[1]	88.97	–	–	93.54
XI.,	VI.	III.[1]	88.97	–	–	93.52
XI.,	VII.	IV.	88.55	90.03	–	93.47
XI.,	VII.	V.	88.55	90.03	–	93.61
XI.,	III.	IV.	88.15	–	71.49	92.84
XI.,	III.	V.	88.15	–	71.49	93.14
XI.,	IV.	IV.	87.22	–	72.12	92.33
XI.,	IV.	V.	87.22	–	72.12	92.16
XI.,	VIII.	IV.	88.92	92.02	72.67	92.50
XI.,	VIII.	V.	88.92	92.02	72.67	92.36
XII.,	IV.	IV.	87.50	–	89.88	92.49
XII.,	IV.	V.	87.50	–	89.88	92.23
XII.,	XIV.	II.Y.	90.65	91.13	–	94.37
XII.,	III.	II.[1]	87.80	–	73.45	92.05
XII.,	III.	III.[1]	87.80	–	73.45	92.16
XII.,	V.	IV.	87.85	89.68	73.37	91.41
XII.,	V.	V.	87.85	89.68	73.37	91.42
XII.,	VII.	IV.	88.07	90.14	73.61	92.95
XII.,	VII.	V.	88.07	90.14	73.61	92.70
XII.,	X.	IV.	89.25	90.87	73.61	93.51
XII.,	XI.	II.Y.	90.57	89.98	74.18	93.87

Dry Matter Determinations made at Time of weighing out the Different Foods, and Dry Matter in Air-dry Fæces (Per Cent.).

Series.	Period.	Sheep Number.	English Hay.	Gluten Feed.	Corn Meal.	Molasses.	Fæces.
XIII.,	V.	I.	90.07	–	–	–	93.65
XIII.,	V.	II.	90.07	–	–	–	93.65
XIII.,	IV.	III.	89.65	–	89.32	–	94.14
XIII.,	VII.	II.	89.12	–	90.36	–	94.31
XIII.,	I.	I.	88.62	–	–	72.93	93.35
XIII.,	I.	II.	88.62	–	–	72.93	93.58
XIII.,	III.	I.	89.30	–	–	72.93	93.74
XIII.,	III.	II.	89.30	–	–	72.93	93.67
XIII.,	VI.	III.	90.10	–	90.64	72.70	93.34
XIII.,	VIII.	II.	89.05	–	90.24	72.78	93.65
XIV.,	XI.	I.	90.05	–	–	–	93.41
XIV.,	XI.	II.	90.05	–	–	–	93.49
XIV.,	III.	I.	88.42	90.75	–	–	93.13
XIV.,	III.	II.	88.42	90.75	–	–	93.11
XIV.,	V.	III.	89.45	91.15	–	–	94.16
XIV.,	V.	IV.	89.45	91.15	–	–	91.26
XIV.,	IV.	III.	89.27	91.00	–	74.51	92.38
XIV.,	IV.	IV.	89.27	91.00	–	74.51	92.48
XIV.,	VI.	III.	89.47	91.52	–	74.84	93.99
XIV.,	VI.	IV.	89.47	91.52	–	74.84	94.01
XIV.,	VII.	III.	89.72	93.24	–	75.26	93.74
XIV.,	VII.	IV.	89.72	93.24	–	75.26	93.79
XIV.,	IX.	IV.	90.25	91.27	–	74.80	93.36

[1] Old sheep.

Average Daily Amount of Manure execreted and Water drunk (Grams).

Series.	Periods.	Sheep Number.	Feed or Ration.	Manure. excreted daily.	One-tenth Manure Air Dry.	Water drunk daily.
X.	VI.	IV.	English hay,	678	32.15	1,138
X.	IX.	V.	English hay,	699	31.41	1,924
XI.	V.	IV.	English hay,	610	26.11	1,781
XI.	V.	V.	English hay,	623	27.02	1,642
XI.	VI.	II.	English hay,	613	26.21	1,694
XI.	VI.	III.	English hay,	608	28.80	1,544
XI.	VII.	IV.	English hay,	460	20.82	1,498
XI.	VII.	V.	English hay,	459	20.01	1,318
XI.	III.	IV.	Hay and molasses,	674	31.10	1,725
XI.	III.	V.	Hay and molasses,	745	32.86	1,995
XI.	IV.	IV.	Hay and molasses,	738	33.34	2,114
XI.	IV.	V.	Hay and molasses,	855	34.12	2,014
XI.	VIII.	IV.	Hay, gluten feed and molasses,	635	25.84	1,843
XI.	VIII.	V.	Hay, gluten feed and molasses,	655	25.86	1,953
XII.	IV.	IV.	Hay and gluten feed,	455	40.70[1]	1,382
XII.	IV.	V.	Hay and gluten feed,	639	41.72[1]	1,351
XII.	XIV.	II.Y.	Hay and gluten feed,	1,020	23.86	2,436
XII.	III.	II.	Hay and molasses,	628	26.99	1,836
XII.	III.	III.	Hay and molasses,	581	24.41	1,927
XII.	V.	IV.	Hay, gluten feed and molasses,	593	24.70	2,071
XII.	V.	V.	Hay, gluten feed and molasses,	688	24.97	1,786
XII.	VII.	IV.	Hay, gluten feed and molasses,	683	24.26	1,770
XII.	VII.	V.	Hay, gluten feed and molasses,	862	24.82	2,167
XII.	X.	IV.	Hay, gluten feed and molasses,	743	23.76	2,429
XII.	XI.	II.Y.	Hay, gluten feed and molasses,	945	29.90	2,500
XIII.	V.	I.	English hay,	508	21.91	2,214
XIII.	V.	II.	English hay,	531	23.02	2,193
XIII.	IV.	III.	Hay and corn meal,	516	18.91	2,500
XIII.	VII.	II.	Hay and corn meal,	442	17.64	2,369
XIII.	I.	I.	Hay and molasses,	468	19.02	1,631
XIII.	I.	II.	Hay and molasses,	450	19.29	1,649
XIII.	III.	I.	Hay and molasses,	528	20.79	1,414
XIII.	III.	II.	Hay and molasses,	620	23.02	1,536
XIII.	VI.	III.	Hay, corn meal and molasses,	588	20.36	2,150
XIII.	VIII.	II.	Hay, corn meal and molasses,	526	21.59	2,159
XIV.	XI.	I.	English hay,	633	24.55	2,292
XIV.	XI.	II.	English hay,	722	26.62	2,251
XIV.	III.	I.	Hay and gluten feed,	389	17.21	2,246
XIV.	III.	II.	Hay and gluten feed,	451	19.84	2,407
XIV.	V.	III.	Hay and gluten feed,	469	19.64	2,385
XIV.	V.	IV.	Hay and gluten feed,	378	17.90	1,639
XIV.	IV.	III.	Hay, gluten feed and molasses,	560	23.81	2,470
XIV.	IV.	IV.	Hay, gluten feed and molasses,	508	21.81	2,450
XIV.	VI.	III.	Hay, gluten feed and molasses,	591	22.36	2,212
XIV.	VI.	IV.	Hay, gluten feed and molasses,	455	21.00	1,269
XIV.	VII.	III.	Hay, gluten feed and molasses,	744	22.79	2,464
XIV.	VII.	IV.	Hay, gluten feed and molasses,	513	22.15	2,338
XIV.	IX.	IV.	Hay, gluten feed and molasses,	827	22.85	2,089

[1] One-fifth of sample.

Weight of Animals at Beginning and End of Period (Pounds).

Series.	Period.	Sheep Number.	Feed or Ration.	Beginning.	End.	Gain or Loss.
X.	VI.	IV.	English hay, ...	156.00	155.50	—.50
X.	IX.	V.	English hay, ...	133.25	137.75	+4.50
XI.	V.	IV.	English hay, ...	142.00	144.00	+2.00
XI.	V.	V.	English hay, ...	122.00	121.50	—.50
XI.	VI.	II.	English hay, ...	154.00	150.00	—4.00
XI.	VI.	III.	English hay, ...	146.50	145.00	—1.50
XI.	VII.	IV.	Hay and gluten feed, . .	141.50	141.00	—.50
XI.	VII.	V.	Hay and gluten feed, . .	118.50	120.00	+1.50
XI.	III.	IV.	Hay and molasses, . . .	144.00	142.00	—2.00
XI.	III.	V.	Hay and molasses, . . .	124.00	122.00	—2.00
XI.	IV.	IV.	Hay and molasses, . . .	145.50	150.00	+4.50
XI.	IV.	V.	Hay and molasses, . . .	122.50	125.50	+3.00
XI.	VIII.	IV.	Hay, gluten feed and molasses,	145.00	142.00	—3.00
XI.	VIII.	V.	Hay, gluten feed and molasses,	125.50	122.50	—3.00
XII.	IV.	IV.	Hay and gluten feed, . .	121.50	119.00	—2.50
XII.	IV.	V.	Hay and gluten feed, . .	110.50	108.50	—2.00
XII.	XIV.	II.Y.	Hay and gluten feed, . .	94.50	91.50	—3.00
XII.	III.	II.	Hay and molasses, . . .	108.00	107.00	—1.00
XII.	III.	III.	Hay and molasses, . . .	125.00	125.00	-
XII.	V.	IV.	Hay, gluten feed and molasses,	121.00	125.50	+4.50
XII.	V.	V.	Hay, gluten feed and molasses,	115.50	112.00	—3.50
XII.	VII.	IV.	Hay, gluten feed and molasses,	127.00	123.00	—4.00
XII.	VII.	V.	Hay, gluten feed and molasses,	115.00	110.00	—5.00
XII.	X.	IV.	Hay, gluten feed and molasses,	128.00	120.00	—8.00
XII.	XI.	II.Y.	Hay, gluten feed and molasses,	95.50	95.50	-
XIII.	V.	I.	English hay, ...	81.25	85.00	+3.75
XIII.	V.	II.	English hay, ...	78.50	78.50	-
XIII.	IV.	III.	Hay and corn meal, . . .	83.00	83.50	+.50
XIII.	VII.	II.	Hay and corn meal, . . .	80.00	80.00	-
XIII.	I.	I.	Hay and molasses, . . .	76.50	79.50	+3.00
XIII.	I.	II.	Hay and molasses, . . .	72.50	72.50	-
XIII.	III.	I.	Hay and molasses, . . .	83.25	82.50	—.75
XIII.	III.	II.	Hay and molasses, . . .	79.50	80.75	+1.25
XIII.	VI.	III.	Hay, corn meal and molasses, .	79.75	84.50	+4.75
XIII.	VIII.	II.	Hay, corn meal and molasses, .	79.00	77.00	+2.00
XIV.	XI.	I.	English hay, ...	90.00	88.50	—1.50
XIV.	XI.	II.	English hay, ...	90.50	88.50	—2.00
XIV.	III.	I.	Hay and gluten feed, . .	91.25	91.00	—.25
XIV.	III.	II.	Hay and gluten feed, . .	87.25	86.25	—1.00
XIV.	V.	III.	Hay and gluten feed, . .	92.25	88.00	—4.25
XIV.	V.	IV.	Hay and gluten feed, . .	95.00	93.00	—2.00
XIV.	IV.	III.	Hay, gluten feed and molasses,	93.50	91.50	—2.00
XIV.	IV.	IV.	Hay, gluten feed and molasses,	101.00	97.50	—3.50
XIV.	VI.	III.	Hay, gluten feed and molasses,	88.50	87.50	—1.00
XIV.	VI.	IV.	Hay, gluten feed and molasses,	96.50	96.00	—.50
XIV.	VII.	III.	Hay, gluten feed and molasses,	85.50	87.50	+2.00
XIV.	VII.	IV.	Hay, gluten feed and molasses,	101.00	101.50	+.50
XIV.	IX.	IV.	Hay, gluten feed and molasses,	95.50	100.25	—4.75

Coefficients employed for the Hay, Hay and Corn Meal and Hay and Gluten Feed, which were applied to the Preceding Feeds and Feed Combinations when fed together with Molasses in Order to show the Depression exerted by the Latter.

Series.	Period.	Sheep Number.	Ration.	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
XI.	III.	IV., V.	Hay and molasses,	57.98	40.52	53.61	59.06	61.41	47.76
XI.	IV.	IV., V.	Hay and molasses,	57.98	40.52	53.61	59.06	61.41	47.76
XI.	VIII.	IV.	Hay, gluten feed and molasses,	72.64	47.18	72.87	77.20	73.86	56.49
XI.	VIII.	V.	Hay, gluten feed and molasses,	73.67	48.78	74.36	77.57	75.03	57.46
XII.	III.	II., III.	Hay and molasses,	67.87	49.17	62.31	76.30	66.39	52.37
XII.	V.	IV., V.	Hay, gluten feed and molasses,	73.00	40.16	73.75	77.35	75.07	54.50
XII.	VII.	IV., V.	Hay, gluten feed and molasses,	73.00	40.16	73.75	77.35	75.07	54.50
XII.	X.	IV.	Hay, gluten feed and molasses,	73.00	40.16	73.75	77.35	75.07	54.50
XII.	XI.	II.Y.	Hay, gluten feed and molasses,	68.86	39.23	65.37	72.14	72.00	57.95
XIII.	I.	I , II.	Hay and molasses,	66.64	52.63	62.09	70.93	68.02	47.87
XIII.	III.	I., II.	Hay and molasses,	66.64	52.63	62.09	70.93	68.02	47.87
XIII.	VI.	III.	Hay, corn meal and molasses,	69.43	50.13	61.00	66.18	74.76	61.12
XIII.	VIII.	II.	Hay, corn meal and molasses,	71.38	42.16	47.45	71.55	77.77	63.11
XIV.	IV.	III.	Hay, gluten feed and molasses,	68.00	44.00	66.00	68.00	72.00	61.00
XIV.	IV.	IV.	Hay, gluten feed and molasses,	72.00	46.00	70.00	73.00	76.00	62.00
XIV.	VI.	III.	Hay, gluten feed and molasses,	68.00	44.00	66 00	68.00	72.00	61.00
XIV.	VI.	IV.	Hay, gluten feed and molasses,	72.00	46.00	70.00	73.00	76.00	62.00
XIV.	VII.	III.	Hay, gluten feed and molasses,	68.00	44.00	66.00	68.00	72.00	61.00
XIV.	VII.	IV.	Hay, gluten feed and molasses,	72.00	46.00	70.00	73.00	76.00	62.00
XIV.	IX.	IV.	Hay, gluten feed and molasses,	72.00	46.00	70.00	73.00	76.00	62.00

Calculation of Coefficients.

Series X., Period VI., Sheep IV.

English Hay.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
800 grams English hay fed,	706.80	55.27	60.50	228.65	344.57	17.81
321.50 grams manure excreted,	300.12	34.84	29.71	92.02	134.78	8.76
Grams digested,	406.68	20.43	30.79	136.63	209.79	9.05
Per cent. digested,	57.54	36.96	50.89	59.76	60.88	50.81

Nutritive ratio of ration, 1: 11.9.

Series X., Period IX., Sheep V.

English Hay.

800 grams English hay fed,	718.16	59.97	63.20	229.02	349.17	16.80
314.13 grams manure excreted,	298.67	33.54	27.60	95.37	132.88	9.29
Grams digested,	419.49	26.43	35.60	133.65	216.29	7.51
Per cent. digested,	58.41	44.07	56.33	58.36	61.94	44.70
Average per cent. for both sheep,	57.98	40.52	53.61	59.06	61.41	47.76

Series XI., Period V., Sheep IV.

English Hay.

800 grams English hay fed,	709.20	47.87	86.74	237.23	316.80	20.57
261.10 grams manure excreted,	240.79	26.92	33.95	58.27	111.34	10.31
Grams digested,	468.41	20.95	52.79	178.96	205.46	10.26
Per cent. digested,	66.05	43.76	60.86	75.44	64.85	49.88

Series XI., Period V., Sheep V.

English Hay.

800 grams English hay fed,	709.20	47.87	86.74	237.23	316.80	20.57
270.20 grams manure excreted,	248.96	26.12	32.79	66.00	113.87	10.18
Grams digested,	460.24	21.75	53.95	171.23	202.93	10.39
Per cent. digested,	64.90	45.44	62.20	72.18	64.06	50.51
Average per cent. for both sheep,	65.48	44.60	61.53	73.81	64.46	50.20

Average nutritive ratio of rations for two sheep, 1: 7.5.

Series XI., Period VI., Sheep II.

English Hay.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
900 grams English hay fed,	800.73	54.05	97.93	267.84	357.69	23.22
262.10 grams manure excreted,	245.17	26.48	36.04	58.82	113.44	10.40
Grams digested,	555.56	27.57	61.89	209.02	244.25	12.82
Per cent. digested,	69.38	51.01	63.20	78.04	68.29	55.21

Series XI., Period VI., Sheep III.

English Hay.

900 grams English hay fed,	800.73	54.05	97.93	267.84	357.69	23.22
288 grams manure excreted,	269.34	28.47	37.79	68.17	123.20	11.72
Grams digested,	531.39	25.58	60.14	199.67	234.49	11.50
Per cent. digested,	66.36	47.33	61.41	74.55	65.56	49.53
Average per cent. for both sheep,	67.87	49.17	62.31	76.30	66.39	52.37

Average nutritive ratio of rations for two sheep, 1: 7.7.

Series XI., Period VII., Sheep IV.

Hay and Gluten Feed.

600 grams English hay fed,	531.30	35.86	64.98	177.72	237.33	15.41
200 grams gluten feed fed,	180.06	3.01	44.98	13.00	114.05	5.02
Amount consumed,	711.36	38.87	109.96	190.72	351.38	20.43
208.20 grams manure excreted,	194.60	20.53	29.83	43.49	91.85	8.89
Grams digested,	516.76	18.34	80.13	147.23	259.53	11.54
Per cent. hay and gluten feed digested.	72.64	47.19	72.87	77.19	73.86	56.40

Series XI., Period VII., Sheep V.

Hay and Gluten Feed.

Amount consumed as above,	711.36	38.87	109.96	190.72	351.38	20.43
200.10 grams manure excreted,	187.31	19.91	28.19	42.78	87.74	8.69
Grams digested,	524.05	18.96	81.77	147.94	263.64	11.74
Per cent. hay and gluten feed digested.	73.67	48.78	74.36	77.57	75.03	57.46

Average nutritive ratio of rations for two sheep, 1: 5.4.

Series XI., Period III., Sheep IV.

Porto Rico Molasses.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
800 grams English hay fed,	705.20	57.83	61.28	226.65	342.45	17.00
150 grams molasses fed,	107.24	9.06	4.23	–	93.95	–
Amount consumed,	812.44	66.89	65.51	226.65	436.40	17.00
311 grams manure excreted,	288.73	35.11	30.95	84.66	129.55	8.46
Grams digested,	523.71	31.78	34.56	141.89	306.85	8.54
Minus hay digested,	408.87	23.43	32.85	133.86	210.30	8.12
Molasses digested (grams),	114.84	8.35	1.71	8.03	96.55	.42
Per cent. digested,	107.09	92.16	40.43	–	102.76	–

Series XI., Period III., Sheep V.

Porto Rico Molasses.

Amount consumed as above,	812.44	66.89	65.51	226.65	436.40	17.00
328.60 grams manure excreted,	306.06	36.21	32.23	92.83	136.10	8.69
Grams digested,	506.38	30.68	33.28	133.82	300.30	8.31
Minus hay digested,	408.87	23.43	32.85	133.86	210.30	8.12
Molasses digested (grams),	97.51	7.25	.43	–	90.00	.19
Per cent. digested,	90.93	80.02	10.17	–	95.80	–
Average per cent. for both sheep,	99.01	86.09	25.30	–	99.28	–

Average nutritive ratio of rations for two sheep, 1: 13.6.

Series XI., Period IV., Sheep IV.

Porto Rico Molasses.

800 grams English hay fed,	697.76	57.22	60.64	224.26	338.82	16.82
250 grams molasses fed,	180.30	15.24	7.10	–	157.96	–
Amount consumed,	878.06	72.46	67.74	224.26	496.78	16.82
333.40 grams manure excreted,	307.83	42.05	35.31	83.51	138.09	8.87
Grams digested,	570.23	30.41	32.43	140.75	358.69	7.95
Minus hay digested,	404.56	23.19	32.51	132.44	208.07	8.03
Molasses digested (grams),	165.67	7.22	—.08	8.31	150.62	–
Per cent. digested,	91.89	47.38	–	–	95.35	–

Series XI., Period IV., Sheep V.

Porto Rico Molasses.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
Amount consumed as above,	878.06	72.46	67.74	224.26	496.78	16.82
341.2 grams manure excreted,	314.45	40.47	36.13	91.03	138.17	8.65
Grams digested,	563.61	31.99	31.61	133.23	358.61	8.17
Minus hay digested,	404.56	23.19	32.51	132.44	208.07	8 03
Molasses digested (grams),	159.05	8.80	.10	.79	150.54	.14
Per cent. digested,	88.21	57.74	–	–	95.30	–
Average per cent. for both sheep,	90.05	52.56	–	–	95.33	–

Average nutritive ratio of rations for two sheep, 1: 16.

Series XI., Period VIII., Sheep IV.

Porto Rico Molasses.

600 grams English hay fed,	533.52	36.01	65.25	178.46	238.32	15.47
200 grams gluten feed fed,	184.04	3.07	45.97	13.29	116.57	5.13
250 grams molasses fed,	181.68	16.75	7.16	–	157.77	–
Amount consumed,	899.24	55.83	118.38	191.75	512.66	20.60
258.40 grams manure excreted,	239.02	26.65	39.10	50.82	113.39	9.06
Grams digested,	660.22	29.18	79.28	140.93	399.27	11.54
Minus hay and gluten feed digested,	521.24	18.44	81.05	–	262.12	–
Molasses digested (grams),	138.98	10.74	–	–	137.15	–
Per cent. digested,	76.50	64.12	–	–	86.93	–

Series XI., Period VIII., Sheep V.

Porto Rico Molasses.

Amount consumed as above,	899.24	55.83	118.38	191.75	512.66	20.60
258.60 grams manure excreted,	238.84	25.84	38.72	52.76	112.61	8.91
Grams digested,	660.40	29.99	79.66	138.99	400.05	11.69
Minus hay and gluten feed digested,	528.63	19.06	82.70	–	266.27	–
Molasses digested (grams),	131.77	10.93	–	–	133.78	–
Per cent. digested,	72.53	65.25	–	–	84.80	–
Average per cent. for both sheep,	74.52	64.69	–	–	85.87	–

Average nutritive ratio of rations for two sheep, 1: 7.1.

Series XII., Period IV., Sheep IV.

Gluten Feed and Hay.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
600 grams English hay,	525.00	35.44	64.21	175.61	234.52	15.23
200 grams gluten feed,	179.76	2.75	47.13	11.32	113.88	4.67
Amount consumed,	704.76	38.19	111.34	186.93	348.40	19.90
Minus 203.52 grams manure excreted,	188.24	23.10	29.18	40.75	86.53	8.68
Grams digested,	516.52	15.09	82.16	146.18	261.87	11.22
Per cent. gluten feed and hay digested.	73.29	39.51	73.79	78.20	75.16	56.38

Series XII., Period IV., Sheep V.

Gluten Feed and Hay.

Amount consumed as above,	704.76	38.19	111.34	186.93	348.40	19.90
Minus 208.62 grams manure excreted,	192.41	22.61	29.28	43.93	87.16	9.43
Grams digested,	512.35	15.58	82.06	143.00	261.24	10.47
Per cent. gluten feed and hay digested.	72.70	40.80	73.70	76.50	74.98	52.61
Average per cent. for both sheep,	73.00	40.16	73.75	77.35	75.07	54.50

Series XII., Period XIV., Sheep II. (Young.)

Gluten Feed and Hay.

550 grams English hay,	498.58	33.65	60.98	166.78	222.72	14.46
250 grams gluten feed,	227.83	3.49	59.74	14.35	144.33	5.92
Amount consumed,	726.41	37.14	120.72	181.13	367.05	20.38
238.64 grams manure excreted,	226.20	22.57	41.80	50.47	102.79	8.57
Grams digested,	500.21	14.57	78.92	130.66	264.26	11.81
Minus hay digested,	328.66	17.48	37.80	121.53	144.01	7.84
Gluten feed digested (grams),	171.55	-	41.12	9.13	120.25	3.97
Per cent. hay and gluten feed digested.	68.86	39.23	65.37	72.14	72.00	57.95

Series XII., Period III., Sheep II. (Old).

Porto Rico Molasses.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
800 grams English hay,	702.40	47.41	85.90	234.95	313.76	20.37
100 grams Porto Rico molasses,	73.45	5.35	2.79	-	65.31	-
Amount consumed,	775.85	52.76	88.69	234.95	379.07	20.37
Minus 269.86 grams manure excreted,	248.41	29.59	36.81	57.13	113.77	11.10
Grams digested,	527.44	23.17	51.88	177.82	265.30	9.27
Minus hay digested,	476.72	23.31	53.52	179.27	208.31	10.67
Molasses digested (grams),	50.72	—.17	—1.64	—1.45	56.99	—1.40
Per cent. digested,	69.05	-	-	-	87.26	-

Series XII., Period III., Sheep III.

Porto Rico Molasses.

Amount consumed as above,	775.85	52.76	88.69	234.95	379.07	20.37
Minus 244.09 grams manure excreted,	224.95	27.24	32.93	50.55	104.42	9.81
Grams digested,	550.90	25.52	55.76	184.40	274.65	10.56
Minus hay digested,	476.72	23.31	53.52	179.27	208.31	10.67
Molasses digested (grams),	74.18	2.21	2.24	5.13	66.34	—.11
Per cent. digested,	100.99	41.31	80.29	-	101.58	-

Series XII., Period V., Sheep IV. (Paige).

Porto Rico Molasses.

600 grams English hay,	527.10	35.58	64.46	176.31	235.46	15.29
200 grams gluten feed,	179.36	2.74	47.03	11.30	113.62	4.66
100 grams Porto Rico molasses,	73.37	5.34	2.79	-	65.24	-
Amount consumed,	779.83	43.66	114.28	187.61	414.32	19.95
246.97 grams manure excreted,	225.76	25.53	36.12	48.65	106.40	9.05
Grams digested,	554.07	18.13	78.16	138.96	307.92	10.90
Minus hay and gluten feed digested,	515.72	15.39	82.22	145.12	262.05	10.87
Molasses digested (grams),	38.35	2.74	—4.06	—6.16	45.87	.03
Per cent. digested,	52.27	51.31	-	-	70.31	-

Series XII., Period V., Sheep V.

Porto Rico Molasses.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
Amount consumed as above, . .	779.83	43.66	114.28	187.61	414.32	19.95
249.67 grams manure excreted, .	228.25	24.13	36.38	52.25	106.80	8.70
Grams digested, ...	551.58	19.53	77.90	135.36	307.52	11.25
Minus hay and gluten feed digested,	515.72	15.39	82.22	145.12	262.05	10.87
Molasses digested (grams), . .	35.86	4.14	—4.32	—9.76	45.47	.38
Per cent. digested, ...	48.88	77.53	–	–	69.70	–
Average per cent. for two sheep, .	50.58	64.42	–	–	70.01	–

Series XII., Period VII., Sheep IV. (Paige).

Porto Rico Molasses.

600 grams English hay, . . .	528.42	35.67	64.63	176.76	236.05	15.32
200 grams gluten feed, . . .	180.28	2.76	47.27	11.36	114.21	4.69
200 grams Porto Rico molasses, .	147.22	10.72	5.59	–	130.91	–
Amount consumed, ...	855.92	49.15	117.49	188.12	481.17	20.01
242.64 grams manure excreted, .	225.53	25.51	37.03	48.80	106.02	8.16
Grams digested, ...	630.39	23.64	80.46	139.32	375.15	11.85
Minus hay and gluten feed digested,	517.35	15.43	82.53	145.51	262.94	10.91
Molasses digested (grams), . .	113.04	8 21	—2.07	—6.19	112.21	.94
Per cent. digested, ...	76.78	76.59	–	–	85.72	–

Series XII., Period VII., Sheep V.

Porto Rico Molasses.

Amount consumed as above, . .	855.92	49.15	117.49	188.12	481.17	20.01
248.17 grams manure excreted, .	230.05	25.03	36.07	53.16	107.99	7.80
Grams digested, ...	625.87	24.12	81.42	134.96	373.18	12.21
Minus hay and gluten feed digested,	517.35	15.43	82.53	145.51	262.94	10.91
Molasses digested (grams), . .	108.52	8.69	—1.11	—10.55	110.24	1.30
Per cent. digested, ...	73.71	81.06	–	–	84.21	–
Average per cent. for two sheep, .	75.25	78.83	–	–	84.97	–

Series XII., Period X., Sheep IV. (Paige).

Porto Rico Molasses.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
600 grams English hay, ...	535.50	36.15	65.49	179.12	239.21	15.53
200 grams gluten feed, ...	181.74	2.78	47.65	11.45	115.13	4.73
300 grams Porto Rico molasses, .	220.83	16.08	8.39	–	196.36	–
Amount consumed, ...	938.07	55.01	121.53	190.57	550.70	20.26
237.57 grams manure excreted, .	222.15	27.44	39.32	44.05	102.88	8.46
Grams digested, ...	715.92	27.57	82.21	146.52	447.82	11.80
Minus hay and gluten feed digested,	523.59	15.63	83.44	147.41	266.00	11.04
Molasses digested (grams), . .	192.33	11.94	—1.23	—.89	181.82	.76
Per cent. digested, ...	87.09	74.25	–	–	92.60	–

Series XII., Period XI., Sheep II. (Young).

Porto Rico Molasses.

600 grams English hay, ...	543.42	36.68	66.46	181.77	242.75	15.76
200 grams gluten feed, ...	179.96	2.75	47.19	11.34	114.00	4.68
250 grams Porto Rico molasses, .	185.45	13.50	7.05	–	164.90	–
Amount consumed, ...	908.83	52.93	120.70	193.11	521.65	20.44
299.04 grams manure excreted, .	280.71	32.11	48.79	61.87	128.06	9.88
Grams digested, ...	628.12	20.82	71.91	131.24	393.59	10.56
Minus hay and gluten feed digested,	498.12	15.47	74.29	139.31	256.86	11.84
Molasses digested (grams), . .	130.00	5.35	—3.38	—8.07	136.73	—.28
Per cent. digested, ...	70.10	39.63	–	–	82.92	–

Series XIII., Period V., Sheep I.

English Hay.

700 grams English hay, ...	630.49	40.73	77.17	184.36	312.03	16.20
Minus 219.10 grams manure excreted,	205.19	19.12	29.22	49.96	98.51	8.37
Grams digested, ...	425.30	21.61	47.95	134.40	213.52	7.83
Per cent. digested, ...	67.46	53.06	62.14	72.90	68.43	48.33

Series XIII., Period V., Sheep II.

English Hay.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
700 grams English hay,	630.49	40.73	77.17	184.36	312.03	16.20
Minus 230.19 grams manure excreted,	215.57	19.47	29.30	57.23	101.06	8.52
Grams digested,	414.92	21.26	47.87	127.13	210.97	7.68
Per cent. digested,	65.81	52.20	62.03	68.96	67.61	47.41
Average per cent. for two sheep,	66.64	52.63	62.09	70.93	68.02	47.87

Series XIII., Period IV., Sheep III.

English Hay, Corn Meal.

500 grams English hay,	448.25	28.96	54.87	131.07	221.84	11.52
150 grams corn meal,	133.98	2.12	14.00	2.81	108.82	6.23
Amount consumed,	582.23	31.08	68.87	133.88	330.66	17.75
189.06 grams manure excreted,	177.98	15.50	26.86	45.28	83.45	6.89
Grams digested,	404.25	15.58	42.01	88.60	247.21	10.86
Per cent. digested,	69.43	50.13	61.00	66.18	74.76	61.12

Series XIII., Period VII., Sheep II.

English Hay, Corn Meal.

500 grams English hay,	445.60	28.65	32.04	151.86	222.00	11.05
150 grams corn meal,	135.54	2.14	14.16	2.85	110.09	6.30
Amount consumed,	581.14	30.79	46.20	154.71	332.09	17.35
176.37 grams manure excreted,	166.33	17.81	24.28	44.01	73.82	6.40
Grams digested,	414.81	12.98	21.92	110.70	258.27	10.95
Per cent. digested,	71.38	42.16	47.45	71.55	77.77	63.11

Series XIII., Period I., Sheep I.

Porto Rico Molasses.

600 grams English hay,	531.72	34.34	65.08	155.47	263.15	13.67
100 grams Porto Rico molasses,	72.93	5.87	3.34	-	63.72	-
Amount consumed,	604.65	40.21	68.42	155.47	326.87	13.67
Minus 190.20 grams manure excreted,	177.55	19.32	26.26	42.47	82.88	6.62
Grams digested,	427.10	20.89	42.16	113.00	243.99	7.05
Minus hay digested,	354.34	18.07	40.41	110.27	178.99	6.54
Molasses digested (grams),	72.76	2.82	1.75	2.73	65.00	.51
Per cent. digested,	99.77	48.04	52.40	-	102.01	-

Series XIII., Period I., Sheep II.*

Porto Rico Molasses.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
Amount consumed as above,	604.65	40.21	68.42	155.47	326.87	13.67
Minus 192.90 grams manure excreted,	180.05	19.36	27.22	42.85	83.74	6.88
Grams digested,	424.60	20.85	41.20	112.62	243.13	6.79
Minus hay digested,	354.34	18.07	40.41	110.27	178.99	6.54
Molasses digested (grams),	70.26	2.78	.79	2.35	64.14	.25
Per cent. digested,	96.34	47.36	23.65	–	100.66	–
Average per cent. for two sheep,	98.06	47.70	38.03	–	101.34	–

Series XIII., Period III., Sheep I.

Porto Rico Molasses.

600 grams English hay,	535.80	34.61	65.58	156.67	265.17	13.78
200 grams Porto Rico molasses,	145.86	11.83	6.86	–	127.18	–
Amount consumed,	681.66	46.44	72.44	156.67	392.35	13.78
Minus 207.86 grams manure excreted,	194.85	21.20	30.24	44.91	91.46	7.03
Grams digested,	486.81	25.24	42.20	111.76	300.89	6.75
Minus hay digested,	357.06	18.22	40.72	111.13	180.37	6.60
Molasses digested (grams),	129.75	7.02	1.48	.63	120.52	.15
Per cent. digested,	88.96	59.34	21.57	–	94.76	–

Series XIII., Period III., Sheep II.

Porto Rico Molasses.

Amount consumed as above,	681.66	46.44	72.44	156.67	392.35	13.78
Minus 230.24 grams manure excreted,	215.67	22.02	31.73	56.53	97.87	7.53
Grams digested,	465.99	24.42	40.71	100.14	294.48	6.25
Minus hay digested,	357.06	18.22	40.72	111.13	180 37	6.60
Molasses digested (grams),	108.93	6.20	.01	10.99	114.11	.35
Per cent. digested,	74.67	52.41	–	–	89.72	–
Average per cent. for two sheep,	81.82	55.88	21.57[1]	–	92.24	–

[1] One sheep.

Series XIII., Period VI., Sheep III.

Porto Rico Molasses.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
500 grams English hay,	450.50	29.10	55.14	131.73	222.95	11.58
150 grams corn meal,	135.96	2.15	14.21	2.86	110.43	6.32
100 grams Porto Rico molasses,	72.70	5.98	3.43	–	63.29	–
Amount consumed,	659.16	37.23	72.78	134.59	396.67	17.90
203.60 grams manure excreted,	190.04	16.86	29.82	46.60	89.66	7.11
Grams digested,	469.12	20.37	42.96	87.99	307.01	10.79
Minus hay and corn meal digested,	407.18	15.67	42.30	89.07	249.23	10.94
Molasses digested (grams),	61.94	4.70	.66	–	57.78	–
Per cent. digested,	85.20	78.60	19.24	–	91.29	–

Series XIII., Period VIII., Sheep II.

Porto Rico Molasses.

500 grams English hay,	445.25	28.63	32.01	151.74	221.82	11.04
150 grams corn meal,	135.36	2.14	14.15	2.84	109.94	6.29
200 grams Porto Rico molasses,	145.56	11.89	6.85	–	126.81	–
Amount consumed,	726.17	42.66	53.01	154.58	458.57	17.33
Minus 215.89 grams manure excreted,	202.18	19.83	26.97	56.17	92.90	6.31
Grams digested,	523.99	22.83	26.04	98.41	365.67	11.02
Minus hay and corn meal digested,	414.44	12.97	21.90	110.60	258.01	10.94
Molasses digested (grams),	109.55	9.86	4.14	–	107.66	–
Per cent. digested,	75.26	23.11	60.44	–	84.90	–

Series XIV., Period XI., Sheep I.

English Hay.

700 grams English hay,	630.35	44.82	48.85	205.74	315.24	15.70
245.46 grams manure excreted,	229.28	25.59	24.42	63.69	107.56	8.02
Grams digested,	401.07	19.23	24.43	142.05	207.68	7.68
Per cent. digested,	63.63	42.91	50.01	69.04	65.88	48.92

Series XIV., Period XI., Sheep II.

English Hay.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
700 grams English hay,	630.35	44.82	48.85	205.74	315.24	15.70
266.16 grams manure excreted,	248.83	26.00	25.31	73.53	116.08	7.91
Grams digested,	381.52	18.82	23.54	132.21	199.16	7.79
Per cent. digested,	60.53	41.99	48.19	64.27	63.18	49.62
Average per cent. for both sheep,	62.08	42.45	49.10	66.66	64.53	49.27

Series XIV., Period III., Sheep I.

Gluten Feed and Hay.

500 grams English hay,	442.10	30.15	33.91	134.21	233.35	10.48
150 grams gluten feed,	136.13	5.61	37.05	10.63	76.97	5.87
Amount consumed,	578.23	35.76	70.96	144.84	310.32	16.35
Minus 172.09 grams manure excreted,	160.27	18.45	21.65	37.90	76.80	5.47
Grams hay and gluten feed digested,	417.96	17.31	49.31	106.94	233.52	10.88
Per cent. hay and gluten feed digested.	72.28	48.41	69.49	73.83	75.25	66.54

Series XIV., Period III., Sheep II.

Gluten Feed and Hay.

Amount consumed as above,	578.23	35.76	70.96	144.84	310.32	16.35
Minus 198.37 grams manure excreted,	184.70	21.17	23.81	46.30	87.08	6.34
Grams hay and gluten feed digested,	393.53	14.59	47.15	98.54	223.24	10.01
Per cent. hay and gluten feed digested.	68.06	40.80	66.45	61.13	71.94	61.22
Average per cent. for both sheep,	70.17	44.61	67.97	67.48	73.60	63.88

Series XIV., Period V., Sheep III.

Gluten Feed and Hay.

500 grams English hay,	447.25	30.50	34.30	135.74	236.11	10.60
150 grams gluten feed,	136.73	5.63	37.22	10.68	77.31	5.89
Amount consumed,	583.98	36.13	71.52	146.42	313.42	16.49
Minus 196.35 grams manure excreted,	184.88	20.13	24.25	46.74	87.25	6.51
Grams hay and gluten feed digested,	399.10	16.00	47.27	99.68	226.17	9.98
Per cent. hay and gluten feed digested.	68.34	44.20	66.09	68.08	72.16	60.52

Series XIV., Period V., Sheep IV.

Gluten Feed and Hay.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
Amount consumed as above,	583.98	36.13	71.52	146.42	313.42	16.49
Minus 179.00 grams manure excreted,	163.36	19.36	21.74	39.76	76.27	6.23
Grams hay and gluten feed digested,	420.62	16.77	49.78	106.66	237.15	10.26
Per cent. hay and gluten feed digested.	72.03	46.42	69.60	72.85	75.67	62.22
Average per cent. for both sheep,	70.19	45.31	67.85	70.47	73.92	61.37

Series XIV., Period IV., Sheep III.

Porto Rico Molasses.

500 grams English hay,	446.35	30.44	34.24	135.47	235.62	10.58
150 grams gluten feed,	136.50	5.62	37.16	10.66	77.18	5.88
200 grams molasses,	149.02	12.41	8.60	-	128.01	-
Amount consumed,	731.87	48.47	80.00	146.13	440.81	16.46
238.06 grams manure excreted,	219.92	26.74	30.80	53.22	102.56	6.60
Grams digested,	511.95	21.73	49.20	92.91	338.25	9.86
Minus hay and gluten feed digested,	396.34	15.87	47.12	99.37	225.22	10.04
Molasses digested (grams),	115.61	5.86	2.08	—6.46	113.03	—.18
Per cent. digested,	77.58	47.22	24.19	-	88.30	-

Series XIV., Period IV., Sheep IV.

Porto Rico Molasses.

Amount consumed as above,	731.87	48.47	80.00	146.13	440.81	16.46
218.07 grams manure excreted,	201.67	25.89	29.93	45.46	94.00	6.39
Grams digested,	530.20	22.58	50.07	100.67	346.81	10.07
Minus hay and gluten feed digested,	419.65	16.59	49.98	106.67	237.73	10.21
Molasses digested (grams),	110.55	5.99	.09	—6.00	109.08	—.14
Per cent. digested,	74.18	48.27	1.05	-	85.21	-
Average per cent. for both sheep,	75.88	47.75	12.62	-	86.76	-

Series XIV., Period VI., Sheep III.

Porto Rico Molasses.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
500 grams English hay,	447.25	30.50	34.30	135.74	236.11	10.60
150 grams gluten feed,	137.28	5.65	37.37	10.72	77.62	5.92
50 grams molasses,	37.42	3.06	2.23	-	32.13	-
Amount consumed,	621.95	39.21	73.90	146.46	345.86	16.52
223.6 grams manure excreted,	210.18	24.34	28.63	51.70	98.74	6.77
Grams digested,	411.77	14.87	45.27	94.76	247.12	9.75
Minus hay and gluten feed digested,	397.48	15.91	47.30	99.59	225.89	10.08
Molasses digested (grams),	14.29	—1.04	—2.03	—4.83	21.23	—.30
Per cent. digested,	38.19	-	-	-	66.08	-

Series XIV., Period VI., Sheep IV.

Porto Rico Molasses.

Amount consumed as above,	621.95	39.21	73.90	146.46	345.86	16.52
210.03 grams manure excreted,	197.45	22.96	26.08	46.80	95.07	6.54
Grams digested,	424.50	16.25	47.82	99.66	250.79	9.98
Minus hay and gluten feed digested,	420.86	16.63	50.17	106.92	238.43	10.24
Molasses digested (grams),	3.64	—.38	—2.35	—7.26	12.36	—.26
Per cent. digested,	9.73	-	-	-	38.47	-
Average per cent. for both sheep,	23.96	-	-	-	52.28	-

Series XIV., Period VII., Sheep III.

Porto Rico Molasses.

500 grams English hay,	448.60	30.59	34.41	136.15	236.82	10.63
150 grams gluten feed,	139.86	5.76	38.07	10.92	79.08	6.03
100 grams molasses,	75.26	6.17	4.51	-	64.58	-
Amount consumed,	663.72	42.52	76.99	147.07	380.48	16.66
227.90 grams manure excreted,	213.63	25.32	30.72	53.79	97.48	6.32
Grams digested,	450.09	17.20	46.27	93.28	283.00	10.34
Minus hay and gluten feed digested,	400.15	15.99	47.84	100.01	227.45	10.16
Molasses digested (grams),	49.94	1.21	—.57	—6.73	55.55	.18
Per cent. digested,	66.37	19.61	-	-	86.02	-

Series XIV., Period VII., Sheep IV.

Porto Rico Molasses.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
Amount consumed as above,	663.72	42.52	76.99	147.07	380.48	16.66
221.48 grams manure excreted,	207.73	23.64	27.57	51.68	98.11	6.73
Grams digested,	455.99	18.88	49.42	95.39	282.37	9.93
Minus hay and gluten feed digested,	423.69	16.72	50.74	107.36	240.08	10.33
Molasses digested (grams),	32.30	2.12	—1.32	—11.97	42.29	—.40
Per cent. digested,	42.92	34.36	–	–	65.48	–
Average per cent. for both sheep,	54.65	26.99	–	–	75.75	–

Series XIV., Period IX., Sheep IV.

Porto Rico Molasses.

500 grams English hay,	451.25	30.77	34.61	136.95	238.23	10.69
150 grams gluten feed,	136.90	5.98	36.14	9.84	79.66	5.28
150 grams molasses,	112.20	9.39	6.68	–	96.13	–
Amount consumed,	700.35	46.14	77.43	146.79	414.02	15.97
228.51 grams manure excreted,	213.34	26.39	32.53	49.47	98.53	6.42
Grams digested,	487.01	19.75	44.90	97.32	315.49	9.55
Minus hay and gluten feed digested,	423.47	16.91	49.53	107.16	241.60	9.90
Molasses digested (grams),	63.54	2.84	—4.63	—9.84	73.89	—.35
Per cent. digested,	56.63	30.24	–	–	76.86	–

STABILITY OF BUTTER-FAT SAMPLES.[1]

BY E. B. HOLLAND, M.SC.

In the examination of butter fat, the question of stability is one of prime importance. Should appreciable changes take place in the samples, results would be vitiated and deductions as to the effect of feed would be of questionable value. That oils and fats are readily acted upon by a number of agents has been long recognized, but whether butter-fat samples as ordinarily treated would be sufficiently changed as to affect analytical results is uncertain, though quite probable from the nature of the substance. To secure definite information on the subject it was necessary to carry out several experiments, of which a description with data follows.

The object of the first experiment was to determine the action of air, light and moisture, respectively, at the same temperature, upon butter fat. Heat as an independent factor could not be studied at that time as it would have increased the work to a point beyond which it could have been handled, but the action of heat was noted more particularly in another experiment. About ten pounds of butter fat were prepared by melting fresh butter and filtering the supernatant fat through paper in a jacketed funnel. Two-ounce bottles, 73 in number, were filled with the melted fat and placed in the north window of the station creamery building in March, 1908. These bottles were divided into seven sets, four of which were closed with a glass stopper and sealed with ceresin to practically eliminate the oxidizing action of the air, and the remainder simply protected by a single thickness of unbleached cotton cloth tied over the top, which readily permitted circulation of the air. One set of

[1] This work was undertaken jointly with Dr. R. D. MacLaurin, but owing to the resignation of Dr. MacLaurin it has been completed and prepared for publication by Mr. Holland.

the sealed bottles was guarded from light [1] and from moisture, and served as a check. Two sets of both closed and open bottles had 1 cubic centimeter of water added, one set of each being exposed to north and east light (not sun) and one set protected from light.[1] Another set of both closed and open bottles was exposed to the light. From these various combinations it was thought deductions might be drawn as to the relative action of air, light and moisture upon butter fat.

The fat was of fair average composition, as shown by the analytical results: —

Saponification number,	232.47
Acid number,	1.48
Reichert-Meissl number,	29.84
Mean molecular weight of volatile acids,	96.90
Insoluble acids (per cent.),	88.21
Mean molecular weight of insoluble acids,	253.08
Iodine number,	28.40
Melting point (Wiley method),	32.95° C.
Refractive index, 40° C.,	1.4525
Valenta test,	28.50° C.

One or two samples were drawn from every series in June and December, 1908, and March and October, 1909, melted, filtered and analyzed. The testing in June, 1908, was more or less unsatisfactory, especially the iodine number, because of the high temperature prevailing, and what deductions may be offered will be based largely upon the remaining data, which represents periods of six, twelve and eighteen months.

Physical Changes.

The original fat, when melted, gave a transparent oil of a pronounced yellow color and a slight but characteristic odor. On standing, the color gradually faded. This, however, was far from uniform, even with members of the same series. The checks were very irregular, varying at the end of the test from yellow to almost white; with moisture the color was less intense, with light similar, and with moisture and light rather better

[1] In providing for the circulation of air, a little diffused light reached the samples.

than the checks. Light, in the absence of air, did not accelerate loss of color.

Air induced the most uniform destruction of color. As the air always carried more or less moisture, it was impossible to differentiate as to the effect of light and added moisture. The most notable change was obtained from the combined action of all three factors.

The sealed samples were porous, and developed a slight odor, unlike that of the original fat. The open samples were more like tallow, both in appearance and odor. Old samples containing added water were turbid on melting, and required considerable time to settle clear.

Chemical Changes.

As decomposition of fats and oil seems to progress along two fairly well-defined lines, that of hydrolysis and that of oxidation, only such determinations were planned as would readily serve to measure these changes; acid and saponification numbers for the former, and iodine number for the latter. Too much must not be expected of these determinations for so complex a reaction, but they are at least indicative. If the decomposition became extensive, other tests would be warranted.

As shown by Table 1, added moisture, in the absence of air, had no appreciable hydrolytic action in excess of the check. Light alone, and with moisture present, preserved the original fat practically unchanged for eighteen months while the check manifested a noticeable breaking down. Moist air increased hydrolysis, both light and added water intensified the reaction. Lewkowitsch states that dry air without light has no action on oils and fats, and his explanation will be presented later.

Aldehydes were produced in both open and closed samples, as shown by the brown color of the saponification test (October, 1909), except in the sealed samples exposed to light.

TABLE 1. — *Saponification Number.*

	MARCH, 1908.	JUNE, 1908.		SEPTEMBER, 1908.		MARCH, 1909.		OCTOBER, 1909.	
	Test.	Test.	Difference.	Test.	Difference.	Test.	Difference.	Test.	Difference.
Check,	232.47	233.32	+.75	232.93	+.46	232.81	+.34	234.28	+1.81
Moisture,	-	233.25	+.78	232.60	+.13	232.66	+.19	234.26	+1.79
Light,	-	233.20	+.73	232.33	—.14	232.33	—.14	231.99	—.48
Light and moisture,	-	232.80	+.33	232.53	+.06	232.75	+.28	232.36	—.11
Air and moisture,	-	233.63	+1.16	232.97	+.50	235.19	+2.72	235.63	+3.16
Air and light,	-	234.24	+1.77	233.72	+1.25	235.98	+3.51	237.32	+4.85
Air, light and moisture,	-	234.51	+2.04	234.74	+2.27	238.21	+5.74	239.28	+6.81

Acid Number.

Check,	1.46	1.40	—.06	1.51	+.05	1.42	—.04	2.75	+1.29
Moisture,	-	1.44	—.02	1.51	+.05	1.59	+.13	2.80	+1.34
Light,	-	1.40	—.05	1.40	—.06	1.39	—.07	1.60	+.14
Light and moisture,	-	1.41	—.05	1.44	—.02	1.59	+.13	1.93	+.47
Air and moisture,	-	1.43	—.03	1.54	+.08	2.12	+.66	3.39	+1.93
Air and light,	-	1.48	+.02	1.57	+.11	2.29	+.83	4.03	+2.57
Air, light and moisture,	-	1.58	+.12	1.88	+.42	3.29	+1.83	5.90	+4.44

Ether Number.

Check,	231.01	231.82	+.81	231.42	+.41	231.39	+.38	231.53	+.52
Moisture,	-	231.81	+.80	231.09	+.08	231.07	+.06	231.46	+.45
Light,	-	231.80	+.79	230.93	—.08	230.94	—.07	230.39	—.62
Light and moisture,	-	231.39	+.38	231.09	+.08	231.16	+.15	230.43	—.58
Air and moisture,	-	232.20	+1.19	231.43	+.42	233.07	+2.06	232.24	+1.23
Air and light,	-	232.76	+1.75	232.15	+1.14	233.69	+2.68	233.29	+2.28
Air, light and moisture,	-	232.93	+1.92	232.86	+1.85	234.92	+3.91	233.38	+2.37

TABLE 2. — *Iodine Number.*

	MARCH, 1908.	JUNE, 1908.		SEPTEMBER, 1908.		MARCH, 1909.		OCTOBER, 1909.	
	Test.	Test.	Difference.	Test.	Difference.	Test.	Difference.	Test.	Difference.
Check,	28.40	29.13	+.73	26.70	—1.70	27.88	—.52	25.88	—2.52
Moisture,	-	28.74	+.34	28.29	—.11	28.13	—.27	25.93	—2.47
Light,	-	28.26	—.14	28.08	—.32	27.38	—1.02	27.43	—.97
Light and moisture,	-	26.86	—1.54	27.83	—.57	27.98	—.42	28.31	—.09
Air and moisture,	-	28.69	+.29	28.02	—.38	26.23	—2.17	25.42	—2.98
Air and light,	-	28.04	—.36	27.79	—.61	25.81	—2.59	24.66	—3.74
Air, light and moisture,	-	27.59	—.81	26.88	—1.52	24.43	—3.97	24.29	—4.11

In the absence of air, added moisture appeared to have no effect as compared with the check on the unsaturated compounds, while light both with and without moisture prevented oxidation to some extent as measured by the iodine number (Table 2). The experiments of Ritsert[1] proved that light, in the absolute exclusion of air, could not produce rancidity, but the preserving action here noted is a peculiar feature worthy of further study.

Moist air increased the oxidation of the fat, with light and added moisture contributing factors. Light in the presence of moist air was destructive, a marked contrast to its action when air was excluded.

The hypothesis of Lewkowitsch,[2] supported by the investigations of Geitel[3] and Duclaux,[4] offers an explanation of the probable changes that take place in the development of rancidity in oils and fats. The initial change he ascribes to the action of moisture in the presence of fat-splitting enzymes. The free fatty acids resulting from the hydrolysis are oxidized by the air in the presence of light. Ritsert[1] asserts that oxygen and light must act simultaneously, neither of the agents alone being able to produce rancidity.

On the basis of the above assumption the hydrolysis of the check samples must have been due to traces of moisture in the fat and in the air between fat and stopper, and the oxidation to the air and a very limited amount of diffused light. This may be possible, as the changes were not, in themselves, excessive, though rather out of proportion to the conditions prevailing. It fails, however, to explain why similar samples in the light gave less rather than equal or greater changes under conditions which naturally should have been more favorable. The changes in the open samples were not wholly in accord with the theory. Light was a factor in oxidation, as was to be expected, but also in hydrolysis, which is difficult to explain. With many points indecisive and others unconsidered, the prime object of the experiment has been attained in showing that filtered butter-fat samples of normal acidity can be satisfactorily preserved in well-stoppered bottles. The action of high temperatures and sunlight

[1] Untersuchungen über d. Ranzigwerden der Fette. Inaug. Dissert. Berlin, 1890.
[2] Chemical Technology and Analysis of Oils, Fats and Waxes, 3d Edition, Vol. I., pp. 23, 24.
[3] Journ. f. prakt. Chemie, 1897 (55), 448.
[4] Annales de l'Institut Pasteur, 1887; Compt. rend. 102, 1077.

should, of course, be avoided. As to the specific action of air, light and moisture, the experiment should be considered only preliminary, pointing the way for further work under "control" conditions.

Action of Heat.

The object of the second experiment was to ascertain what changes might take place upon heating butter fat several days at 50° C. Fresh samples were prepared. After heating a sample twenty-four hours in a water bath, varying amounts were weighed for saponification, acid and iodine numbers; similar portions were withdrawn at the end of forty-eight hours, and again after seventy-two hours' heating.

The analysis of the check sample and of the heated fat are presented in the following table: —

	Saponification Number.	Acid Number.	Ether Number.	Iodine. Number.
Check,	233.07	.84	232.23	28.18
Heated twenty-four hours,	233.99	.74	233.25	28.10
Heated forty-eight hours,	233.30	.81	232.49	28.17
Heated seventy-two hours,	233.62	.83	232.79	28.16

The results indicate a slight difference between the two samples in spite of careful mixing, as shown by the saponification and acid numbers. Heating gave a very slight increase in acid number, otherwise no change is noticeable. It seems evident, therefore, that any reasonable heating of butter fat at a temperature not exceeding 50° C. would have little appreciable effect upon analytical results.

ADDITIONAL NOTES FOR METHODS IN FAT ANALYSIS.[1]

BY E. B. HOLLAND, M.SC.

In the titration of saponification and acid numbers of the fat, and neutralization number of the insoluble acids, 1 cubic centimeter of indicator should be used. This has been our practice for some years, though not so stated in the methods, and gives a more definite end point, especially in the case of acid number. The writer has also noted the rather ambiguous statements relative to desired temperature for the above titrations. A temperature of 40° to 45° C. has proved very satisfactory. It is sufficiently high to maintain the soaps and fatty acids in solution and yet not destroy the sensitiveness of the indicator. Slight saponification may take place in the determination of acid number, but the error is less than the opposite fault of too great chilling.

Sulfuric acid is preferable to hydrochloric for the decomposition of the soap in the determination of insoluble acids; 150 cubic centimeters of water together with 5 cubic centimeters of sulfuric acid (1–4) clears the solution rapidly with little apparent action on the fatty acids.

The variable results in iodine number at a high temperature are evidently due to volatilization of iodine and not to a secondary reaction. Moistening of the cork stopper with potassium iodide solution will reduce the loss, but not prevent it, if the temperature exceeds 10° to 15° C.

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[1] Massachusetts Agricultural Experiment Station, twenty-first report (1909), pp. 120–138.

VOLUMETRIC DETERMINATION OF COPPER.[1]

BY E. B. HOLLAND, M.SC.

The co-operation of the laboratory in the experiments conducted by other departments of the station has often rendered necessary quantitative determinations of reducing sugar, sucrose, lactose and starch in a variety of products. The final step in every case is the determination of the cuprous oxide precipitated from Allihn's solution by the reducing action of the sugar. After a considerable study of different methods of filtration, and various ways of determining the amount of precipitate as copper, cuprous and cupric oxides, the following method was adopted, having proved highly satisfactory if reasonable attention is paid to details. It might be said, further, that as such work often has to be done at odd times, it is desirable to maintain a supply of sugar tubes,[2] and only to titrate when there are a number of tests on hand. By exercising a little care the same tubes can be used repeatedly without change of felt.

The process consists of heating an aliquot part of the sugar solution with the mixed Allihn's solution (30 cubic centimeters of "white," 30 cubic centimeters of "blue" and 60 cubic centimeters of water) and filtering by aid of suction through a sugar tube with an asbestos felt supported by glass wool. The cuprous precipitate is transferred to the tube, washed with hot water until free from alkali and then with alcohol. The copper is dissolved in 5 cubic centimeters of concentrated nitric acid, thoroughly washed with hot water, and the filtrate run into an Erlenmeyer flask by means of suction. The solution is evaporated to small volume to expel excess of acid, and afterwards diluted with 60 cubic centimeters of water. Too great concentration should be avoided, as it often results in the precipi-

[1] An adaptation of the Low zinc-acetate method.

[2] Eimer and Amend, No. 3263.

tation of a very insoluble form of copper and the loss of the determination. Twenty-five cubic centimeters of a saturated solution of zinc acetate and 20 cubic centimeters of potassium iodide (165 grams to 1,000 cubic centimeters) are added, and the free iodine titrated with N/10 sodium thiosulfate solution (24.83 grams per liter). The thiosulfate is run in gradually, with constant shaking, until the brownish yellow color (iodine) has been largely destroyed; then 2 cubic centimeters of starch paste (1 gram to 200 cubic centimeters) are added and the titration continued until the blue particles have entirely disappeared. Towards the end of the reaction the flask should be stoppered and shaken thoroughly.

The copper equivalent of the thiosulfate is determined by diluting 25 cubic centimeters of a standard copper solution with water, evaporating and titrating exactly as in the test. The standard solution is prepared by dissolving 10 grams of pure dry metallic copper in 200 cubic centimeters of concentrated nitric acid, and making up to a liter with water at 20° C. The solution should be analyzed gravimetrically, and will keep almost indefinitely. From this data the reducing action of the sugar solution can be readily calculated in terms of copper, and by conversion tables the corresponding amount of sugar. The method has been more recently applied to the determination of copper in Paris green and arsenite of copper, and found equally satisfactory. The copper is precipitated from a hydrochloric acid solution in the presence of sodium acetate with a slight excess of sodium hydrate. The resulting cuprous oxide is transferred to a sugar tube and determined as above. While the first reading of this method might give the impression that it was rather difficult, in reality it is extremely simple, can be carried out rapidly and the titration is very sensitive.

READING THE BABCOCK TEST.

BY P. H. SMITH.

Introduction.

During the summer of 1909 an investigation was undertaken to determine the best method of reading the column of fat in the manipulation of the Babcock test.

Babcock [1] in his first description of the test advocates reading "the divisions which mark the highest and lowest limits of the fat," which would, of course, include the upper and lower meniscus. Subsequent experiments proved that such a practice gave too high results, especially for cream tests in cases where 30 and 50 per cent. 6-inch Connecticut cream bottles were used, and the method of reading to the *bottom* of the upper meniscus became quite prevalent in certain sections of the country. This station has held, however, that until recognized authorities advocated this method, it was better to hold to the original method, in order that results of different chemists and creamery men might be comparative. It was not, therefore, until 1908, when a widely used text-book [2] recommended omitting the upper meniscus from the reading, that it was considered by the Massachusetts experiment station.

An objection to reading tests to the bottom of the upper meniscus is founded upon the fact that the *depth* of the meniscus is influenced by several factors, including diameter of the neck of the bottle, color and clearness of the fat column and different light effects. Different persons conscientiously attempting to read the same test correctly may vary considerably in their results. In order to eliminate this error Eckles [3] recommends the use of

[1] Bulletin 24, Wisconsin Agricultural Experiment Station.
[2] Testing Milk and its Products, Farrington and Woll.
[3] Chicago Dairy Produce, July, 1908.

amyl alcohol, — colored a bright red by fuchsin or any common red dye, — a small quantity of which is dropped on top of the fat column at the completion of the test. Being lighter than butter fat it floats upon the fat, doing away with the meniscus and giving a sharply defined line between alcohol and fat. Farrington,[1] at the suggestion of Babcock, recommends ethyl alcohol saturated with butter fat, which is used in the same manner as the amyl alcohol. "The fat-saturated alcohol is prepared by adding about a teaspoonful of butter fat to 6 ounces of alcohol in a bottle. Warm and shake the bottle until the alcohol has dissolved all the fat possible; some of it will be left undissolved at the bottom of the bottle." Butter fat at the temperature when usually read has a specific gravity of 0.9. It is necessary to have the alcohol reasonably pure, otherwise there is a possibility of its being heavier than the butter fat, in which case it would pass through the fat column instead of floating on top. Ethyl alcohol containing 42 per cent. water has approximately the same specific gravity as butter fat.

Observations at this Station.

Six-inch test bottles having as wide a diversity in size of neck as could be brought together were used. These bottles were carefully cleaned, and before using were washed out with ether to remove all traces of fat. Pure butter fat was then weighed into the bottles on a delicate balance, and enough hot water added to make up to 18 grams. The bottles were then placed in a Babcock tester and whirled three times, five, three and two minutes, respectively, as for the regular test. Readings including and without the upper meniscus were taken immediately; alcohol according to the Farrington method was then added and readings again taken. The theoretical readings were then computed and the results compared. Following is the tabulated data: —

[1] Special circular, Wisconsin Dairy School.

TABLE 1.

KIND OF BOTTLE.	Length of Scale (Millimeters).	Ten Per Cent. on Scale equals (Millimeters).	Each Division represents (Per Cent.).	Grams Fat taken.	Theoretical Reading.	Actual Reading, Top Meniscus.	Error (Per Cent.).	Actual Reading, Bottom Meniscus.	Error (Per Cent.).	Actual Reading, Farrington Method.	Error (Per Cent.).
5 per cent. double neck,	61.0	122.0	.1	.5816	3.23	3.20	—.03	3.15	—.08	3.20	—.03
8 per cent. milk,	73.0	91.2	.1	.9665	5.37	5.50	+.13	5.30	—.07	5.40	+.03
10 per cent. milk,	65.0	65.0	.2	1.0629	5.91	6.20	+.29	5.90	—.01	6.00	+.09
10 per cent. milk,	63.5	63.5	.2	1.1009	6.12	6.40	+.28	6.20	+.08	6.30	+.18
30 per cent. cream,	78.0	26.0	.5	4.0551	22.53	23.25	+.72	22.25	—.28	22.50	—.03
30 per cent. cream,	80.5	26.8	.5	4.0330	22.41	23.50	+1.09	22.50	+.09	22.50	+.09
30 per cent. cream,	77.5	25.8	.5	4.3870	24.37	25.00	+.63	24.25	—.12	24.50	+.13
30 per cent. cream,	71.0	23.7	.5	4.4060	24.48	25.25	+.77	24.75	+.27	-	-
30 per cent. cream,	66.0	22.0	.5	4.3572	24.21	25.50	+1.29	24.75	+.54	-	-
30 per cent. cream,	75.0	25.0	.5	3.2235	17.89	18.75	+.86	18.00	+.11	-	-
30 per cent. cream,	69.0	23.0	.5	3.0236	16.78	17.75	+.97	17.00	+.22	-	-
30 per cent. cream,	66.0	22.0	.5	1.7083	9.49	10.50	+1.01	9.75	+.26	-	-
30 per cent. cream,	74.0	24.7	.5	1.7188	9.55	10.50	+.95	9.75	+.20	-	-
50 per cent. cream,	72.0	14.4	1.0	6.6740	37.08	38.50	+1.42	37.00	—.08	37.50	+.42
50 per cent. cream,	57.0	11.4	1.0	6.6110	36.73	38.50	+1.77	36.50	—.23	37.00	+.27

The results reported were all made with 6-inch bottles, because we were attempting to find the most accurate method for reading tests made under conditions existing at the experiment station laboratory. It would have been quite instructive to have been able to run more tests, using the 9-inch bottles, which require a special machine on account of the longer neck.

Conclusions.

1. With one exception the readings taken to the top of the upper meniscus were too high, the amount of error being in most cases proportional to the diameter of the bottle neck.

2. Where the readings were taken to the bottom of the upper meniscus the results were much more uniform. In several cases, however, there was considerable variation, due very likely to the difficulty of determining accurately the lowest point of the upper meniscus.

3. The alcohol method, where used, showed more concordant results, especially for the 10 and 30 per cent. bottles. The difference between these results and the theoretical test was no greater than might be expected between duplicate tests by the gravimetric method. The tests made in the 50 per cent. bottles varied materially, which might reasonably be attributed to the difficulty of reading these bottles accurately on account of the large diameter of the neck.

It was suggested that the method might give somewhat different results if a mixture of a definite amount of butter fat and skim milk was used in place of butter fat and water, the former mixture more closely resembling milk or cream. In order to test this point butter fat was weighed into several 10 and 30 per cent. thoroughly cleaned bottles, together with sufficient separator skim milk (which had been previously tested) to make the contents of the bottles weigh 18 grams. Sulfuric acid was then added and the test completed as usual. The results are as follows: —

TABLE 2.

KIND OF BOTTLE.	Grams Fat taken.	Theoretical Reading.	Actual Reading, Top Meniscus.	Error (Per Cent.).	Actual Reading, Bottom Meniscus.	Error (Per Cent.).	Actual Reading, Farrington Method.	Error (Per Cent.).
10 per cent. milk,	.9740	5.41	5.60	+.19	5.40	—.01	5.50	+.09
10 per cent. milk,	.9823	5.46	5.80	+.34	5.55	+.09	5.60	+.14
10 per cent. milk,	.9880	5.49	5.80	+.31	5.60	+.11	5.70	+.21
10 per cent. milk,	1.0500	5.84	6.10	+.26	5.80	—.04	6.00	+.16
30 per cent. cream,	4.1509	23.06	24.25	+1.19	23.75	+.69	23.25	+.19
30 per cent. cream,	4.1512	23.06	24.00	+.94	23.50	+.44	23.00	—.06
30 per cent. cream,	4.1717	23.18	24.25	+1.07	23.75	+.57	23.25	+.07

As in the former trials, reading to the top of the meniscus gave high results, proportional in most cases to the diameter of the graduated neck; reading to the bottom of the meniscus gave results more nearly corresponding to theory, while the results with the alcohol method were quite uniform and consistent. The high results obtained by attempting to read to the bottom of the meniscus in the case of the three cream bottles was due to the cloudiness of the fat, which made an accurate reading difficult, if not impossible.

Webster and Gray,[1] as a result of experiment, recommend the following procedure, in reading cream tests: "Read from the bottom to the extreme top of fat column, then read the depth of the meniscus and deduct four-fifths of it from previous reading."

Hunziker [2] advocates reading to the bottom of the upper meniscus and adding one-third of meniscus to reading in cream tests.

The introduction of any factor in reading the test tends toward making the method more complicated, and one unacquainted with its scientific aspects may discredit it entirely. With our present knowledge, and pending further investigation, the writer would advocate reading the tests made in 10 per cent. milk bottles from the bottom to the extreme top of the fat column, including the meniscus, as is now generally practiced; while for 30 per cent., 6-inch Connecticut cream bottles the reading should be taken from the extreme bottom of the fat column to the bottom of the upper meniscus, preferably by the use of alcohol, as described either by Eckles or Farrington.

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[1] Bulletin 58, Bureau of Animal Industry, United States Department of Agriculture.

[2] Report read before annual meeting of Official Dairy Instructors and Investigators Association, at Milwaukee, 1909.

THE USE OF THE ZEISS IMMERSION REFRACTOMETER IN THE DETECTION OF WATERED MILK.

BY P. H. SMITH AND J. C. REED.

The campaign before the 1910 session of the Massachusetts Legislature, for a change in the milk standard, brought prominently to the public mind the question as to whether slightly watered milk might be detected and differentiated from normal low-grade milk by methods available to the analytical chemist. In addition to the relative proportion of solids and fat, the index of refraction of the milk serum, as determined by the Zeiss immersion refractometer, has been advocated as a valuable aid in the detection of added water. The details of this method were perfected by Leach and Lythgoe [1] who claim, after careful investigation, that " if a milk serum is found with a refraction lower than 39, it is safe to allege that the sample was fraudulently watered, especially if, in addition to this, the solids not fat stand below 7.3 per cent."

In order to obtain further light on the subject we have made a complete analysis of the milk from three herds, together with the analysis of several samples systematically skimmed and watered. The analytical methods used were those advocated by the Association of Official Agricultural Chemists, while for determining the refractive index the procedure given by Leach [2] was adopted. The results follow in tabular form: —

[1] Thirty-fifth annual report, Massachusetts State Board of Health, 1903, p. 483; Journal American Chemical Society, 1904, 26: 1195.

[2] Food Inspection and Analysis, Leach, p. 765, published by John Wiley & Sons, New York.

Northampton State Hospital (Holsteins).

Number.	Number of Months in Milk.	Approximate Daily Production at Time of Sampling (Pounds).	Specific Gravity.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Proteids N x 6.25 (Per Cent.).	Ash (Per Cent.).	Sugar by Difference (Per Cent.).	Refractive Index.
1,	3	26	1.0305	11.74	3.70	8.04	2.98	.70	4.36	41.12
2,	5	27	1.0320	12.24	3.50	8.74	3.15	.67	4.92	40.00
3,	8	24	1.0315	11.99	3.50	8.49	3.16	.67	4.66	43.00
4,	6	27	1.0300	12.33	3.90	8.43	2.97	.75	4.71	-
5,	8	26	1.0350	13.39	4.10	9.29	3.91	.76	4.62	-
6,	3	23	1.0315	11.72	3.40	8.32	3.08	.66	4.58	42.32
7,	4	28	1.0320	11.96	3.60	8.36	2.60	.65	5.11	43.82
8,	9	23	1.0310	11.95	3.70	8.25	3.06	.69	4.50	-
9,	6	27	1.0330	13.07	4.50	8.57	3.39	.68	4.50	-
10,	3	35	1.0300	12.61	4.60	8.01	3.10	.75	4.16	-
11,	5	29	1.0330	12.89	4.00	8.89	3.25	.67	4.97	-
12,	3	24	1.0325	12.69	3.70	8.99	3.23	.66	5.10	-
13,	6	26	1.0300	11.64	3.60	8.04	2.98	.66	4.40	41.26
14,	6	30	1.0330	12.17	3.80	8.37	3.11	.72	4.54	-
15,	1	34	1.0330	12.70	4.10	8.60	3.22	.75	4.63	-
16,	1	65	1.0300	11.63	3.60	8.03	2.78	.68	4.57	41.18
17,	9	21	1.0325	13.18	4.10	9.08	3.46	.67	4.95	-
18,	6	27	1.0310	12.21	3.70	8.51	3.10	.71	4.70	-
19,	6	23	1.0305	11.80	3.60	8.20	3.30	.67	4.23	41.85
20,	5	27	1.0335	13.15	4.20	8.95	3.49	.73	4.73	-

Massachusetts Agricultural College Herd.

No.	Breed.	Number of Months in Milk.	Approximate Daily Production at Time of Sampling (Pounds).	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Proteids N x 6.25 (Per Cent.).	Ash (Per Cent.).	Sugar by Difference (Per Cent.).	Refractive Index.
1	Jersey,	3	24	14.68	5.70	8.98	3.71	.71	4.56	44.30
2	Jersey,	12	13	15.28	6.10	9.18	4.00	.77	4.41	44.56
3	Jersey grade,	8	13	14.19	5.70	8.49	3.34	.75	4.40	43.70
4	Guernsey grade,	2	26	15.21	6.10	9.11	3.72	.73	4.66	44.39
5	Guernsey grade,	4	23	13.14	4.50	8.64	3.18	.75	4.71	44.10
6	Ayrshire,	10	5	14.75	5.45	9.35	4.42	.85	4.03	44.45
7	Ayrshire,	3	41	12.04	4.20	7.84	2.81	.69	4.34	41.65
8	Ayrshire,	10	9	12.75	4.60	8.16	3.72	.69	3.74	41.70
9	Ayrshire,	10	13	13.77	4.85	8.92	3.50	.74	4.68	45.15
10	Ayrshire,	2	20	13.70	4.90	8.80	3.32	.69	4.79	45.60
11	Ayrshire grade,	1	36	14.11	5.55	8.56	3.60	.72	4.24	43.05
12	Ayrshire grade,	1	38	12.56	4.10	8.46	3.03	.69	4.74	44.27
13	Ayrshire grade,	1	43	12.46	4.00	8.46	3.04	.71	4.71	43.59
14	Ayrshire grade,	2	33	13.39	5.05	8.34	3.03	.71	4.60	44.14
15	Ayrshire grade,	5	23	12.16	4.00	8.16	2.85	.69	4.62	43.26
16	Ayrshire grade,	7	24	13.75	5.10	8.65	3.63	.70	4.32	43.28
17	Ayrshire grade,	–	17	12.37	3.50	8.87	3.27	.69	4.91	44.11
18	Holstein,	7	22	13.02	4.35	8.67	3.34	.70	4.63	43.84
19	Holstein,	15	5	13.43	4.40	9.03	3.85	.82	4.36	43.88
20	Holstein,	1	46	11.58	3.75	7.83	2.97	.74	4.12	42.08
21	Holstein,	6	29	13.98	4.80	9.18	3.95	.73	4.50	44.65
22	Holstein,	9	9	14.85	5.50	9.35	4.00	.74	4.61	45.15
23	Holstein grade,	–	22	13.62	4.80	8.82	3.63	.72	4.47	41.05
24	Holstein grade,	5	43	12.19	3.80	8.39	3.10	.72	4.57	43.30
25	Shorthorn grade,	3	33	12.32	3.90	8.42	3.12	.67	4.63	43.60
26	Mixed herd,	–	–	12.77	4.10	8.67	3.17	.72	4.78	43.22

Miscellaneous Analyses.

No.	Milk from —	Number of Months in Milk.	Approximate Daily Production at Time of Sampling (Pounds).	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.	Proteids N x 6.25 (Per Cent.).	Ash (Per Cent.).	Sugar by Difference (Per Cent.).	Refractive Index.	Specific Gravity.
1	College herd, .	–	–	12.77	4.10	8.67	3.17	.72	4.78	43.22	–
2	College herd, .	–	–	11.76	3.70	8.06	2.99	.69	4.38	41.62	–
3	College herd, .	–	–	11.49	3.69	7.80	2.85	.65	4.30	40.08	–
4	College herd, .	–	–	10.22	3.28	6.94	2.54	.58	3.82	37.35	–
5	College herd, .	–	–	11.06	3.30	7.76	2.88	.63	4.25	40.10	–
6	Holstein grade, .	5	43	12.04	3.60	8.44	3.11	.71	4.62	42.90	–
7	Holstein grade, .	–	–	10.84	3.24	7.60	2.80	.64	4.16	39.80	–
8	Holstein grade, .	–	–	9.63	2.88	6.75	2.49	.57	3.69	37.15	–
9	Ayrshire grade, .	–	17	12.97	4.40	8.57	3.07	.69	4.81	43.52	–
10	Ayrshire grade, .	–	–	10.38	3.52	6.86	2.46	.55	3.85	37.52	–
11	Holstein, . .	1	110	9.87	2.30	7.57	2.69	.71	4.17	39.97	1.0300
12	Jersey-Holstein, .	7	19	15.51	6.50	9.01	3.87	.77	4.37	44.20	1.0340
13	Jersey-Holstein, .	–	–	13.41	5.00	8.41	3.56	.70	4.15	42.05	1.0315

Notes.

No. 2. Same as No. 1, with 5 per cent. water and 5 per cent. skim milk added.
No. 3. Same as No. 1, with 10 per cent. water added.
No. 4. Same as No. 1, with 20 per cent. water added.
No. 5. Same as No. 1, with 10 per cent. water and 10 per cent. skim milk added.
No. 7. Same as No. 6, with 10 per cent. water added.
No. 8. Same as No. 6, with 20 per cent. water added.
No. 10. Same as No. 9, with 20 per cent. water added.
No. 11. Pure-bred cow on forced test.
No. 13. One liter of No. 12 allowed to stand in cylinder over night, 20 per cent. of the cream (by volume) removed and 10 per cent. of water added.

Massachusetts Agricultural Experiment Station Herd.

No.	Breed.	Number of Months in Milk.	Approximate Daily Production at Time of Sampling (Pounds).	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Proteids N x 6.25 (Per Cent.).	Refractive Index.
1	Jersey,	5	18	14.61	5.40	9.21	3.94	45.32
2	Jersey,	5	19	14.65	6.20	8.45	3.06	44.04
3	Jersey,	3	23	14.03	5.30	8.73	—	44.18
4	Jersey high grade,	4	19	14.82	5.85	8.97	3.88	44.20
5	Jersey high grade,	5	17	15.58	6.40	9.18	4.00	44.60
6	Jersey high grade,	4	20	13.91	5.55	8.36	3.31	42.75
7	Jersey-Ayrshire,	5	17	13.80	4.85	8.95	3.63	44.25
8	Jersey-Holstein,	7	19	15.58	6.55	9.03	3.81	44.25
9	Holstein grade,	6	15	12.84	4.30	8.54	3.44	43.55
10	Holstein grade,	6	20	13.81	5.05	8.76	3.44	44.11
11	Holstein grade,	6	20	13.31	4.45	8.86	3.50	44.25

The results secured and tabulated above justify the following tentative conclusions: —

1. The serum of a milk of known purity is not likely to have a refractive index below 40.

2. It seems probable that the refractive index depends, to an extent, upon the stage of lactation of the cow, being highest in the advanced stages, when the animal is giving but little milk. More data are needed, however, to confirm this statement.

3. Rich milk, containing 4 per cent. or more of fat, has a tendency to give a higher index of refraction than thin milk (less than 4 per cent. fat). This rule, however, does not always hold true.

4. Many milks, especially those produced by Jerseys and Guernseys and their grades, can be adulterated with 10 per cent. of water, or 5 per cent. of water and 5 per cent. of skim milk, and escape detection by means of the index of refraction. In case of very rich milk, *i.e.*, pure milk containing 6 per cent. of fat, it may be possible to add 20 per cent. of water, or 10 per

cent. of water and 10 per cent. of skim milk, without positively detecting its presence by the aid of the refractometer.

5. It is believed that the Zeiss refractometer will prove very helpful in the detection of added water in milk. The evidence furnished, however, must be considered in connection with that secured by direct chemical analysis.

It is believed that the percentage of ash in milk is likely to prove fully as helpful in many cases as the index of refraction in detecting the presence of added water. Mixed milk falling substantially below .70 per cent. of ash must be regarded with suspicion, and that testing below .65 per cent. of ash as watered.

The impression held by some milk inspectors and producers, that the immersion refractometer will detect very small amounts of added water, is erroneous. Such an impression, firmly fixed in the minds of unscrupulous producers and dealers might have a salutary effect, but it is not justified by results in actual practice.

MALNUTRITION.

BY G. E. STONE.

Malnutrition is a term referring to certain pathological conditions in a plant which result from the improper use of plant foods. It may occur from a lack of plant foods of any kind, or starvation; or it may result from an excess of some particular plant food.

An increasing number of troubles has been called to our attention the past five or six years which have been found to be typical cases of malnutrition, induced by an excess of some particular substance in the soil. By far the larger number occur in greenhouses, being found chiefly in the houses of growers of limited skill and experience in handling greenhouse crops. These troubles all originate from an injudicious use of commercial fertilizers, or from applying certain manures to crops in excess of what they can stand.

The symptoms of malnutrition, as might be expected, are more or less specific, the nature of the response depending not only on the crop but also on the nature and amount of plant food used. Identical stimuli may produce different effects upon different individuals, or plants remotely related to one another may react similarly. The reaction of the plant to stimuli is dependent more upon its individuality than upon the nature of the stimulus which might give rise to any series of responses; in other words, the principal factor determining the nature of the reaction is more a property of the individual than one associated with the stimulus.

In some cases an excess of fertilizers causes burning of the roots, which results in the death of the plant, but these are not necessarily cases of malnutrition, since by the rapid and more or less complete destruction of the root system little or none of the substances is absorbed. Burning and collapse of the root system also have been observed where an excessive amount of muriate or carbonate of potash had been applied, and an excess of tannin, such as is found in the sawdust from certain trees, will cause the roots of plants to turn yellow and eventually die.

The effects of chemical substances on roots are not always the same, although ultimate death may follow their use. Certain chemical substances, on coming into contact with the roots, may merely cause plasmolysis of the cells. The immediate result here may not be death of the cells, but if the cells remain in a state of plasmolysis for any length of time, the collapse of the plant follows.

Any substance in the soil which affects the osmotic tension or turgidity of the cell would naturally prevent root absorption, and if the plant was transpiring very freely it would sooner or later wilt and collapse. On the other hand, a large number of chemical substances act as direct poisons to the protoplasm, killing it the moment of contact.

By far the largest number of cases of malnutrition which have been brought to our notice are found in greenhouse plants, although outdoor crops are by no means wholly free from it. Conditions in a greenhouse are entirely different from those out-of-doors. The frequent rainfalls, together with the action of frosts in winter, naturally hasten the process of leaching, and soil in the field which might become abnormal from injudicious fertilizing is kept in a normal condition. In the greenhouse the leaching is not so thorough, since the water and plant food are usually confined to the surface in a concentrated form. Moreover, in the greenhouse new supplies of plant food are being constantly added, and in the end do harm. When the soil is treated with hot water or steam, as is often the case, additional soluble food becomes available, which, in a soil already rich, is likely to produce ideal conditions for malnutrition. It would appear from the results of our experiments and observations that by far the greater amount of trouble from malnutrition comes from excess of nitrates in the soil.

Some years ago a potted specimen of a Johnsonian lily which had a number of eruptions or blisters on its leaves was called to our attention. These reddish blisters, on careful examination, showed no evidence of the presence of fungi or insects. The cells in the vicinity of the blisters, however, indicated that they had been greatly stimulated. This had resulted in excessive cell division, causing rupturing and a ragged, wounded appearance of the tissue. An experiment with perfectly healthy lilies was made, in which the plants were liberally fertilized with Chili saltpeter, and in a short time we obtained practically the same characteristics, that is, the blisters or eruptions. Blisters developed on a cyclamen were also observed, and were shown to be due to an excessive use of nitrate of soda.

Many cases of injury from overwatering and forcing have come to our attention in connection with such plants as carnations, tomatoes, etc.

The effects of nitrates on plants have long been known, and instances are mentioned by Czapek. Cases have been brought to our attention several times where tomato plants have been affected by the excessive use of fertilizers, and tests of the foliage for nitrates revealed an excess in the leaves. The tomato leaves in such cases had a curled and crinkled appearance, caused by the contorted vascular bundles or veins. A somewhat similar contortion of the foliage has been observed by us in soy beans when grown under certain conditions. These symptoms have been occasionally found in the field as well as in plants growing in pots in the greenhouse, and analyses have revealed an excess of nitrates in the foliage.

Greenhouse cucumbers are more susceptible to injury from manures and fertilizers than any crop known to us, and produce more cases of malnutrition than any of the others grown under glass. The condition of the soil which will destroy a crop of cucumbers will not, however, affect lettuce or tomato plants, while a rose or carnation plant might appear underfed in such a soil.

From a long experience in growing cucumbers under glass, as well as years of experimenting with this crop, and annual observations on a large number of commercial houses in the State, we are convinced that it is not safe for the ordinary grower to apply commercial fertilizers to a crop of this kind. Commercial fertilizers undoubtedly could be used on cucumbers, but would have to be used very sparingly, and only with the advice of the expert.

The best soil for cucumbers is composed of loam, decomposed sod and horse manure. No other manure of any kind is necessary, and should not be applied except sparingly, and as for commercial fertilizers, none should be used except ground bone and wood ashes, and it is questionable whether these are of any value. Cucumbers require a porous soil, and this is furnished by the sod and horse manure. When growing in solid beds the crop can be treated with horse manure if necessary to furnish underground heat, but trenching of the horse manure should be at least eight inches or one foot below the surface.

Malnutrition in cucumbers is characterized by a rolling of the foliage, producing a convexity of the upper surface of the leaf. The edges or margins of the leaf may or may not be slightly burned or dead, but this symptom is often associated with malnutrition. This latter condition may also be caused by a lack of root absorption and excessive transpiration. In extreme cases, besides the more or less severe curling of the leaves, the vascular bundles or veins become badly contorted, the leaves arrested in growth and the apex of the stem curled up into a mass; and plants once in this condition may remain so for weeks. There is, however, a certain amount of plasticity in cucumber plants, as in all others, and they sometimes succeed in adapting themselves to extreme conditions, and showing some attempt to recover or outgrow these symptoms. In very severe cases, such as were found to be associated with a rich soil to which had been added an excessive amount of pulverized sheep manure, and which had received the hot-water treatment, the fruit becomes mottled and irregular in shape, the surface often presenting excrescences or tubercular growths.

We have had occasion to observe a large number of cases of malnutrition in greenhouses in this as well as in other States, and a few of the conditions which produce it may be mentioned here. It should be pointed out that practically all greenhouse growers of cucumbers start with a well-manured soil composed of sod, loam and horse manure. A soil prepared in this way is suitable, without the addition of anything else for the normal production of cucumbers, and even if well supplied with horse manure it is not likely to produce cases of malnutrition. There is, to be sure, much difference in horse manure, some being much more concentrated than others, but we have grown cucumbers in boxes in soil to which 75 per cent. of horse manure had been added without producing any abnormal symptoms. Excessive use of horse manure, especially if it is too strong, may cause symptoms of malnutrition, but no trouble should be caused by a careful use of this manure each year. Constant watering of cucumber plants with liquid fertilizer or manure of any kind will cause malnutrition, and the addition of pig or cow manure to the horse manure, or the use of either alone, is very likely to produce it. We have frequently observed trouble from the use of pig manure mixed with horse manure, and Professor Whetzel of Cornell University has called our attention to the injury caused by this combination in New York State. In one particular case the plants, in addition to being treated with horse manure containing considerable amounts of pig manure, were watered frequently with a strong decoction of these manures.

Some of the most severe cases of malnutrition we have observed resulted from the use of hen manure worked into soil already provided with an abundance of plant food, such as would be obtained from a constant use of horse manure. In practically all the instances which have come to our notice where hen manure had been applied rather freely, symptoms of malnutrition have followed.

A more recent tendency among cucumber growers is to make use of dried, pulverized sheep manure, either alone or in combination with cow manure. Two cases of malnutrition in cucumber houses have recently been brought to our attention, one extremely severe and the other more or less so. These were caused by the use of pulverized sheep manure and various fertilizers. One grower, having some 2,800 feet in length of houses, applied 3 tons of pulverized sheep and cow manure, with the result that the whole crop died. This house had been used for some years without changing the soil, and had received every year probably from 30 to 60 tons per acre of horse manure. The soil was naturally in good condition, and had plenty of plant food without the addition of the sheep manure. The malnutrition symptoms were so marked on this crop that even the young seedlings were affected. In addition to this the hot-water treatment was used, which only served to aggravate the trouble.

We have recently seen another case in which the plants in a range of houses about 1,800 feet in length were more or less affected. Besides the application of horse manure for a number of years, the houses had been treated with cow manure, various kinds of phosphates, nitrate of soda, lime, hen manure and pulverized sheep manure, as well as hot water. Different types of greenhouses were represented in this establishment, and the houses were also of different ages. The older houses, which had been manured and fertilized the most heavily, were decidedly the worst. The new houses, where less manure and fertilizer had been applied, were least affected. In the older houses it had become almost impossible to grow good crops of cucumbers, but fairly goods crops were growing in the new houses. These houses had been used occasionally for growing other crops, like tomatoes and radishes, which were not affected in any way. This practice of rotation is beneficial, and has a tendency to make the soil more suitable for cucumber growing.

The extensive use of nitrate of soda is responsible for many cases of malnutrition. We have demonstrated by experiments that potted plants of cucumbers watered with potassium or sodium nitrate will wilt in the sunshine more quickly than those treated with water alone. Nitrate of soda, when used in greenhouses, often acts by preventing root absorption. As a consequence of this reduction of the root absorptive capacity of the plant, particularly when the house is warm and dry and transpiration very active, the leaf edges of the cucumber wilt and die, which causes a rolling of the leaf or convexity of the upper surface.

Wetting down the soil with hot water, or steaming it, as already pointed out, is favorable to malnutrition, for the reason that a considerable amount of plant food already in the soil is by this practice made more available. This is shown by the greatly increased growth of plants in such soil, and the increased number of bacteria present.

In the growing of greenhouse crops of all kinds, manure is extensively used. For example, lettuce has been grown for forty years in soil which has been repeatedly manured with horse manure and straw, and no indications of malnutrition caused by this extensive manuring have ever been noticed. It is generally considered that the older a lettuce soil, the better it is for this crop, but if commercial fertilizers are employed indiscriminately in a lettuce house already well supplied with plant food, the chances are that a case of malnutrition will result.

Roses, carnations and violets require a rich soil, and a considerable amount of manure is used by floriculturists in their soil. Cases of malnutrition are prevented here by never growing these crops in the same soil more than one year, the benches being refilled with fresh soil each year. A typical rose soil is composed of one-third loam, one-third pulverized sod and one-third cow manure. In addition to this, the plants are watered once a week with a strong liquid manure. Cases of malnutrition with this treatment seldom if ever occur with roses.

A few years ago an experiment was conducted in one of our houses devoted exclusively to the growing of American Beauty roses. The soil was prepared as described above, and liquid manure was applied freely once a week or oftener. The first year the roses did well, and for the purpose of experiment we attempted to grow a new crop of roses in the same soil which had been used the previous year. The soil was partially renovated by the addition of new sod and some cow manure, and besides this it received its customary application of liquid cow manure. The plants had not been in the soil many weeks, however, before they commenced to die, and it was not unusual for a number to die in a single week. The results of this experiment were only what was expected, but a careful examination of the plants was made which showed them to be free from pathogenic organisms. The roots, however, were in a bad state, their condition showing plainly what was the matter. Since it was thought that this experiment had then proceeded far enough, we decided to flood the beds with water, and make analyses of the percolate which came through the bottom of the beds. The beds were flooded for two hours each, and the water that came through first was, as might naturally be expected, highly colored, while that which came through later was clearer. The last percolate, after two hours' drenching, was remarkably clear. Samples of this water were collected at intervals of every fifteen minutes, and chemical tests for acids and other substances were made. The results of the analyses were quite surprising, and it was difficult to conceive of any plant living under such conditions. After the soil had been drenched and the injurious substances washed out, not a single death occurred among the plants.

The question was put to a number of florists, through a leading florists' journal, why they changed their soil in growing roses, carnations and other plants. None of the growers gave a satisfactory reply; they simply knew from experience that it was not practicable to attempt to grow these crops in the same soil two consecutive seasons. An analysis of the percolated water showed such large amounts of soluble compounds that it is not surprising that the plants failed to grow.

One occasionally finds instances of what appear to be typical cases of malnutrition in the suckers on stumps of trees on cut-off woodland. Different species of trees develop different symptoms in their leaves when growing from the stumps. In some cases the leaves are abnormally large, and in others they are highly colored and more or less contorted or malformed. Here we have an instance of a small amount of foliage being supplied with food from a root system which formerly supported a large tree, and this excess of food supply causes, as it were, congestion. Chemical analyses of these abnormal leaves, made by Mr. G. H. Chapman in our laboratory, show them to be unusually rich in nitrates. A feature often observed by us in connection with these growths, but which may possibly be of no significance whatsoever, is their greater susceptibility to attacks of aphids. It is not improbable, however, that their abnormal chemical condition would affect their natural immunity to attacks from aphids and other insects.

From the nature of the conditions causing malnutrition, a remedy is not difficult to find. It is first essential, of course, to be careful in the use of manures and fertilizers. If the soil in a house has become unfit for use from the injudicious application of manures and fertilizers, subsoiling may be done to good advantage. Washing out the soil thoroughly, as previously described in our experiments with roses, would also prove helpful in some cases, but it should be pointed out that there is more danger in a soggy soil to cucumber roots than those of roses. If leaching out has to be done when the plants are in the soil, it should be done only in sunshiny weather, when the soil will dry out quickly, so that its original porosity can be regained by cultivating. It is always best to use any such treatment as this, if possible, when there are no plants in the soil.

Another succesful treatment consists in covering the surface of the soil with two or three inches of loam. We have frequently seen this done with the best results. New roots have quickly formed in the loam, and these have supplied the plant with food proper to its development.

CALICO OR MOSAIC DISEASE OF CUCUMBER AND MELON.

BY G. E. STONE.

For a number of years our attention has been called to mottled cucumber leaves occasionally found in greenhouses. This trouble has the same characteristics as the so-called "calico" on tobacco, or "mosaic disease," as it is often termed. It also occasionally occurs on other plants.

A case of calico was noticed on melon plants grown under glass in the department's conservatory the past summer. Only four plants were affected, and there was no evidence of contagion or infection. This disease, so far as is known, is not associated with pathogenic organisms, and little is known concerning it.

The trouble is characterized by a mottled or spotted appearance of the foliage, and the whole plant appears abnormal. The plants were growing in soil well enriched with horse manure, and in all cases the laterals were kept pruned, and the affected plants topped. A similar spotting and mottling occurred on pruned tomato plants, and was more abundant when the plants were topped than when the laterals were pruned.

A study of this peculiar and little known trouble is now being made by Mr. G. H. Chapman of this department.

NOTES ON THE OCCURRENCE OF FUNGOUS SPORES ON ONION SEED.

BY GEORGE H. CHAPMAN.

It has been found in the seed separation and germination work in this department that spores of various fungi are often found on market seeds. This has been especially noticed in the germination work, for in many cases, no matter how carefully the germinating dishes were sterilized and the tests carried on, some of the samples would mold much worse than others. It was also thought that in the case of onion seed the spores of onion smut might be carried from one locality to another, and thus spread the disease in that way.

Under the direction of the head of this department several samples of onion seed were examined during the past year and the different kinds of spores present noted. The method of examination was as follows: —

A representative sample of the lot was taken, and then of this sample about 15 grams were shaken up with warm, distilled water for ten minutes. The supernatant liquid was then drawn off in a pipette and drops placed on a slide for examination. Several examinations of each sample were made and the different kinds of spores found were noted. This method of detaching the spores may be open to objections, but it is thought that enough of the spores are detached to give an idea of the different kinds present.

In all, ten different samples of seed were examined, and in two, onion smut spores were found in small quantity. It has been the generally accepted opinion that the smut spores do not occur on the seed, but this idea is probably due to the fact that only in very few cases do these spores appear to be present. From our results we are forced to conclude that onion smut spores may be found on seed and may thus be transferred from one locality to another. They were also found last season by Dr. G. E. Stone of this department.

As stated above, in ten samples of seed, two were found to contain spores of onion smut, and in addition nearly all contained mold spores, such as *Penicillium* (blue mold), *Mucor* (bread mold), etc. These mold spores may to a certain extent be on the seed before it is gathered, but the probabilities are that the seed becomes contaminated after gathering, during the cleaning and drying processes, and results from improper drying and cleaning or dampness in the storehouse. Other spores and pollen grains were found which were in no way associated directly with onion diseases. These are perfectly harmless and come from various sources. Among these may be mentioned various conidia and rust spores which do not have the onion for a host.

Among the spores found which cause diseases of the onion were *Urocystis cepulæ* (Frost) (onion smut), *Macrosporium Porri* (Ellis) (brown mold) and *Peronospora Schleidenina* (D By) (downy mildew). The spores of these fungi do not, of course, inhibit the germination of the seed.

The presence of smut spores and others is objectionable in the seed since the ones just mentioned are capable of causing infection to the crop, and the molds cause the molding of the seed, thus lessening the vitality of the seed and sometimes killing it during a germination test.

Macrosporium Porri, the so-called brown or black mold, affects seed onions. *Peronospora* (downy mildew) spores were found in many cases, and this disease has occasionally caused some trouble in Connecticut and elsewhere. This disease, like the preceding one, is confined to seed onions, the fungus penetrating the tissue in all directions, causing a yellow, sickly looking growth, eventually killing the plant. The summer spores, or conidia, are very short lived, however, and do not retain their vitality for any length of time, but the oöspores or resting spores are capable of propagating the disease from year to year.

The kinds of spores found in each sample are shown in the following table.

Showing Spores found on Onion Seed.

Sample Number.	Spores Noxious to Onion.			Non-noxious Spores.	
	Onion Smut (Urocystis cepulæ).	Brown Mold (Macrosporium).	Downy Mildew (Peronospora).	Molds.	Other Spores.
1,	Very few,	Present,	Absent,	Penicillium, Eurotium,	Pollen.
2,	Absent,	Present,	Present,	Penicillium, Mucor,	Various conidia, Teleutospores.
3,	Absent,	Absent,	Present,	Absent,	Pollen.
4,	Absent,	Present,	Absent,	Penicillium,	Rust spores, pollen.
5,	Absent,	Absent,	Absent,	Penicillium, Eurotium, abundant,	Conidia, pollen.
6,	Absent,	Present, abundant,	Present, abundant,	Penicillium, scarce,	Pollen, conidia.
7,	Absent,	Present,	Absent,	Eurotium, Penicillium, Mucor,	Rust spores, pollen.
8,	Few,	Present,	Present,	Penicillium, Eurotium,	Rust spores, conidia, pollen.
9,	Absent,	Absent,	Absent,	Eurotium, Mucor,	Conidia.
10,	Absent,	Present,	Absent,	Absent,	Rust spores.

No attempt has been made to specifically identify many of these spores as that is not within the scope of this experiment.

By disinfecting and sterilizing the seed used for germination tests, and also for planting, it is believed that much of this excessive molding may be prevented. Work of this character is being carried on in this laboratory. Some favorable results have been obtained, but these have not been verified sufficiently to warrant publication at present.

PLANT BREEDING STUDIES IN PEAS.

BY F. A. WAUGH AND J. K. SHAW.

The department of horticulture has had various plant-breeding investigations under way for several years. These have included studies in variation, correlation and heredity in peas. Two reports on this general subject have already been made.[1] The year 1909 has enabled us to collect a large amount of additional data, the most interesting of which are here presented.

Character of Variation in Peas.

At the beginning of these experiments, a commercial strain of Nott's Excelsior was made the basis of study. The same strain has been maintained till the present time, so that we may now discover whether or not the range and character of variation have changed. In looking over the figures, it must be remembered that absolute figures have been greatly affected by the nature of the growing season. Thus, in 1908, with severe drought on naturally dry land, the size of plants and all other measurements fell very low. With this in mind we may profitably study the following table, giving statistics of variation for three years: —

[1] Massachusetts experiment station report, 20, p. 171 (1908), and Massachusetts experiment station report, 21, p. 167 (1909).

Variation in Peas — Nott's Excelsior. Series I.

	1907.	1908.	1909.
Number of vines measured,	179	225	1,770
Length of vine (centimeters): —			
Minimum,	20.00	19.00	6.00
Maximum,	88.00	61.00	83.00
Range,	68.00	42.00	77.00
Average,	54.70	38.22	45.90
Number of pods per vine: —			
Minimum,	1.00	1.00	1.00
Maximum,	13.00	12.00	37.00
Range,	12.00	11.00	36.00
Average,	4.68	3.91	6.74
Number of peas per pod: —			
Minimum,	-	-	-
Maximum,	9.00	8.00	9.00
Range,	9.00	8.00	9.00
Average,	3.46	3.44	-
Length of pod (centimeters): —			
Minimum,	2.00	2.00	-
Maximum,	9.50	8.00	-
Range,	7.50	6.00	-
Average,	6.88	6.10	-

Differences in Variability.

As was shown in our last report, there are great differences in variability to be seen in different strains, even within the same variety. The progeny of nine different parents, all belonging to the same variety, was compared in this respect. These same strains may now be compared again, bringing into comparison the progeny grown in another year's crop. In the following table CV stands for "coefficient of variability," which is simply a mathematical function showing the relative variability of the various strains. It is secured by dividing the standard deviation by the mean. The larger the figure the greater the variability indicated.

Comparison of Variability — Nott's Excelsior.

	CV.		Rank.	
	1908.	1909.	1908.	1909.
Vine length: —				
Strain A,	12.1	22.4	4	4
Strain B,	14.1	25.4	5	8
Strain C,	11.8	16.5	3	1
Strain D,	15.8	23.9	8	7
Strain E,	20.2	27.8	9	9
Strain G,	14.7	21.4	6	3
Strain H,	15.1	22.8	7	5
Strain J,	10.1	23.1	2	6
Strain K,	8.8	19.9	1	2
Pods per vine: —				
Strain A,	25.3	43.7	8	3
Strain B,	10.1	45.7	6	6
Strain C,	52.1	50.2	9	7
Strain D,	8.1	45.1	4	5
Strain E,	9.1	50.8	5	8
Strain G,	16.7	38.1	7	1
Strain H,	8.0	44.6	3	4
Strain J,	6.3	41.4	1	2
Strain K,	7.4	57.5	2	9
Total peas per plant: —				
Strain A,	40.6	49.3	6	5
Strain B,	23.7	54.1	1	8
Strain C,	49.0	51.6	9	6
Strain D,	41.7	41.1	7	1
Strain E,	46.2	52.1	8	7
Strain G,	31.3	45.9	4	3
Strain H,	40.2	46.5	5	4
Strain J,	23.9	45.6	2	2
Strain K,	27.7	57.8	3	9

Three interesting facts appear from this table: —

1. The plants were markedly more variable in 1909 than in 1908. This appears in all characters, and there is hardly a single exception to the rule. On the surface, it would seem that the dry season and unfavorable conditions of 1908 decreased the amount of variation, while the comparatively strong growth of 1909 increased the amount of variation.

2. The amount of variation is less and the fluctuations less in the case of vine length than in pods per vine or peas per vine. In other words, the vegetative characters seem to be more stable than reproductive characters.

3. There is a manifest (though not very strong) tendency to transmit the quality of variability (or stability). In a number of instances the strains which were most variable in 1908 were the most variable in 1909, and those which were most stable one year were most stable the next. Out of the 27 comparisons made in the foregoing table, 11 show a decided correspondence, while

only 6 show decided shift. Counting the disagreements in rank by units, the results are as follows: —

In vine lengths,	16
In pods per vine,	26
In peas per plant,	26

These figures indicate once more the relative stability of the vegetative character — vine length — as discussed in paragraph 2 above.

Correlation of Characters.

In former reports, some figures have been given on correlation of character, particularly between the average number of peas per pod and the number of pods per vine. It might be supposed that the vines bearing the largest number of pods would have the smallest pods with fewest peas. The general fact seems to be the contrary, — a fact which is of considerable practical importance in the development of prolific strains and varieties.

This year we have fresh figures at hand for three separate groups. Series I. consists of a number of strains of Nott's Excelsior, all having the same origin. They are, in fact, the same plants spoken of as Strain A, Strain B, etc., in the experiments reported herewith, p. 170, — the whole series being combined for the purposes of this computation. Series II. is the group of Nott's Excelsior from which the progenitors of Series I. were selected in 1907. Series III. is a strain of Earliest of All which we have had under study for two years.

Taking this material, therefore, and computing the correlation coefficients (in which complete correlation equals + 1 and no correlation equals 0), we get the following results: —

	Correlation Coefficient.[1]
Series I. (Nott's Excelsior),	$-.0081 \pm .0012$
Series II. (Nott's Excelsior),	$+.1300 \pm .0095$
Series III. (Earliest of All),	$+.3200 \pm .0120$

[1] It is probable that the coefficient of Series III. most nearly represents the true correlation, and the lower coefficient for Series I. and possibly Series II. is due to rather strict selection that has been practiced, Series I. being the second generation from 10 selected plants. See Pearson, Phil. Transactions A, Vol. 193, p. 278; also Rietz, Biometrika, Vol. VII., p. 106.

In Series I. no relation between number of pods and peas per pod is shown. In Series II. there is exhibited a distinct tendency toward the production of the largest and fullest pods on those plants which produce at the same time the largest number of pods; and this tendency becomes fairly emphatic in Series III.

Heredity in Peas.

One of the prime objects in this series of experiments has been the study of heredity. We have wanted to know in what degree the various characters were transmitted in peas. Some figures in this field were published last year.[1] The figures this year are still more interesting, especially when compared with last year's results.

The reader may know that heredity is now commonly calculated by a mathematical formula which gives results theoretically varying between + 1 and — 1 (practically between + 1 and 0). Ordinary inheritance, in which parental characters are transmitted in the usual degree, will show a coefficient of +.25 to +.40. Larger coefficients are rare; lower coefficients are surprisingly frequent. Taking our peas in Series I. (omitting Strain C on account of its abnormal character), we secure the following heredity coefficients from the crop of 1909: —

Coefficients of Heredity.

Vine length,	+ .2483 ± .0164
Pods per vine,	+ .0792 ± .0017
Total peas per vine,	+ .0544 ± .0018

Here it will be seen that vine length is transmitted much more fully than either of the other characters. This fact is apparently closely related to the one mentioned above (p. 170). The vegetative character is more stable and is more perfectly transmitted than the reproductive characters.

Prepotency.

In all old-time discussions of heredity, much was made of prepotency. Though this word and the idea have to a large extent been submerged in recent discussions of plant breeding,

[1] Massachusetts Experiment Station Report, 21, p. 171 (1909).

the idea is still sound and the word still holds. Moreover, the facts are of great practical importance to the actual breeder.

The question is, Does one individual transmit its characters more perfectly and surely than another? In order to answer this question, it was found necessary to adopt a new method of calculating coefficients of heredity, explained in the article referred to.[1] The study of the material which we then had in hand seemed to give a positive answer to the main question. Apparently, certain individuals did show decided superiority over others in their ability to transmit their characters to their offspring. This conclusion seems to be confirmed with all the other material which we have been able to study, and it would be very interesting to see the same method — or some improvement of it — applied to other plants and animals. For the present, the most interesting feature of our experiment lies in a comparison of the prepotency of parent and offspring, — in an attempt to answer the question whether prepotency is inherited or not.

In the following tables we will present first the figures showing the inheritance of vine length, then those dealing with pods per vine, and finally those dealing with total peas per vine. In each case we present first the coefficients of heredity (computed as shown in the footnote), followed by figures denoting the rank of the several strains in each comparison. The designations f_1, f_2 and f_3 will be understood at once by students of thremmatology. They refer to the three generations of peas compared: f_3 represents the crop of 1909, f_2 represents their parents (crop of 1908), while f_1 represents the grandparents, with which this experiment began.

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[1] *Ibid.*, p. 172. The formula is $C = \frac{1}{\sigma D}$.

C = coefficient of heredity.
σ = standard deviation.
D = difference between the numerical value of the parent character and the mean of the same character in the progeny.

This we have been calling "Waugh's formula," for the sake of a distinctive name.

Coefficients of Heredity — (Prepotency).

Vine Length.

	Coefficients.			Rank.		
	$f_1 : f_2$	$f_2 : f_3$	$f_1 : f_3$	$f_1 : f_2$	$f_2 : f_3$	$f_1 : f_3$
Strain A,	.0068	.0383	.0028	7	3	9
Strain B,	.0085	.0183	.0065	5	6	4
Strain C,	.0106	.0079	.0244	2	9	1
Strain D,	.0086	.0090	.0093	4	8	3
Strain E,	.0042	.0265	.0031	9	4	8
Strain G,	.0061	.0260	.0045	8	5	6
Strain H,	.0071	.0158	.0054	6	7	5
Strain J,	.0095	.0596	.0042	3	2	7
Strain K,	.0250	.0707	.0126	1	1	2
Pods per Vine.						
Strain A,	.145	.193	.076	7	5	7
Strain B,	.011	.210	.222	9	4	4
Strain C,	.104	.023	.047	8	9	9
Strain D,	.512	.093	1.562	4	8	1
Strain E,	3.003	.144	.387	3	6	3
Strain G,	.327	.350	.145	6	1	5
Strain H,	.490	.279	.075	5	2	8
Strain J,	5.555	.262	.532	2	3	2
Strain K,	14.285	.121	.135	1	7	6
Total Peas per Vine.						
Strain A,	.007	.010	.006	8	4	6
Strain B,	.027	.012	.221	3	2	2
Strain C,	.006	.001	.002	9	9	9
Strain D,	.013	.006	.068	5	6	3
Strain E,	.016	.006	1.000	4	8	1
Strain G,	.008	.009	.005	6	7	7
Strain H,	.007	.012	.004	7	3	8
Strain J,	.027	.012	.021	2	1	4
Strain K,	.068	.008	.013	1	5	5

It can hardly be claimed that these figures show any fixed lines in prepotency. Certain individuals are plainly relatively prepotent with respect to certain characters, though not always with respect to other characters. While the figures do not show any striking inheritance or prepotency, there are a few instances wherein such inheritance may be strongly suspected. Certain points will bear statement at least.

1. In the transmission of vine length, Strain K is notably prepotent, while Strain E is notably deficient.

2. In the transmission of pods per vine and total peas per vine (reproductive characters representing fecundity), Strain C is remarkably defective. This is curious from the fact that Strain C is notably the most prolific one in the experiment.

3. In the transmission of pods per vine, Strain J leads by a good margin; while in the transmission of total peas per vine, Strains B and J stand equal.

4. Strain K, which in last year's comparison stood first in every column, now, in the whole comparison, ranks first in the transmission of vine length, seventh in pods per vine and third in total peas.

It seems fair to conclude, in general terms, that a careful study of prepotency will sometimes reveal tendencies sufficiently strong and trustworthy to be useful to the practical plant breeder.

THE BEN DAVIS GROUP OF APPLES.[1]

BY J. K. SHAW.

It is generally agreed by pomologists that the most feasible and satisfactory method of classifying varieties of fruits is by segregating them in groups typified by more or less well-known sorts, each differing in considerable degree from the type of the neighboring groups. Many writers speak of the Ben Davis group, but so far as is known to the present writer the only real attempt to single out the members of this group is that given by Hedrick, Bul. 275 of the New York State Experiment Station.

Starting with the group as given here as a foundation, a somewhat thorough examination of all available literature and suggestions from several men, authorities in systematic pomology, gave a list of forty varieties which were considered as candidates for this group. In order to decide, with some feeling of certainty, just which of these properly belong here would require much longer time and more material than has been available. The personal study of material was necessarily limited to the fruit with nearly every variety, and with many of the varieties it was impossible to obtain specimens, making it necessary to rely upon printed descriptions and the opinions of others, and everything of this kind available has been carefully considered.

As a result of this study the following varieties are believed to belong here, and are separately considered and described in this paper: —

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[1] This article is a condensation of a part of a thesis presented to the faculty and trustees of the Massachusetts Agricultural College for the degree of M.S. The work was done under the direction of Prof. F. C. Sears, and special thanks are due him and to Prof. F. A. Waugh for advice and encouragement in the work; also to many horticulturists, fruit growers and others who have supplied information regarding the different varieties.

Arkansas Beauty.
Arkansas Belle.
Ben Davis.
Ben Hur.
Black Ben Davis.
Coffelt.
Cole Davis.
Eicke.
Etris.
Extra.
Flat Ben Davis.
Gano.
Improved Ben Davis.
Nordhaussan.
Ostrakavis.
Paris.
Shackleford.
Shirley.
Sweet Ben Davis.
White Ben Davis.

Many of these are of minor importance, and doubtless some are not propagated and will soon disappear from cultivation. Almost without exception they are of southern origin and best adapted to growing under southern conditions. When grown north of the southern Missouri and Ohio valleys they are inferior in quality, though fairly hardy and bearing good crops.

The fruit is generally roundish conic in form, nearly regular, with regular cavity and basin, the latter generally more or less abrupt. In color, greenish yellow, usually overspread with bright red, more or less striped. The flesh is generally white and firm, of medium or coarse texture. They are of only moderately good quality but long keepers and good shippers. With one exception they are more or less acid in flavor, generally a mild subacid. A notable characteristic common to all varieties examined was the presence of a pistil point or the persistent base of the pistil, a character rarely found in apples not belonging to this group.

Description of Varieties.

Arkansas Beauty.

I have not seen this apple and have been able to learn little about it. Stinson gives the following description and notes concerning it: —

Size, medium to large; form, roundish, slightly inclined to conical; stem, very long and rather slender; cavity, small, smooth; basin, small; core, open, with a peculiar marking of a white growth or downy substance in seed cavities; color, skin yellow, striped with two shades of red, rather dull in color, giving it a brownish-red appearance; flesh, yellow, fine grained, subacid and very good, juicy. It is grown to some extent in a few sections of the State; it is probably more grown in Johnson County than elsewhere. It has not proved valuable.

Arkansas Belle.

This variety very closely resembles the Gano, and it has been claimed that the two are identical. A letter from Mr. D. Branchcomb of Rhea, Ark., states that he planted the seed from which grew the original tree. It does not seem to have been much planted and probably will not be, as it does not appear that it is in any way superior to the Gano.

Ben Davis.

The place of origin of this variety has always been in doubt. Downing, in "Fruits and Fruit Trees of America," edition of 1857, says it is supposed to have come from Todd County, Ky., but in the edition of 1872 he says that the origin is unknown. It has been attributed to Virginia, North Carolina, New York, Missouri, Kentucky and Tennessee. The statements giving New York and Missouri origins are without doubt erroneous. Those attributing it to North Carolina and Virginia are to the effect that the trees or scions were taken from one or the other of these States to Kentucky, from whence it was disseminated. So far as the writer is aware, there is no record of its occurrence in either of these States except as introduced from outside nurseries. It is extremely probable that the apple originated or at least was first propagated from scions in either Kentucky or Tennessee. The late Wm. M. Howsley of Kansas gives the following account of its origin: —

> In the year 1789, Wm. Davis and John D. Hill emigrated to Kentucky and settled in that part of Logan County now called Butler County. They located near Capt. Ben Davis, the brother of Wm. Davis and the brother-in-law of Hill. A few years afterward, Hill returned to Virginia on business, and when he returned to Kentucky he brought some apple grafts with him. Hill and Wm. Davis raised fruit from these grafts. Capt. Ben Davis, finding the apple a desirable one, grafted the same for himself, as well as raised a young nursery of it. These were sold throughout the country. For want of knowing any other name, the people called it the Ben Davis apple. The Davis family, however, called it the Virginia Pippin.[1]

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[1] Watts, Bulletin Tennessee Experiment Station, IX., 1, p. 7.

Mr. J. C. Hodges of Morristown, Tenn., thinks it is a Tennessee apple, and gives the following story of its origin: —

During most of the first half of the present century, and up to 1860 or thereabouts, there lived on Nolichucky River, within this (Hamblin) county, a wealthy farmer whose name was Ben Davis. His son, R. A. Davis, resides now at White Pine, Jefferson County, Tenn. On the farm owned by Ben Davis originated the apple in question. From the original tree others were propagated, and for many years before the death of Ben Davis he raised and harvested large quantities of these apples. The house of Ben Davis was on the great stock route from Kentucky to the Carolinas. Many drovers made it a point to stop with him in going and returning to the south. It was his custom to supply their saddle bags with these apples, especially on their return trips. There was no name of the apple known to them, so they called it the Ben Davis. Grafts or scions were taken to Kentucky, and the apple was propagated and disseminated there before it was in Tennessee. I have obtained these facts on personal inquiry from the sons of Ben Davis, above mentioned. And besides, these facts are well known in the neighborhood among the older people.[1]

The writer has made considerable effort to follow up both of these accounts and to ascertain if either one is the true history of the variety.

Concerning the Kentucky account, Mr. Ben McKenney of Maquon, Ill., states that the Ben Davis mentioned, who was his grandfather, lived at Berry's Lick, Butler County, Ky., and that it was from a neighbor of his, Nat Porter by name, that Dr. Housely obtained the account above given. Ben Davis was a nurseryman as well as a farmer and introduced several other varieties.

Concerning the Tennessee account, a letter from Mr. Hodges expresses the conviction that this is the true origin of the variety. It is stated by a daughter of this Ben Davis, who is not connected with the Kentuckian of the same name, that the original tree, which was well known to her, was destroyed in 1860, and that it was eighteen years old at the time. This would seem to indicate that this was not the original Ben Davis tree, as the variety was well known over Kentucky, southern Indiana and Illinois at about this time. Mr. Hodges, however, expresses the belief that this particular tree was a sprout from the original,

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[1] Watts, Bulletin Tennessee Experiment Station, IX., 1, p. 7.

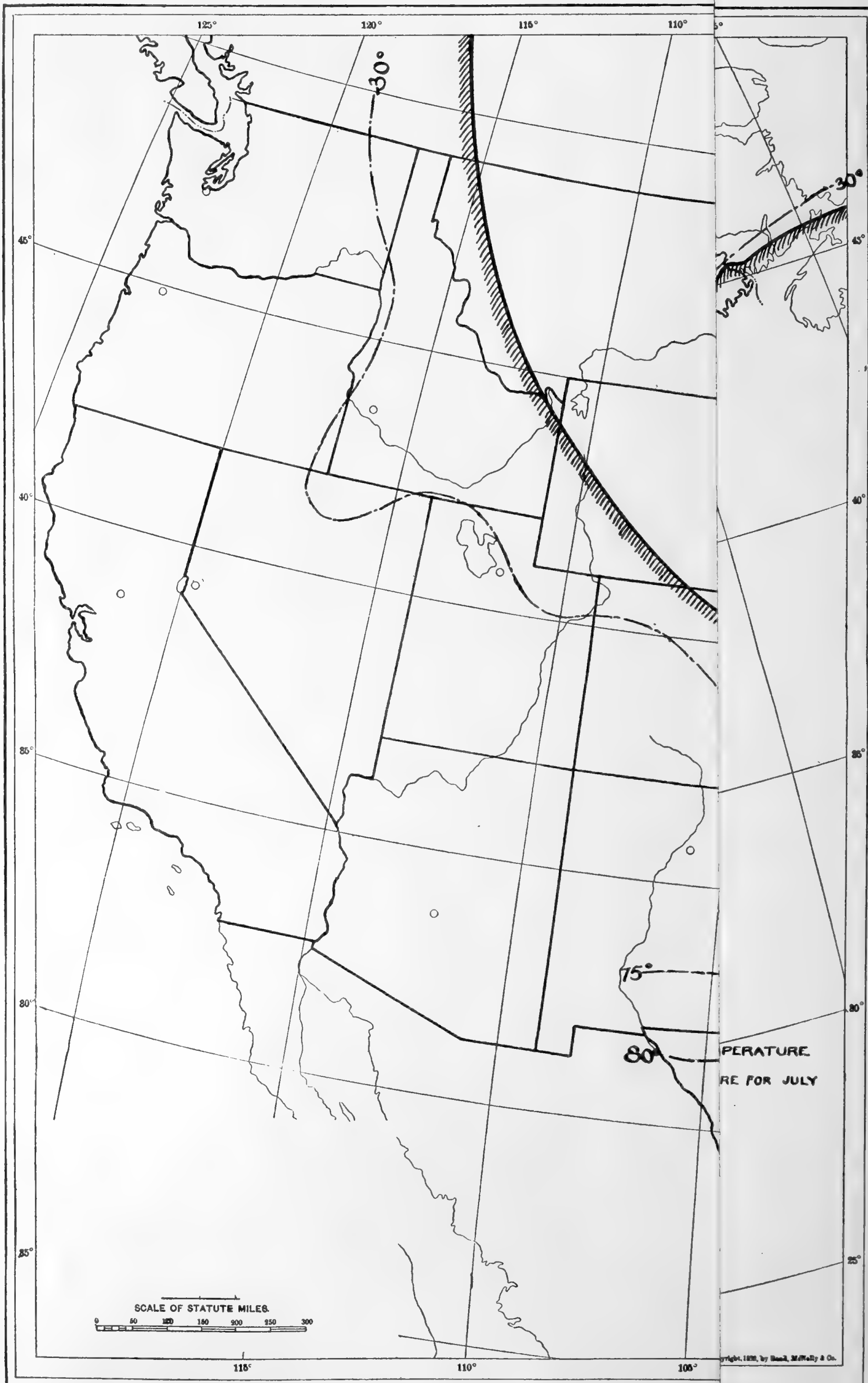
which would seem reasonable, for Ben Davis died in 1852 at the age of fifty-six, or soon after the earliest date at which this tree could have borne, and in this case he could not have been concerned with the growth and distribution of the fruit, as it seems beyond question that he was. The writer has attempted to learn the facts about this, but thus far without success.

It would seem possible that the apple originated in Tennessee, as related by Mr. Hodges, and that the fruit, carried by the drovers into Kentucky, came to the notice of the Kentucky Ben Davis, who lived on the route which would be traveled, and, being a nurseryman, he was attracted by the fruit and took steps to secure scions, by which he propagated and disseminated the variety. If this is true, however, it is hard to explain why the apple was called the Virginia Pippin.

Another possible explanation is that the apple may have "originated" twice, or, to put it in another way, two varieties appeared, one in Kentucky and the other in Tennessee, and both were called the Ben Davis and resembled each other so closely as to be confused; or it is even possible that the two were distinct, and that one of them was not the Ben Davis we now know at all. A third possibility is that it first appeared in Kentucky, and that the Tennessee tree was a graft derived from it.

That both the accounts are true in the main, at least, is not doubted by the writer, and the Tennessee story is vouched for by several people of prominence and reliability residing in that neighborhood. It is likewise evident that the whole truth is not set forth.

Wherever the place of origin may have been, the variety was first brought to public notice from Kentucky. The first published notice of it seems to have been in the "Horticulturist" for 1856, and Downing describes it in the "Fruits and Fruit Trees of America," edition of 1857, as received from Mr. J. S. Downer of Elkton, Ky. From this time on the mention of it in pomological publications is frequent. At the time when Downing described it it was spread over Kentucky, southern Indiana and Illinois, and was known in Missouri. It is stated by Ezekiel Honsinger of Burnt Prairie, Ill., that his father grafted the Ben Davis in White County, Ill., about 1825, obtaining the scions from a neighbor, Mr. Funkhouser, and he



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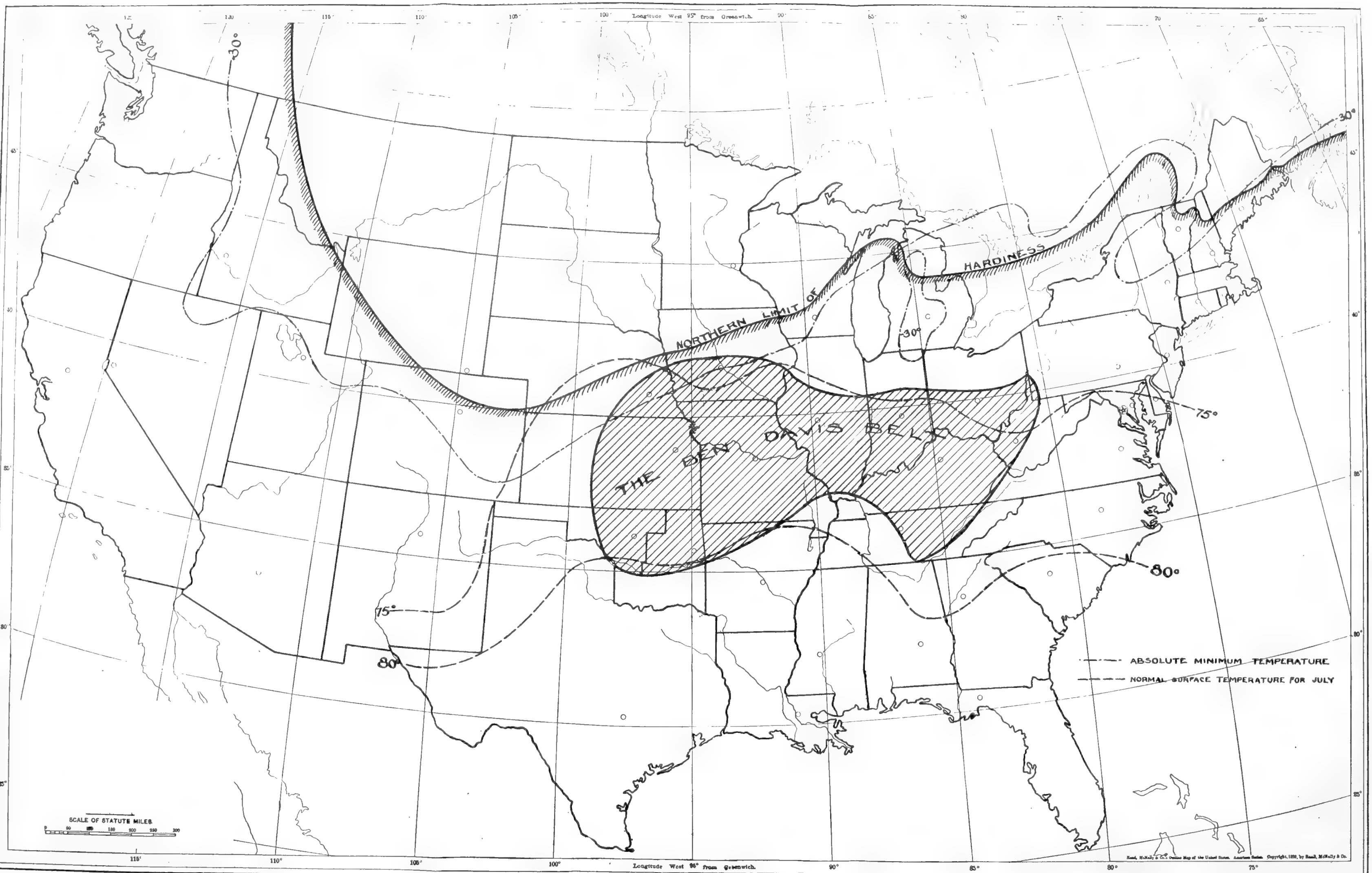

DISTRIBUTION OF THE BEN DAVIS.

from Mr. Newman, who brought them from Kentucky before 1820. Here is explained how the variety obtained the names Funkhouser and Newman. A nursery was established in this neighborhood in 1839, and was instrumental in disseminating the variety far and wide.

With the rise of commercial orcharding in this region, after the civil war, the variety attained widespread favor, and it may justly claim the first place among commercial varieties, taking the country as a whole. No other commercial variety is so widely planted, and none succeeds so well under such widely varying conditions. It is a sure, abundant bearer, the tree is vigorous, reasonably healthy, a good grower in the nursery, and comes into bearing early, and the fine appearance and excellent shipping and keeping qualities of the fruit are well known. That it is of excellent quality as a dessert fruit no one will contend, but much of its evil reputation in this way comes through its being grown in localities where it should never have been planted. When well grown, near the region of its origin, it is not of poor quality; when grown in the colder north, it does not have time to fully develop, and is most decidedly an inferior apple.

An attempt was made by means of library research and by correspondence to learn something of the limits of culture of the Ben Davis. The map shown herewith shows approximately the northern limit of the variety, and also what may be spoken of as the Ben Davis belt, where this is easily the leading commercial sort. It will be noted that the limit of hardiness is a little north of the isotherm of an absolute minimum temperature of — 30° F., indicating that a temperature of between 30° and 35° below zero is likely to kill the trees. In the Rocky Mountains the limit of hardiness is indicated only in a general way, as it here depends largely on altitude, and would be difficult to accurately define.

It is interesting to note the coincidence of the limits of the Ben Davis belt with the normal surface temperature for July of 75° on the north, and, more especially, for 80° on the south. In as much as the line showing the limits of the belt is intended to show where it is actually grown, and not where it is possible to grow it well, it is probable that it would succeed equally well farther to the southeast in the mountains of northern Georgia and Alabama, and thus its southern limit of successful growth conform more closely to this isotherm than is indicated.

Ever since the Ben Davis became known, fifty or more years ago, there has been much unfavorable comment on its quality, and many have predicted its speedy disappearance from the orchard and market. All the while the Ben Davis trees have borne full crops and have filled the owner's pocket in years when other sorts were delinquent in these most important qualities of a commercial apple. During the past season (1908–09) reply postcards were sent to over 225 nurserymen in the United States and Canada asking the following questions: —

How do your sales of Ben Davis compare with those of other varieties?

In what States are your sales of Ben Davis increasing, and how rapidly?

In what States are they decreasing, and how rapidly?

In what States are they practically stationary?

Is it being replaced by other varieties, and if so, what ones?

One hundred and thirty-one of these cards were returned. A few gave no definite replies, owing to various reasons, but from the great majority the following facts are gleaned: —

Number reporting increased sales,	8
Number reporting decreased sales,	59
Number reporting no change,	27

From the replies to the question as to what varieties are replacing the Ben Davis the following summary is made: —

	Number of Times mentioned.		Number of Times mentioned.
Jonathan,	26	Baldwin,	5
Gano,	19	Esopus Spitzenburg,	5
Winesap,	17	McIntosh,	4
Arkansas (*Mam. Blk. Twig*),	15	Newtown Pippin,	4
Grimes Golden,	12	Delicious,	3
York Imperial,	12	Wagner,	3
Rome Beauty,	9	Missouri Pippin,	2
Stayman Winesap,	7	Oldenburg,	2
Northern Spy,	6	Paragon,	2
Stark,	6	Wealthy,	2
Arkansas Black,	5		

And the following, once each; Aiken, Black Ben Davis, Blenheim, Belleflower, Cox Orange, Fameuse, Gates, Ingram, Janet, Kinnaird, Maiden Blush, Oliver, Red Russett, Salome, Transparent and Winter Banana.

It is evident that, on the whole, the sales of nursery trees of this variety are decreasing, and with some nurserymen with considerable rapidity. One firm reports a falling off of one-half in three years, another of 90 per cent. in five years and another of 50 per cent. decrease this year. One says, "We formerly grew as many as of all others; now 5 per cent." A few say they have ceased to propagate it. None report any marked increase in sales. The firms reporting an increase are largely in New York, and a few in Canada and some parts of the south. Among the large nurserymen in the Ben Davis belt, the report is almost unanimous that there is a falling off, and often a large one. West of the great plains it is planted hardly at all. In some parts of Maine and in southern Ontario and the Georgian Bay district it seems to be slightly on the increase. In the northwest prairie States it has not proved hardy and has been discarded.

The variety mentioned the most times as replacing the Ben Davis is Jonathan, which is of much better quality, and of the others that are taking its place in the Ben Davis belt, York, Winesap and Grimes Golden are notably better. In the northeast Stark is coming in and the McIntosh is gaining in popularity. In the northwest the Northwestern Greening is increasing, and in New York and Ontario the Spy is frequently mentioned. In the Pacific northwest it is scarcely planted at all, and many of the bearing trees are being worked over to other sorts, such as Jonathan, Gano, Rome Beauty, Newtown Pippin and Esopus.

On the strength of this inquiry the writer ventures to predict that the long-looked-for decadence of the Ben Davis is at hand, and that twenty-five years hence it will have become a variety of minor importance.

Description of Fruit.[1] — Size, below medium to large, fairly uniform; form, roundish to roundish conic or oblong, base broad and flattened

[1] Descriptions are original where not otherwise noted. This description is intended to include all forms of the variety as grown in the United States and Canada.

to narrow and rounded, apex rounded to sharp conic, fairly regular, slightly compressed, fairly equal sides, fairly uniform in any given locality; color, clear greenish yellow, covered with dull pinkish red to bright or deep red, 50 per cent. to 90 per cent. mottled, splashed and striped, deepening almost to blush on sunny side; bloom, medium, greasy or waxy; skin, medium thick, rather tough, smooth and shining; dots, inconspicuous, few to medium, small to medium, roundish, whitish to yellowish or russet, scattered, slightly raised; cavity, shallow to very deep, medium to very wide, flaring to abrupt, acute to acuminate, fairly regular, filled with russet; stem, short to very long, medium to slender, curved, brownish red, smooth; basin, very shallow to very deep, medium to very wide, generally abrupt, round obtuse, almost always very regular; calyx, closed to partly open, medium size, pubescent; segments, medium size, long, pointed, reflexed; tube, very short to very long, medium width, conic or funnel form, median stamens, pistil point present; core, axile to very abaxile, medium or below, central, turbinate to oval, with clasping core lines; cells, closed to open, medium in size, symmetrical to asymmetrical; carpels, roundish to obovate, emarginate, usually slightly slit, medium concave; seeds, few to medium, fairly plump, medium in size, brownish red, oval, pointed; axis, straight, rather short to very long; flesh, white, sometimes slightly tinged with yellowish, rather coarse, generally very firm, medium juicy to dry; flavor, mild subacid, often slightly aromatic, sometimes rather flat, sometimes slightly astringent; quality, poor to good.

Ben Hur.

This a comparatively new sort, offered by Stark Brothers of Louisiana, Mo., who state that it originated in Perry County, Ind., and that it is a cross of the Ben Davis and Rome Beauty. Prof. J. C. Whitten writes me, "From the characters of both fruit and tree, I should unhesitatingly put Ben Hur in the Ben Davis type." Stark Brothers describe it as follows: —

Tree, a strong, thrifty grower, young bearer, productive; fruit, fully as large or larger than Ben Davis, brilliantly striped and splashed with red; flesh, tender, fine grained, juicy, highly flavored, excellent.

Black Ben Davis.

This variety is said to have originated near Fayetteville, Ark., about the year 1880. An earnest controversy has arisen as to whether it is identical with the Gano. A number of samples of apples were received under these two names and examined with some care. It was easy to distinguish two types of apples, but they were connected by intermediate forms in such a way as to render it difficult to say whether two distinct varieties were represented or not. The most striking difference was in color, this varying from a distinctly striped apple to those with a clear blush, with no sign of stripes, a rather remarkable variation to appear in a single variety, but which exists in the McIntosh. It was evident that if the varieties were really distinct the names were confused, for the apples that were the most typical of the Black Ben Davis were called Gano; and of another sample, consisting of two apples, one would be called Gano and the other Black Ben Davis. In addition to examining these apples, the writer has consulted all the available literature on this point, and after considering everything with care, is, on the whole, inclined to the opinion that these are two distinct varieties, and describes them accordingly.

Description of Fruit. — Size, below medium to above, not uniform; form, round conic, almost regular, slightly compressed, generally with unequal sides, rounded base and round conic apex; color, bright greenish yellow, covered with rich, dark red, 20 per cent. to 95 per cent., blushed and mottled, sometimes showing slight tendency to striping; bloom, medium to heavy, waxy; skin, medium thick, rather tough, smooth and shining; dots, inconspicuous, medium in number, small, round, gray, scattering, scarcely raised; cavity, medium in depth and breadth, sloping, acute, nearly regular, slightly compressed, partly filled with greenish russet; stem, long, very slender, curved, brownish red, smooth; basin, rather shallow, medium, generally abrupt, nearly regular, slightly compressed; calyx, closed or partly open, medium, pubescent; segments, medium, reflexed; tube, short, medium width, conic, medium stamens, pistil point present; core, axile, large, central, turbinate, core lines meeting or clasping; cells, closed, medium; carpels, broad oval, emarginate, smooth, medium concavity; seeds, few to medium, plump, medium size, medium brown, oval, medium pointed; axis, medium to rather long, straight; flesh, white, firm, medium coarse, rather dry; flavor, subacid; quality, good. Described from six specimens received from the New York Experiment Station.

Coffelt.

This apple originated with Wyatt Coffelt of Bentonville, Ark., and is said by Henthorn to be a seedling of the Red Limbertwig, though Beach says that some nursery catalogues state that it is a seedling of the Ben Davis. As received from the New York

Experiment Station, it strongly resembles the Ben Davis. It has been planted to a limited extent in Arkansas, but it does not appear that it is superior to others of this group.

Description of Fruit. — Size, small, uniform; form, roundish oblate, nearly regular, slightly unequal sides, rounded base and roundish, slightly conic apex, uniform; color, yellowish green, covered with rather dull deep red, 65 per cent. to 95 per cent., mottled, more or less obscurely splashed, deepening almost to blush on sunny side; bloom, medium, waxy; skin, rather thick, medium texture, fairly smooth and bright; dots, more or less conspicuous, few to many, medium size, angular, russet, slightly raised; cavity, rather shallow, wide, flaring, broad acute, nearly regular, sometimes partly filled with russet; stem, long, slender, inclined, brownish red, smooth; basin, shallow, broad, flaring, flat obtuse, pentangular; calyx, open, medium size, slightly pubescent; segments, medium size, long, pointed, reflexed, separate at base; tube, medium in length and breadth, funnel form, medium stamens, pistil point present; core, axile, small, central, oval, clasping core lines; cells, closed, small, symmetrical; carpels, obvate, emarginate, smooth, concavity medium; seeds, few, plump, medium size, medium brown, oval; axis, medium, straight; flesh, white, slightly yellowish, a little tinged with green, fine, medium firm, moderately juicy; flavor, mild subacid, almost sweetish; quality, good. Described from specimens received from the New York Experiment Station.

Cole Davis.

This variety originated with S. T. Cole of Lincoln, Ark., about a dozen years ago, the original tree appearing in an orchard of Ben Davis. According to Mr. Cole the apple was of higher color than the Ben Davis, but otherwise much the same. It was propagated for a time by the Stark Brothers, but so far as known is not now offered for sale.

Eicke.

Concerning this variety the writer has been able to learn but little. Specimens received from the New York Experiment Station resemble the Ben Davis, and Hedrick groups it here. Ragan gives its origin as Nebraska.

Description of Fruit. — Size, small, uniform; form, roundish, regular, slightly compressed, nearly equal sides, rounded base and apex, uniform; color, bright greenish yellow covered with bright, rather deep red, 50 per cent. to 85 per cent., striped, splashed and mottled, deepening almost to blush on sunny side; bloom, heavy, waxy; skin, rather thin, medium texture, smooth and bright; dots, inconspicuous, few to medium, rather small, roundish, light gray, general, very slightly raised; cavity, rather shallow, medium width, sloping, acute approaching obtuse, nearly regular, partly filled with russet; stem, long, slender, inclined or curved, brownish red, smooth; basin, shallow, medium width, abrupt, somewhat ribbed and plaited; calyx, closed or partly open, medium size, pubescent; segments, medium size, medium long, pointed, reflexed; tube, rather short, medium, conic, medium stamens, pistil point present; core, abaxile, medium size, central or distant, broad oval, slightly clasping core lines; cells, open, medium size, asymmetrical; carpels, obovate, emarginate, slightly slit, concavity medium; seeds, medium in number, plump, medium size or above, dark brown, oval, more or less straight on one side; axis, rather short, straight; flesh, whitish, slightly tinged with yellowish green, fine, medium firm, medium juicy; flavor, subacid to slightly acid; quality good. Appears to resemble Coffelt. Described from specimens received from the New York Experiment Station.

Etris.

According to Professor Stinson, this variety was first fruited near Bentonville, in the orchard of A. K. Etris, the trees coming from the nursery of John Breathwait, about fifteen years ago. It is not generally disseminated, but is considerably grown in the county of its origin. It is quite possible that it is identical with Gano.

Extra.

An apple was offered by Stark Brothers under this name about ten years ago, described as being larger and higher colored than Ben Davis. It is not now sold. It may have been a distinct or a special strain of Ben Davis.

Flat Ben Davis.

A distinct strain of the Ben Davis was observed by the writer in 1909 growing in an orchard in Monmouth, Me. It differed from the usual type in being larger and decidedly more oblate in form. The striping seemed to be coarser and more distinct than on neighboring trees of the common type. The tree also differed in being more open and apparently of rather less vigorous growth. There were several trees in this and a neighboring orchard. It appears to be in no way markedly superior to the ordinary Ben Davis.

Gano.

The exact origin of this variety is not perfectly clear. It is said to have been grown by Mr. Ely Jacks, in Howard County, Mo., in 1840, and to have been somewhat disseminated in that vicinity. It was first brought to general notice in 1884, when it was exhibited before the Missouri Horticultural Society, and about this time it was named Gano, for Mr. W. G. Gano who was concerned with its introduction. Mr. Gano states that the original tree came from a lot of Ben Davis, and was planted in the orchard under the supposition that it was of that variety, but on fruiting it proved to be different. Prof. S. A. Beach advances the theory that it is a bud sport of the Ben Davis.[1] He thinks that it is improbable that a seedling stock should prove to be so like the Ben Davis, the variety supposedly worked on the stock. If, however the Gano originated as a bud sport in the same way that Red Gravenstein has originated from Gravenstein, and Collamer Twenty Ounce from the original Twenty Ounce, then the fact that the Gano appeared under propagation in a lot of Ben Davis apple trees is easily and naturally accounted for.

As compared with the Ben Davis, it is a little smaller, not quite as prolific a bearer, considerably higher colored, perhaps slightly better in quality, and sells for a little more per barrel. It takes second place in importance in this group, and is being planted in the southwest in place of the Ben Davis to a considerable extent, but has been planted but little in a commercial way elsewhere.

Description of Fruit. — Size, medium, uniform; form, roundish, more or less conic, nearly regular, slightly compressed, nearly equal sides, rounded base, apex round or conic, not very uniform; color, clear greenish yellow covered with deep rich red, 15 per cent. to 70 per cent., mottled, blushed and striped, always blushed on sunny side, slightly russet; bloom, rather light, waxy; skin, rather thick, medium tough, smooth and shining; dots, inconspicuous, few, medium size, roundish, gray, scattering, slightly raised; cavity, medium in depth and breadth, sloping, acute, fairly regular, filled with greenish russet; stem, long, slender, straight, brownish red, smooth; basin, shallow, medium width, steep to abrupt, ribbed and plaited; calyx, closed or partly open, medium or above, pubescent; segments, medium to large, long, pointed,

[1] Personal letter from S. A. Beach.

reflexed; tube, short to medium, medium breadth, conic basal stamens, pistil point present; core, axile, medium size, central, turbinate, core lines meeting; cells, nearly closed, medium or above, asymmetrical; carpels, slightly obovate, strongly emarginate, nearly smooth, concavity variable; seeds, medium in number, plump, medium size, oval or angular, rather short; axis, medium, straight; flesh, white, slightly tinged with greenish yellow, firm, medium texture, medium juicy; flavor, mild subacid, very slightly astringent; quality, good. Described from specimens received from the New York Experiment Station.

Improved Ben Davis.

It is stated in the report of the Illinois Horticultural Society for 1899, p. 89, that on several occasions an Improved Ben Davis has been brought to the attention of the society. It is rather probable that these were simply superior strains of the Ben Davis and not a distinct variety. So far as known, no variety of this name is being propagated.

Nordhaussan.

Scions of this sort were sent to the Division of Pomology at Washington by Mr. John Gabler of Springfield, Mo., in 1896, and by them distributed to various State experiment stations, including that of Massachusetts. Professor Waugh informs me that in both tree and fruit it resembled the Ben Davis. This tree was destroyed some few years ago, and I have not been able to secure either specimens or any further information concerning it. So far as known it is not offered for sale at the present time.

Ostrakavis.

A cross of the Ostrakoff and Ben Davis, originated at the Iowa Experiment Station. Distributed only for trial and not considered to be of value.

Description of Fruit.[1] — Fruit medium or below, conical, regular, surface oily; color, yellow, with faint bronze blush; cavity, regular, deep, obtuse, with faint trace of russet; basin, wide, very shallow, minutely wrinkled; core, wide open, meeting; cells, large, roomy, ovate, slit; tube funnel shaped; stamens, median; seeds, twelve, large, plump; flesh, white, sweet. Season probably late fall or early winter. Interesting as showing that a cross of two sour apples may produce a sweet apple.

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[1] From S. D. Bulletin, 76, p. 80.

Paris.

Reported by Mr. L. A. Goodman as a new apple of the Ben Davis family, sent by Mr. Ambrose of Paris, Mo., to the meeting of the Missouri Horticultural Society.

Shackleford.

This variety is first mentioned in the report of the Illinois Horticultural Society for 1883, at which time it appears to have been known in southern Illinois and adjacent parts of Missouri. Beach says that it originated near Athens, Mo. It has been planted considerably in the southwest, but has not attained great favor as a commercial sort. It is generally of rather poor color and is said to be a straggling grower. It does not appear to be in any way superior to the Ben Davis and in some qualities it is inferior.

Description of Fruit. — Size, medium, uniform; form, roundish oblate, slightly conic, nearly regular, slightly compressed, sides generally nearly equal, base rounded, apex round conic, uniform; color, clear waxy greenish yellow covered with bright red, 10 per cent. to 50 per cent., splashed mottled and short striped, deeper on sunny side of some specimens; bloom, light, waxy; skin, rather thick, medium texture, smooth, and fairly bright; dots, very inconspicuous, few to medium, very small, round, gray russet or greenish, scattering, even or submerged; cavity, rather shallow, medium width, sloping to flaring, nearly obtuse, nearly regular, markings none; stem, medium long, slender, straight or inclined, brownish red, smooth; basin, medium in depth and breadth, abrupt, truncate conic, fairly regular, sometimes slightly ribbed and plaited; calyx, closed, medium size, pubescent; segments, large, broad, pointed, reflexed; tube, short, medium width, conic, stamens median, pistil point present; core, abaxile, small, central, broad oval, core lines meeting; cells, partly open, medium size, symmetrical; carpels, oblong, emarginate, slit, concavity medium; seeds, medium in number and size, plump, medium brown, oval, medium long, pointed; axis, medium in length, straight; flesh, greenish white, medium firm, rather coarse, fairly juicy; flavor, brisk subacid; quality, good. Described from specimens received from the Ontario Agricultural College.

Shirley.

Mr. T. V. Munson of Dennison, Tex., gives the following history of this variety.

This apple was found growing in two old orchards, namely the A. Alkire orchard, some four miles west of Dennison, Tex., and the Alex. Shirley orchard, some five miles southeast of Dennison. The writer saw these trees in said orchards about the year 1880, and made diligent inquiry as to their origin, but neither Mr. Alkire nor Mr. Shirley (both now deceased some years) knew from whence they came. I presume they came from some local Texas or Louisiana nursery that passed out of existence soon and left no history of the variety. The orchards were planted before railroads were built into Texas. There was a small nursery at Paris, Tex., and another at Clarksville, farther east, and one at Shreveport, La., the latter conducted by G. W. Storer, the others by a Mr. Walker at Clarksville and his son, J. Q. A. Walker, at Paris, Tex. These nurseries were the first in Texas and sold trees all through north Texas. They handled only southern varieties. The elder Walker came to Texas from Tennessee about the year 1838.

In 1880 or 1881 I sent samples of the apples to Charles Downing, with whom I corresponded often for a number of years. Mr. Downing could not identify it. As the apple was a sure and prolific bearer, a large, handsome, salable fruit of fine keeping qualities, I began propagating and advertising it over twenty-five years ago. Mr. Shirley sold the apple in Dennison and Sherman markets, where it acquired the name Shirley apple or sometimes Shirley Keeper. I described it in my catalogue as Shirley, which name it has retained ever since.

In tree and fruit it resembles York Imperial more than any other variety. It was the first to point out before the public this similarity; but the two are distinct. The Shirley is better in tree and fruit, somewhat larger and brighter, and in quality a little better.[1]

As grown in Texas this apple resembles the York Imperial, but the specimens received from the New York Experiment Station are clearly of the Ben Davis type. The trees were received from Mr. Munson and the apples were identified by Mr. Munson as the Shirley.

Description of Fruit. — Size, small, uniform; form, roundish oblate, nearly regular, often slightly compressed, nearly equal sides, base rounded, apex rounded or slightly conic, quite uniform; color, clear greenish yellow covered with bright medium red, 40 per cent. to 80 per cent., mottled, splashed and striped, deepening almost to blush on sunny side; bloom, scant, waxy; skin, medium thick, rather tough, smooth and bright; dots, inconspicuous, medium in number, small, roundish, light gray, generally slightly raised; cavity, medium in depth, rather wide, flaring, broad acute, nearly regular, generally without markings; stem, long, slender, straight or inclined, brownish red, smooth;

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[1] Personal letter from Mr. T. V. Munson.

basin, medium in depth and width, abrupt, truncate conic, smooth and nearly regular; calyx, closed or partly open, rather small, pubescent; segments, medium, short, pointed, reflexed; tube, long, medium in breadth, funnel form, stamens median or basal, pistil point present; core, abaxile, medium to small, central, oval turbinate, core lines clasping; cells, closed, rather small, symmetrical; carpels, roundish to obovate, emarginate, smooth, concavity medium; seeds, medium to many, plump medium brown, irregular or oval, obtuse; axis, medium straight; flesh, white, slightly tinged with yellowish green, firm, moderately coarse, medium juicy; flavor, brisk subacid; quality, good. Described from nine specimens received from the New York Experiment Station.

Sweet Ben Davis.

Concerning this variety, Heiges makes the following statement in the report of the pomologist for 1895. The apples were from Prof. John T. Stinson of Fayetteville, Ark., who presumably furnished the facts of origin, etc.

Originated about 1870 on farm of Garret Williams in Madison county, Ark. The tree resembles Ben Davis in shape, wood and leaf, and is nearly as good a bearer. The fruit ripens about two weeks earlier than Ben Davis. Roundish, truncated, slightly oblique, slightly unequal; large, smooth, except for a few russet knobs; greenish yellow, washed with pale red, striped and splashed with crimson; dots, numerous brown; cavity, large, regular, deep, abrupt furrowed and russet netted; calyx segments, short, wide, converging or slightly reflexed; eye, large, partially open; skin, thick, tough; core, large, roundish, clasping, nearly closed; seeds, numerous, large, angular, brown; flesh, whitish satiny, juicy; sweet; good; season, winter.

White Ben Davis.

Professor Stinson says that this apple has been found in several orchards in Missouri. I do not know that it has been much disseminated or that it is now offered for sale.

It has been said that a list of forty varieties was under consideration. Only twenty are given as belonging to this group. Of the remaining ones the following varieties, that have by various writers been more or less clearly and definitely assigned to this group, are considered to properly belong elsewhere: —

Beach.
Dickenson.
Gill (Gill Beauty).
Loy.
Rutledge.
Wallace Howard.

Regarding the following the writer is in some doubt, owing to lack of opportunity for sufficient study, but considers it probable that they do not belong to this group: —

Breckinridge.
Chicago.
Collins (Champion).
Florence.
Givens.
Hastings Red.
Highfill.
King David.
Marion Red.

The remainder of the forty are accounted for as synonyms.

In deciding whether or not any variety should be admitted to a place in the Ben Davis group as here given, the intention has been to be conservative. The study of varieties of fruits by groups has only recently begun and the writer feels that in constituting these groups it is best to include in any group under consideration only such varieties as seem beyond doubt to belong there, even if there are strays left that do not seem to belong anywhere. If any of these odd varieties are of great importance they will in time become the central types of new groups, while if only of minor account they may as well be left by themselves.

It is to be understood that the foregoing is not final, but of the nature of a report of progress. In order to be conclusive the study of the fruit in some cases and of the tree characters in many cases is necessary. It is hoped, however, that it may prove a contribution of some value on this subject and a basis for further study.

VARIATION IN APPLES.[1]

BY J. K. SHAW.

It is safe to assume that the Ben Davis is the most widely cultivated of any commercial variety of apples in America. It is known in almost every apple-growing section. It is therefore grown under a great variety of conditions of climate, from the short hot summers and long cold winters of Quebec to opposite conditions in Arkansas and Texas. It also flourishes in a great variety of soil conditions. Moreover, it seems to be in itself more variable than other sorts, and responds in a greater degree to varying environment than do most other varieties.

These considerations led to its selection as a variety for the study of variation in apples, and the results of two years' investigation are here reported. The matter is presented under two headings, (1) the variation in size and form as grown in the Clark orchard of the Massachusetts Agricultural College, and (2) the variation in form, quality and other characters when grown under widely varying conditions of climate and soil in the United States and Canada.

Variation in the College Orchard.

In the fall of 1908 the product of four trees in the college orchard was picked separately and divided each into four lots, comprising the product of the upper south, lower south, upper north and lower north quarters of the trees. These were studied with reference to size and form. This arrangement gave opportunity for two comparisons: (*a*) from different trees, (*b*) from different parts of the trees.

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[1] Work on this subject was begun by the writer in 1907 as a part of the requirements for the degree of M.S. by the Massachusetts Agricultural College, and was continued and extended in 1908. It was done under the direction of Prof. F. C. Sears, to whom the thanks of the writer are extended for encouragement and suggestions, and also to Prof. F. A. Waugh, who has aided in many ways. Assistance and suggestions have also been received from many horticulturists and fruit growers from various parts of the country. It is impossible to name them here, but the debt to all is gratefully acknowledged.

(a) From Different Trees.

Table 1 shows the means,[1] standard deviations and coefficents of variability, with their probable errors, in the size and form of the apples from each of the four trees. It is evident that there are differences in both size and form.

TABLE 1.

	Size.[2]			Form.			
	Mean.	Standard Deviation.	Coefficient of Variability.	Mean.	Standard Deviation.	Coefficient of Variability.	Number of Apples.
Tree 2, . .	71.02±.14	6.16±.10	8.67±.14	1.1422±.0014	.0576±.0009	3.04±.88	864
Tree 3, . .	68.80±.15	5.31±.10	7.72±.16	1.1399±.0016	.0543±.0011	4.73±.09	567
Tree 5, . .	68.35±.13	5.55±.08	8.12±.13	1.1666±.0019	.0626±.0013	3.76±.08	469
Tree 7, . .	72.80±.18	6.45±.13	8.86±.17	1.1716±.0019	.0578±.0013	3.37±.07	423
	70.23±.08	5.95±.06	8.47±.08	1.1515±.0008	.0589±.0006	5.29±.05	2,321

There seems to be little or no relation between the size of the apples and the yield. Trees 2 and 7 produced the larger apples,

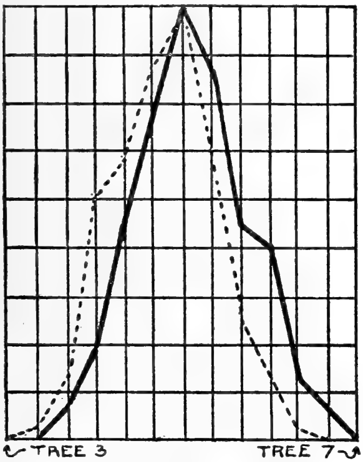

FIG. 1.

and one of these gave the highest yield of all and the other the lowest, less than half as many. There are seen to be slight

[1] For the method of making these calculations, see p. 198.

[2] All measurements are in millimeters.

differences in the variability in size of apples from the different trees.

More striking are the differences in mean index of form, though the variability of form is less than that of size. The difference in form of the apples from Trees 3 and 7 is shown graphically in Fig. 1. These differences in form were perceptible to the eye, and there were also differences in color, apples from Tree 5 being higher colored than the others.

These differences may be attributed to bud variation or to the influence of the stock, for the trees were near each other, and, so far as could be seen, on exactly similar soils. In passing it may be suggested that this method offers means of throwing light on these two disputed questions, namely, bud variation and the mutual influence of stock and scion.

(b) *From Different Parts of the Trees.*

The results of computations of the apples from different parts of the tree are shown in Table 2. It appears from this that apples from the top of the tree are a little larger than those from the lower branches and also slightly more variable. In form the differences in both mean and standard deviation are slight, those from the lower branches being a little longer than those from the top of the tree. The most important thing about this table is that it serves to bring out the greater differences in the products of the individual trees.

TABLE 2.

	SIZE.			FORM.			Number of Apples.
	Mean.	Standard Deviation.	Coefficient of Variability.	Mean.	Standard Deviation.	Coefficient of Variability.	
Upper south, .	70.93±.18	6.40±.13	9.02±.19	1.1643±.0017	.0593±.0012	3.61±.07	518
Lower south, .	69.24±.14	5.68±.10	8.20±.14	1.1512±.0015	.0619±.0011	4.19±.07	714
Upper north, .	71.27±.20	6.14±.15	8.47±.19	1.1553±.0020	.0607±.0014	3.91±.08	414
Lower north, .	69.79±.12	4.96±.08	7.11±.12	1.1406±.0016	.0644±.0011	4.58±.07	676

Climatic Variations.

The variations in the college orchard are comparatively slight when compared with those observed when apples from widely separated localities are compared. This variation has been often observed and noted, but so far as the writer knows there has been no attempt to study systematically and record it. The work here reported is a beginning. The study is based on a careful examination and measurement of twenty lots of apples of the crop of 1907 and of twenty-five of the crop of 1908, received from growers in different localities in the United States and Canada. These lots were generally about a bushel each. The numbers are given in Table 3. An attempt was made to secure apples from the same orchards both years, but on account of crop failures and other reasons this was unsuccessful in a few cases. In addition to these, several smaller samples have been received from other localities which, while not large enough for the same sort of study, serve to indicate the gradual variation of the variety when passing from one region to another. In the following pages the variation of form, size, quality and other characters are separately taken up and considered.

Discussion of the Variation.

Form.

The most important character studied was that of form, and the variation of this was nothing short of remarkable. One familiar with the variety in a certain locality would hardly recognize it as grown perhaps not more than one or two hundred miles away. Much time was given to the study of this, and careful measurements of more than 9,000 apples from the different localities were made and calculated by statistical methods.

The different lots may be grouped in four classes as regards the general form, as follows: —

1. The oblong conic, more or less ribbed form from the Maine seacoast and Nova Scotia and Prince Edward Island.

2. The round conic type from the north central and northeastern United States and southern Canada, from as far south

as Pennsylvania and possibly farther in the mountain regions, and from the Pacific coast.

3. The oblate or oblate conic type from the Delaware peninsula and the valley of the Ohio and its tributaries.

4. The roundish oblate form from the Ozarks and from Colorado.

The outlines of specimens representing these four types are shown in Fig. 2. Each of these types seems to be pretty constant in the localities given, and they gradually shade into each other in passing from one region to the next. These differences in form are closely related with certain other characters which are discussed later.

Coming now to the mathematical expression of the form of the apples, the method was as follows. Each apple was carefully measured, ascertaining in millimeters its greatest transverse and longitudinal diameters, and the figures recorded. Then the transverse diameter of each apple was divided by its greatest longitudinal diameter. The number resulting from this calculation was taken as representing the form of the apple, and is called the index or coefficient of form. If the index is 1 the diameters are equal; if it is less than 1 the apple is longer than broad, and if more than 1 it is broader than long. The calculation of this index for a large number of apples gives an array of numbers representing the forms of the apples measured which may be dealt with by statistical methods.[1]

Calculating the means of the several arrays representing the different lots of apples measured gives the interesting and significant figures shown in Table 3. Translated into simple language these figures mean that in Port Williams, N. S., for example, the average Ben Davis apple of the crop of 1907 was about 1.0196 larger in transverse diameter than in longitudinal diameter, and, as shown by the probable error, the chances are even that this figure is not over .0035 of the transverse diameter away from the truth. This average apple is nearly as long as broad, and to one familiar with this sort of measurement indicates an apple that may be correctly described as oblong.

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[1] For these methods see C. B. Davenport, "Statistical Methods," or "Principles of Breeding," by E. Davenport.

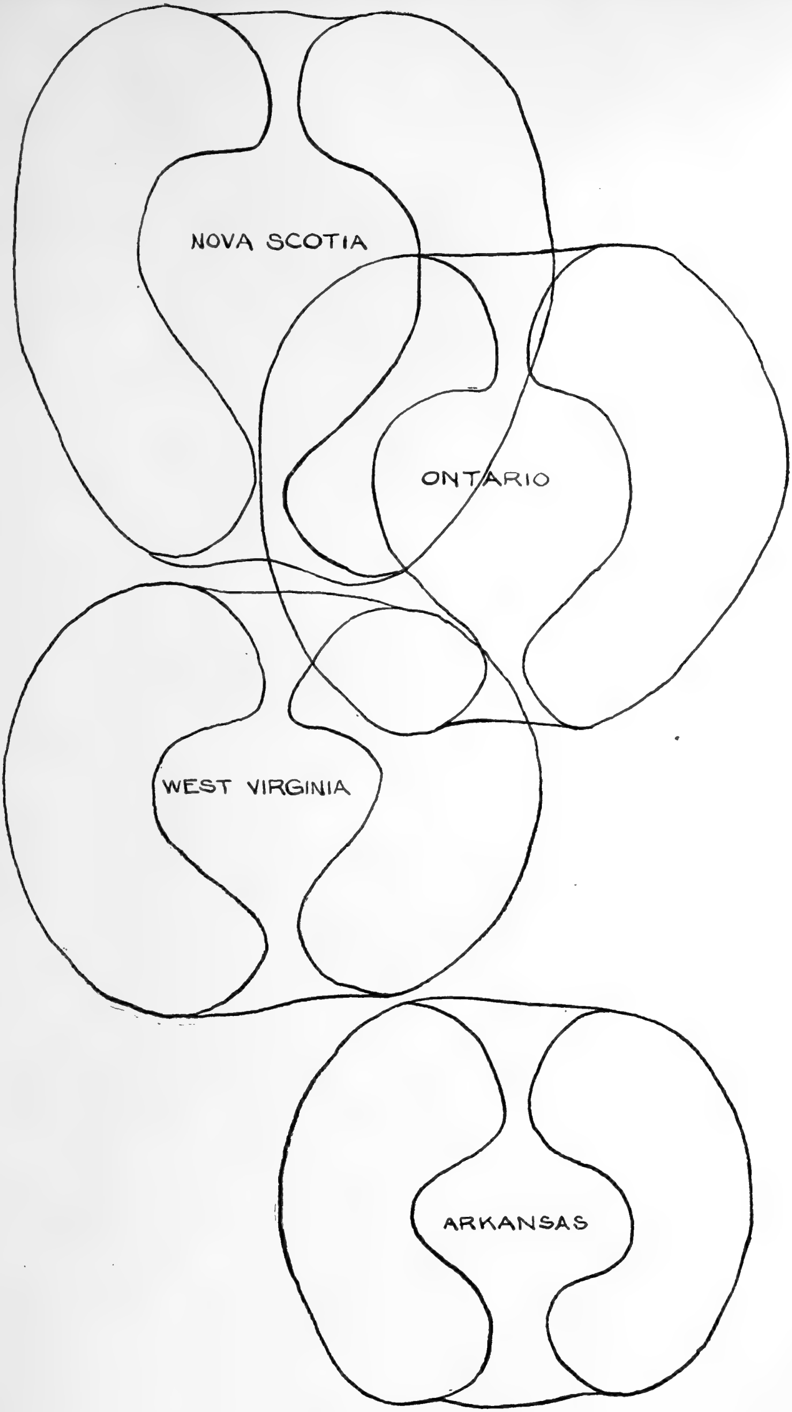

FIG. 2.—Typical Forms of the Ben Davis.

Nova Scotia, the oblong form. Ontario, the round conic form. West Virginia, the oblate form. Arkansas, the roundish form.

TABLE 3. — *Form.*

Apples from —	1907.				1908.			
	Number of Apples.	Mean Index of Form.	Standard Deviation.	Coefficient of Variability.	Number of Apples.	Mean Index of Form.	Standard Deviation.	Coefficient of Variability.
Charlottetown, P. E. I.,	74	1.0511± .0049	.0619± .0034	5.88± .31	122	1.1250± .0052	.0858± .0037	7.63± .33
Port Williams, N. S.,	135	1.0196± .0035	.0656± .0026	6.37± .26	102	1 1183± .0044	.0672± .0031	5.68± .26
Lower Gagetown, N. B.,	–	–	–	–	226	1.0948± .0031	.0465± .0022	4.25± .20
East Sangerville, Me.,	–	–	–	–	197	1.2013± .0028	.0587± .0020	4.88± .17
Skowhegan, Me.,	–	–	–	–	130	1.1041± .0027	.0474± .0020	4.27± .18
Farmington, Me.,	–	–	–	–	149	1.1108± .0031	.0565± .0022	5.10± .19
Livermore Falls, Me.,	–	–	–	–	128	1.1262± .0030	.0519± .0021	4.19± .18
West Paris, Me.,	–	–	–	–	116	1.0934± .0045	.0461± .0031	4.22± .29
Monmouth, Me.,	–	–	–	–	173	1.1128± .0024	.0483± .0017	4.34± .16
Turner, Me.,	237	1.0451± .0025	.0571± .0018	5.71± .18	–	–	–	–
New Gloucester, Me.,	–	–	–	–	97	1.0978± .0031	.0451± .0022	4.11± .19
Marblehead, Mass.,	–	–	–	–	192	1.1021± .0029	.0598± .0021	5.42± .18
Barnstable, Mass.,	–	–	–	–	162	1.1281± .0021	.0407± .0015	3.67± .14
Amherst, Mass.,	284	1.1656± .0023	.0581± .0017	4.98± .14	2,321	1.1515± .0008	.0589± .0006	5.29± .05
Storrs, Conn.,	147	1.1557± .0030	.0534± .0021	4.62± .18	131	1.1423± .0041	.0689± .0029	6.03± .21
Abbotsford, Quebec,	151	1.1788± .0039	.0735± .0028	6.23± .24	129	1.1739± .0041	.0683± .0029	5.82± .23
Isle la Motte, Vt.,	203	1.1547± .0024	.0735± .0024	6.28± .27	170	1.1406± .0027	.0526± .0020	3.74± .15
Guelph, Ont.,	147	1.1309± .0030	.0524± .0020	4.72± .18	–	–	–	–
Belleville, Ont.,	124	1.0829± .0026	.0442± .0019	4.08± .18	135	1.1111± .0025	.0436± .0018	3.92± .16
State College, Pa.,	209	1.1556± .0026	.0568± .0020	4.91± .14	–	–	–	–
New Brunswick, N. J.,	–	–	–	–	36	1.1525± .0051	.0460± .0036	3.99± .32
Middletown, Del.,	87	1.2010± .0060	.0831± .0042	6.92± .35	–	–	–	–
Martinsburg, W. Va.,	157	1.2272± .0035	.0603± .0020	4.91± .18	101	1.1537± .0036	.0563± .0027	4.78± .23
Tiptop, Ky.,	481	1.1914± .0018	.0592± .0013	4.97± .11	–	–	–	–
Mitchell, Ind.,	111	1.1928± .0038	.0599± .0027	5.02± .23	174	1.1758± .0033	.0560± .0020	4.76± .17
Bentonville, Ark.,	183	1.1588± .0024	.0492± .0017	4.24± .15	–	–	–	–
Lincoln, Ark.,	116	1.1536± .0042	.0677± .0015	5.87± .26	–	–	–	–
Manhattan, Kan.,	–	–	–	–	77	1.1629± .0059	.0520± .0042	4.47± .36
Stillwater, Okla.,	107	1.1550± .0035	.0541± .0025	4.68± .22	129	1.1861± .0035	.0584± .0024	4.92± .21
Grand Junct., Col.,	87	1.1409± .0039	.0544± .0028	4.77± .24	132	1.1465± .0036	.0617± .0025	5.38± .22
Redlands, Cal.,	79	1.1086± .0042	.0567± .0030	5.11± .27	87	1.1418± .0052	.0718± .0033	6.29± .37
Kaslo, B. C.,	108	1.0630± .0043	.0671± .0031	6.31± .29	73	1.1045± .0054	.0706± .0039	6.39± .35

At the other extreme stands the lot from West Virginia, with an index of 1.2272 ± .0035. The average apple grown under exactly those conditions under which these apples grew has a cross diameter about 1.2272 times larger than the longitudinal diameter, and we know that the chances are even that this figure is not more than .0035 of the transverse diameter out of the way. Stating this last in another way, it means that the chances are even that the true index of form is not less than 1.2257 nor more than 1.2307.

The third column of Table 3 gives the standard deviation with its probable error, which gives a measure of variability for each lot. This is affected by the selection or want of selection, as the case might be, of the person sending the apples, some growers sending the apples just as they came from the trees and some selecting them more or less, and doubtless throwing out many specimens which were off type, thus reducing the amount of variation in that lot. Several tests showed that the amount of variability among the larger apples and smaller apples of a given lot was about the same, and this was also true of the mean index of form. It is believed, however, that this selection has not greatly modified the figures, and that the mean indexes of form are scarcely affected at all.

The fourth column gives the coefficient of variability and its probable error. This is an abstract number giving, in percentages of the means, the variability of each lot of apples, and enables one to compare the variability in form with that of any other character of the apples, or any character which can be measured and expressed by this method.

The variation in form is shown graphically in the diagrams in plates I. to V. These are based on the same measurements as the mathematical calculations, each lot being reduced to the basis of 200 apples for the sake of uniformity. Many of them are somewhat irregular, owing to the small numbers of specimens measured. The ordinate representing the index of form of 1.1300 is in each case made heavier in order to furnish a standard for comparison, this ordinate being near the average of all apples measured. The shape and relative position of these diagrams show strikingly the differences in variability and in mean index of form of the various lots of apples.

Considering the diagrams and the figures given in the table, we find that in the extreme northeast the Ben Davis is much elongated, and as we go south and west it becomes less elongated and more flattened, till we reach West Virginia and Kentucky, where it becomes a decidedly oblate apple. In the Ozarks it is a little longer, and in southern California still longer, and in British Columbia it is almost as much elongated as in Nova Scotia and neighboring regions. This noticeable elongation of the apples from Belleville, Ont., as compared with those from Guelph, is significant, as Belleville is located not far from the north shore of Lake Erie, while Guelph is some miles inland. The same influence is perhaps shown in the Vermont lot, though the figures for those of Quebec and Massachusetts, which serve to bring this out, are themselves in some degree exceptions to the general rule that the apples are longer as one goes north. Nevertheless, it seems reasonable to conclude that, beginning in the southern Allegheny mountains and in southern California, and going north, the apples become more elongated, and that this elongation is much more pronounced in the vicinity of large bodies of water, either salt or fresh.

The comparison of apples from the same orchard both years shows reasonably close agreement in most cases. Several, however, are quite different. It will be noted that these are among the extremes of form. The maritime provinces and the Pacific coast, that furnished extremely long apples in 1907, gave shorter ones in 1908, and the extremely flattened ones from West Virginia were longer. On the other hand, those near the average form show very slight differences. Professor Sears states that in Nova Scotia there are two types of Ben Davis that differ much in both tree and fruit. The fruit of one generally approaches an oblong form, while the other is more conic. Most of the Nova Scotia apples of 1907 were of the former type, while those of 1908 were more like the latter. The same would apply in some degree to those from Prince Edward Island. Both lots were the run of the orchard, no selection whatever being made. It is possible that the difference in the forms of these apples in the two years may be due to their representing these different types.

The apples from Quebec are flatter than those from farther

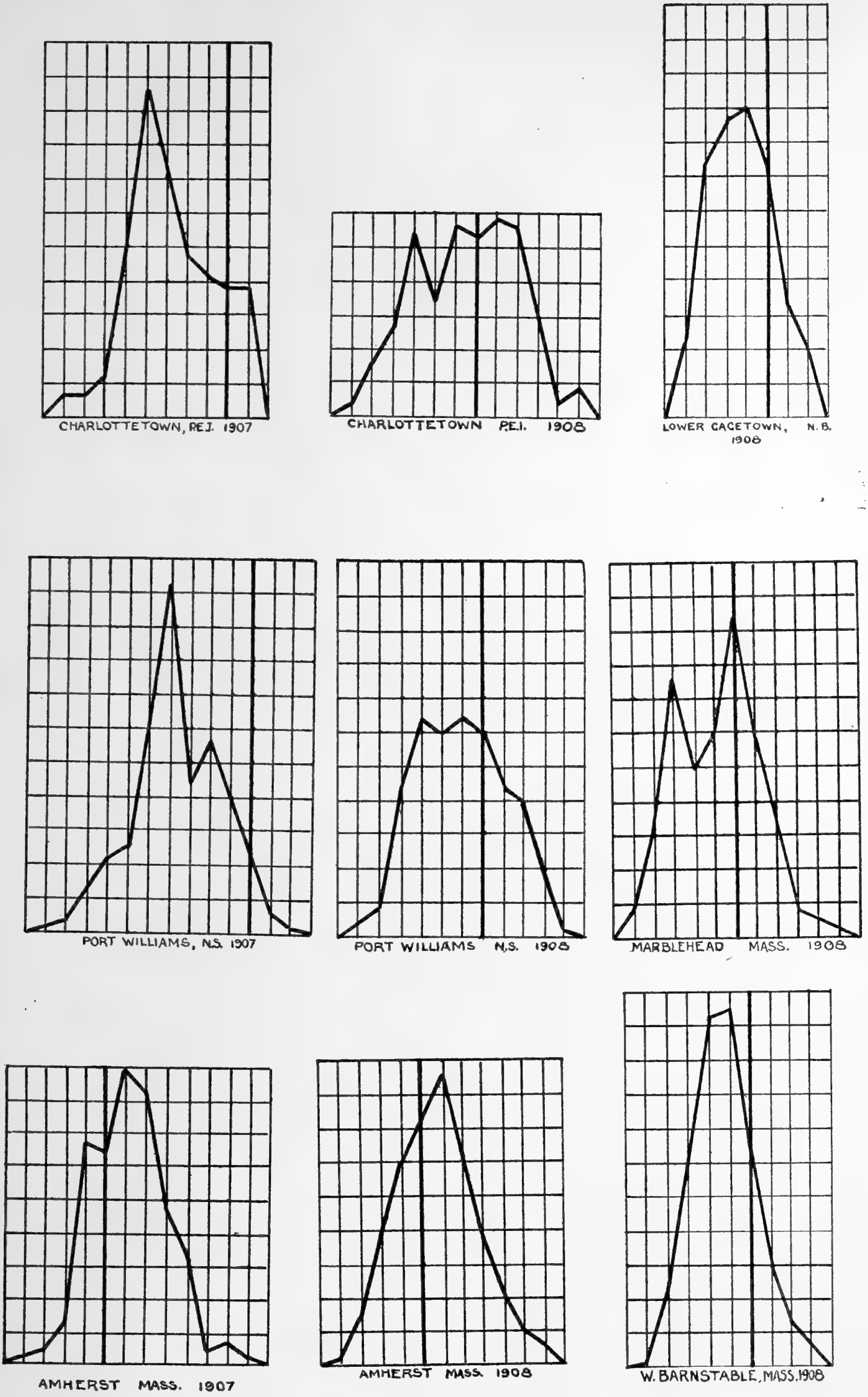
CHARLOTTETOWN, P.E.I. 1907
CHARLOTTETOWN P.E.I. 1908
LOWER GAGETOWN, N.B. 1908
PORT WILLIAMS, N.S. 1907
PORT WILLIAMS N.S. 1908
MARBLEHEAD MASS. 1908
AMHERST MASS. 1907
AMHERST MASS. 1908
W. BARNSTABLE, MASS. 1908

PLATE I.

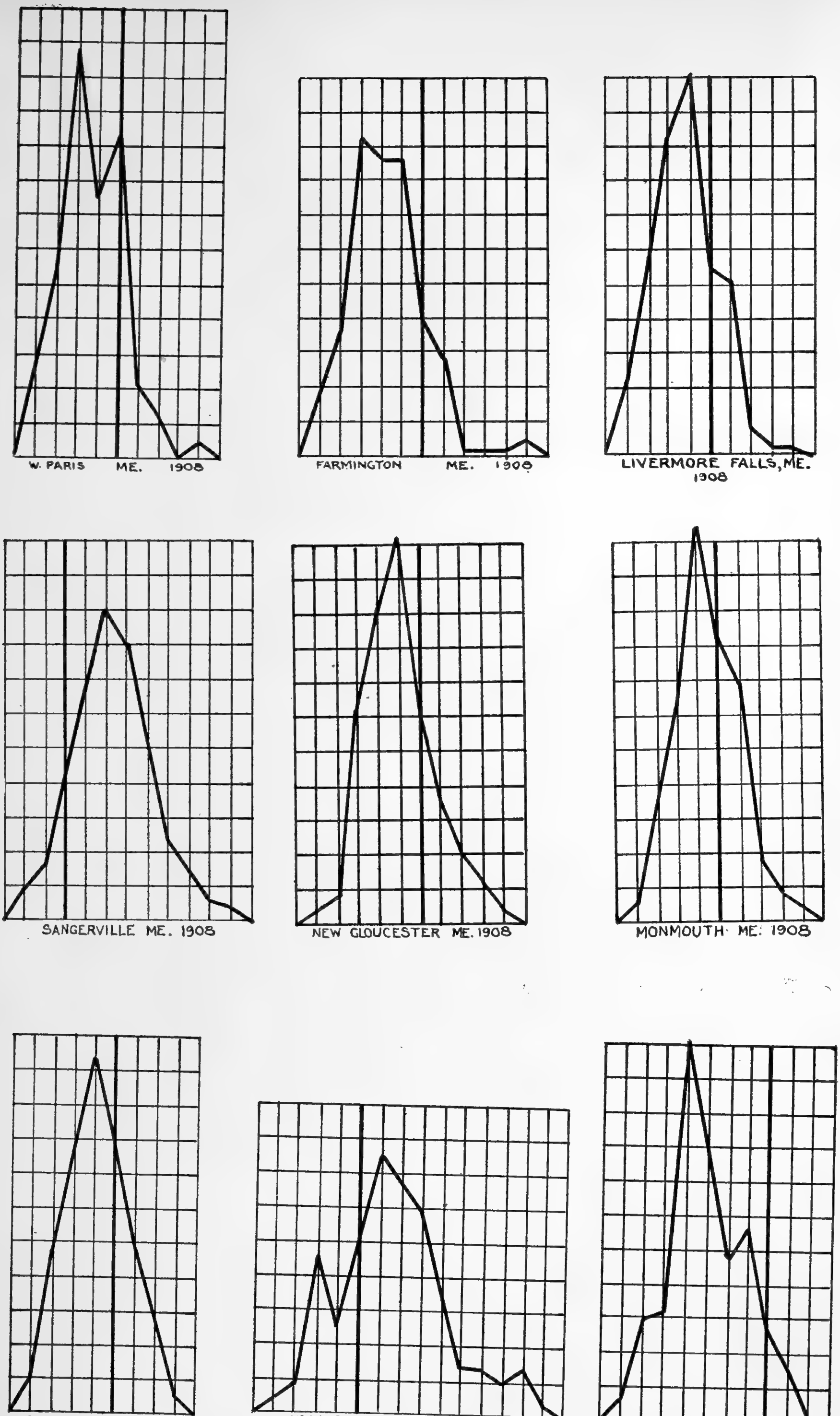
W. PARIS ME. 1908
FARMINGTON ME. 1908
LIVERMORE FALLS, ME. 1908
SANGERVILLE ME. 1908
NEW GLOUCESTER ME. 1908
MONMOUTH ME. 1908
SKOWHEGAN, ME. 1908
NEW GLOUCESTER ME. 1908
TURNER ME. 1907

PLATE II.

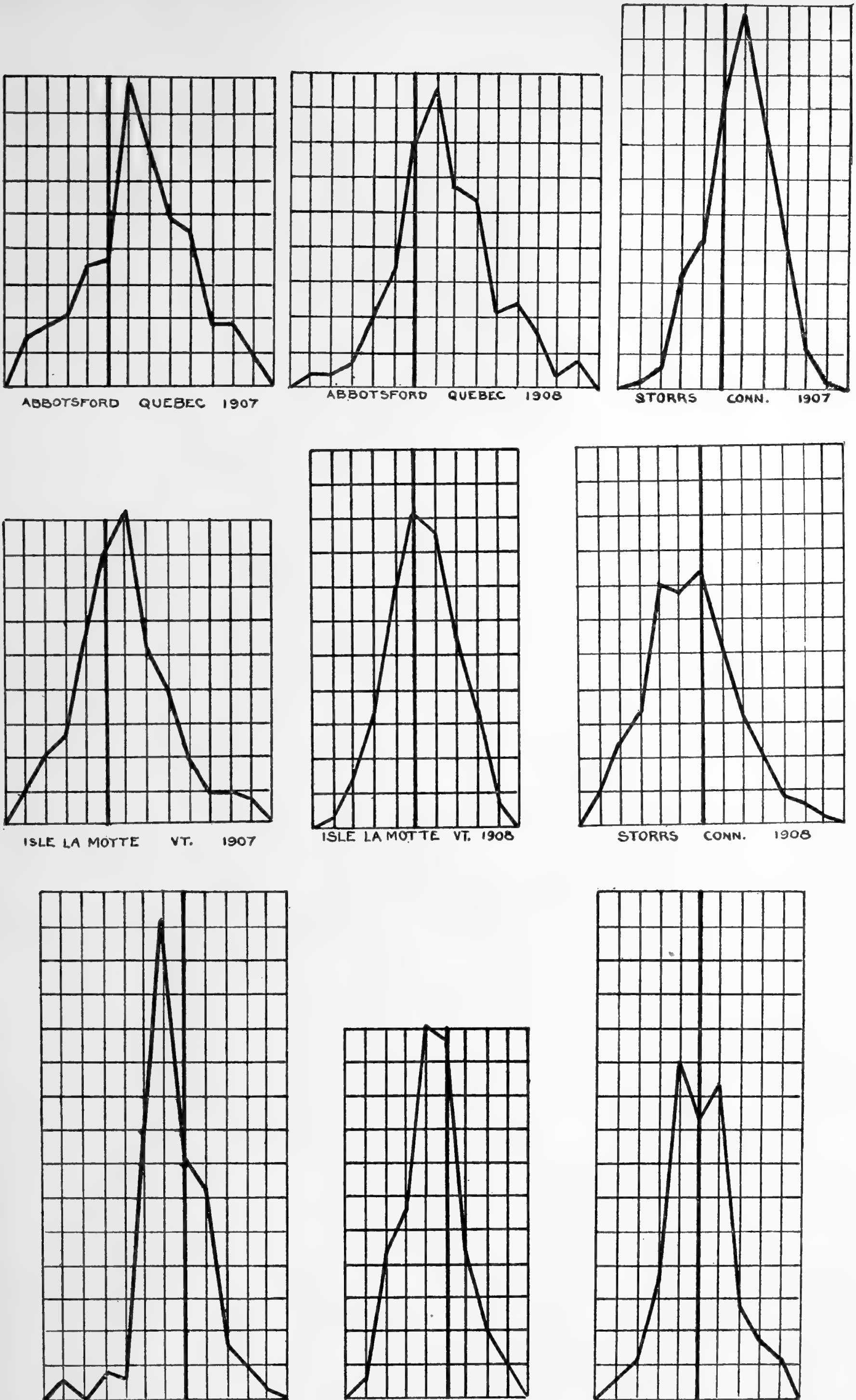
ABBOTSFORD QUEBEC 1907
ABBOTSFORD QUEBEC 1908
STORRS CONN. 1907
ISLE LA MOTTE VT. 1907
ISLE LA MOTTE VT. 1908
STORRS CONN. 1908
BELLEVILLE ONT. 1907
BELLEVILLE ONT. 1908
GUELPH ONT. 1907

PLATE III.

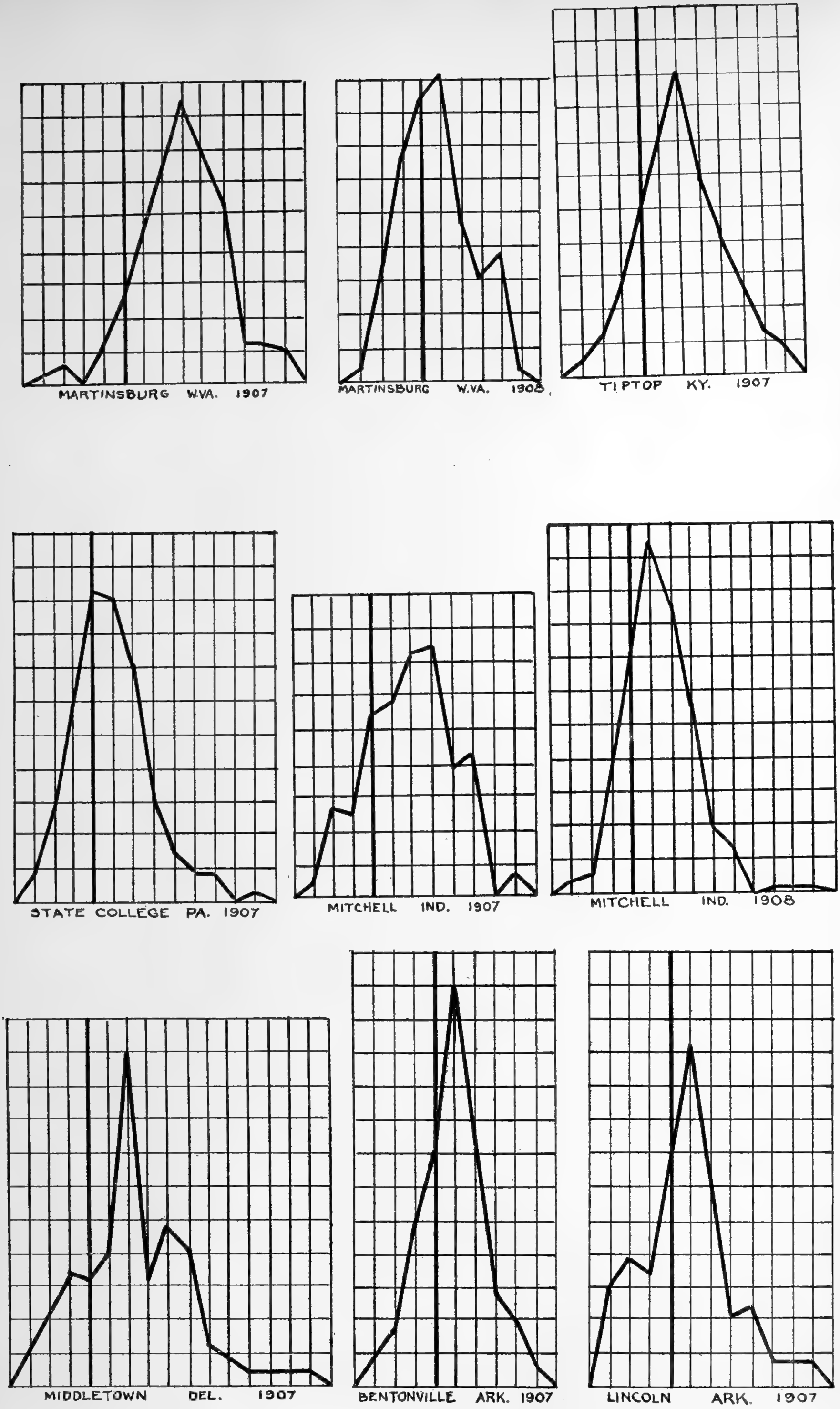
MARTINSBURG W.VA. 1907
MARTINSBURG W.VA. 1908
TIPTOP KY. 1907
STATE COLLEGE PA. 1907
MITCHELL IND. 1907
MITCHELL IND. 1908
MIDDLETOWN DEL. 1907
BENTONVILLE ARK. 1907
LINCOLN ARK. 1907

PLATE IV.

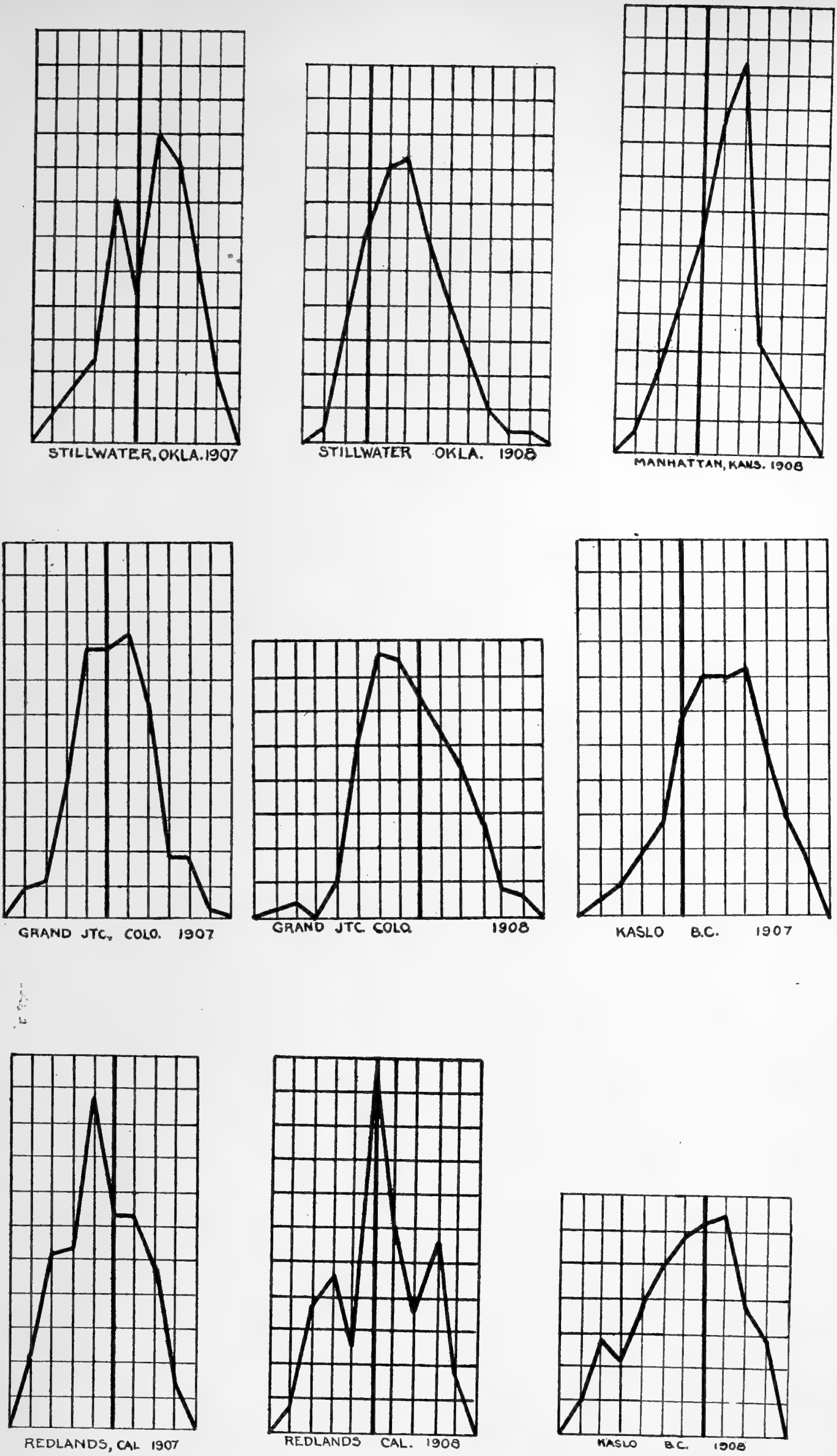
STILLWATER, OKLA. 1907
STILLWATER OKLA. 1908
MANHATTAN, KANS. 1908
GRAND JTC., COLO. 1907
GRAND JTC. COLO. 1908
KASLO B.C. 1907
REDLANDS, CAL 1907
REDLANDS CAL. 1908
KASLO B.C. 1908

PLATE V.

south, and those from Arkansas longer than those from farther north. This suggests the possibility that near the northern and southern extremes of distribution the general rule of elongation, as one goes north, is reversed, and that in the extreme north they are a little flatter than they are a little farther south, and at the extreme south they become slightly elongated. More data are needed to decide this question.

With a feeling that much could be learned by a more detailed study of the apples along the coast and adjacent region of New England and the maritime provinces, a special effort was made in the past season to secure apples from this section. These show the elongation towards the seacoast and northward, but among those from Maine the figures are not as harmonious as might be wished. Sangerville is farthest inland and New Gloucester nearest the coast, and they give the flattest and second longest apples, respectively; but the localities between do not show the gradual change in form that might be expected. These differences, however, are not large, and selection of the sample and local influences may account for it. More information is needed to clear this up.

Variability of the Different Lots.

An examination of the measures of variability of the different lots, bearing in mind the selection or want of selection of the shippers, indicates a somewhat greater variability in northern localities. This is shown both years, but is more pronounced in 1908.

Size.

The size of the apples was in many cases dependent largely on the selection practiced by the grower in making up the lots for shipment. Some were carefully selected and others were the run of the orchard. Any figures on size are, therefore, likely to be of little value. It is doubtless true that the apple attains a larger size in the south than in the extreme north. The season of 1907 was cold in the north and dry in the southwest, and may account for the inferior size of the apples from these regions. The season of 1908 was warmer in the north, and it appears that the apples were larger. Table 4 shows the results

TABLE 4. — *Size.*

APPLES FROM —	1907.				1908.			
	Mean.	Standard Deviation.	Coefficient of Variability.	Temperature (Degrees).	Mean.	Standard Deviation.	Coefficient of Variability.	Temperature (Degrees).
Charlottetown, P. E. I.,	61.36± .30	3.82± .22	6.20± .36	48.9	68.11± .53	8.75± .35	12.80± .52	51.3
Port Williams, N. S.,	63.63± .37	6.51± .26	10.23± .42	50.4	71.29± .42	6.37± .30	8.92± .42	51.2
Amherst, Mass.,	66.80± .20	5.53± .15	8.27± .23	55.9	70.23± .08	5.95± .06	8.47± .08	58.8
Storrs, Conn.,	70.83± .27	4.82± .20	6.80± .27	55.3	70.24± .24	4.32± .17	6.15± .24	58.8
Abbotsford, Quebec,	59.40± .24	4.32± .17	7.27± .28	49.9	66.89± .30	4.81± .21	7.19± .32	52.4
Isle la Motte, Vt.,	59.48± .23	4.85± .16	8.15± .27	53.0	64.40± .29	5.57± .20	8.65± .31	55.6
Belleville, Ont.,	65.45± .36	6.06± .26	9.25± .39	52.4	64.54± .16	2.84± .11	4.40± .18	54.8
Martinsburg, W. Va.,	73.30± .31	5.79± .22	7.89± .30	60.4	75.86± .13	1.99± .08	2.62± .11	63.9
Mitchell, Ind.,	73.89± .37	5.74± .26	7.76± .35	63.2	-	-	-	66.6
Stillwater, Okla.,	71.92± .24	3.61± .17	5.15± .32	68.9	74.49± .25	4.18± .18	5.61± .24	68.9
Redlands, Cal.,	73.21± .34	4.49± .24	6.13± .32	65.9	77.93± .33	4.64± .23	5.95± .31	68.5
Kaslo, B. C.,	71.10± .23	3.61± .17	5.07± .30	49.5	83.88± .30	3.77± .21	4.49± .24	50.9

of measuring a few lots from the same orchard both seasons, where it appears, from correspondence with the growers, safe to make comparisons. For comparison the average monthly mean temperatures for the growing season March to September, inclusive, for the different towns or some near-by station are given. It appears safe to infer that in any given orchard the size of the apple is governed largely by the temperature, but this by no means holds in different localities.

Flesh.

The whiteness of flesh which is characteristic of the variety was always maintained in considerable degree; those from Colorado were notably white of flesh. The less mature specimens had a greenish tinge, which, as the fruit ripened, gave way to a slight yellowish.

The firmness of the flesh likewise gradually gave way with ripening. The Colorado and in less degree the California lots were less firm and more of a spongy texture. Those from California carried well, but those from Colorado were soft enough to bruise quite badly, though this appeared to not seriously injure their keeping qualities, as the bruises showed a tendency to dry out rather than to decay.

The juiciness and quality were found to be variable. The apples were generally more juicy in the south, and of notably better quality. Northern-grown fruit was dry, flat, hard, and in some cases noticeably astringent, and these undesirable qualities did not entirely disappear with ripening.

In an attempt to learn something of the real nature of this, and of the general quality of the flesh, some chemical work was done.[1] Owing to a lack of time this was not as complete as might be wished, but the results, as far as they go, are interesting.

The methods used in this work may be briefly described as follows. One or two small slices, reaching to the core, were cut from three or more carefully selected apples, and dried in a water bath at 90° to 98° C. for about thirty-six hours. The weight of the residue gave the amount of dry matter. This dry residue, after cooling, was ground in a mortar until it

[1] For the opportunity to do this and for many suggestions as to methods, etc., the writer is indebted to the chemical department of the college.

would pass through a very fine sieve, and this fine powder used for the other work. The "insoluble matter" was determined by digesting 1 gram with about 200 cubic centimeters distilled water at room temperature, filtering through a tared filter paper and drying. The filtrate was titrated with n/5 alkali, using phenolphthalein as an indicator, and calculated as malic acid. For crude fiber the methods of the Association of Official Agricultural Chemists were followed, except that the sample was not previously extracted with ether.

The results of this work are shown in Table 5. From this table it appears that there is slight variation in the water content of these apples, those from Arkansas and Oklahoma having a little lower water content that those from the north. There is nothing in this column to account for the observed differences in juiciness and quality.

TABLE 5.— *Chemical Determinations (Per Cent.).*

APPLES FROM —	In Original Subsistence.						In Dry Matter.	
	Water.	Dry Matter.	Soluble Matter.	Insoluble Matter.	Crude Fiber.	Acid, as Malic.	Insoluble Matter.	Crude Fiber.
Prince Edward Island,	84.9	15.1	11.13	3.97	1.07	1.03	26.3	7.15
Nova Scotia,	85.4	14.6	11.11	3.39	1.13	–	23.9	7.75
Maine,	84.6	15.4	–	–	–	.70	–	–
Quebec,	84.2	15.8	11.80	4.00	–	–	25.3	–
Vermont,	84.0	16.0	–	–	–	.76	–	–
Guelph, Ont.,	83.6	16.4	13.52	2.89	–	–	17.5	–
Belleville, Ont.,	83.6	16.4	–	–	–	–	–	–
Pennsylvania,	85.8	14.2	–	–	–	.70	–	–
Massachusetts,	85.2	14.8	11.52	3.26	.99	.73	22.0	6.68
Connecticut,	84.2	15.8	–	–	–	–	–	–
Delaware,	84.3	15.7	–	–	–	.79	–	–
West Virginia,	84.8	15.2	12.00	3.21	.80	.79	21.1	5.28
Kentucky,	84.7	15.3	12.58	2.74	–	–	17.9	–
Indiana,	83.2	16.8	–	–	–	.76	–	–
Bentonville, Ark.,	82.4	17.6	–	–	.93	–	–	5.29
Fayetteville, Ark.,	81.2	18.8	–	–	1.03	.65	–	5.52
Oklahoma,	82.6	17.4	14.30	3.04	–	.66	17.6	–
Colorado,	84.8	15.2	12.82	2.39	1.00	–	15.7	–
California,	83.2	16.8	13.88	2.94	–	.63	17.5	–
British Columbia,	84.5	15.5	–	–	–	–	–	–

The constituents of apples, soluble in water, include the sugars, acids and doubtless some others of minor importance. These are lowest in Nova Scotia and highest in Oklahoma, and samples from intermediate points are generally between these figures in so far at least as determined.

The percentage of insoluble matter, which consists of pectin, cellulose and possibly starch and allied substances, are in general inversely proportional to those of soluble matter, being highest in the north and lower in the more southern part of the range of the variety.

Color.

The body color was, as a rule, closely correlated with the degree of ripeness of the fruit, the riper the apple the more yellowish in color. Aside from this, no variation was noted. The depth of overcolor was closely correlated with latitude, the farther north the deeper the color, and the variation was from a pale pinkish red in Arkansas to a deep crimson in the extreme north. The amount of overcolor did not seem to be dependent on latitude but was probably controlled largely by local conditions. The overcolor was especially good on the Pacific coast apples and on those from Colorado, Pennsylvania and Indiana, though in case of the last it was rather dull. The disposition of the color showed no striking variation. The mottling ran together into a blush on highly colored specimens, and there were always more or less stripes and splashes present. Probably all the russet that appeared was caused by Bordeaux mixture.

Bloom.

The amount of bloom seemed to be rather less in the north than in the south and on the Pacific coast. The nature of the bloom, whether waxy or greasy, seemed to depend largely on the maturity of the fruit.

Skin.

The skin was generally thicker in the south and west than in the northern localities. The texture did not vary greatly. The surface of the fruit varied much, but this seemed to be brought about by local conditions, and most of the roughness was due to Bordeaux mixture. The specially dull rough surface of the Massachusetts specimens was probably due to a heavy application of nitrate of soda the previous year.

Dots.

The size and color of the dots was variable, but the number and form were quite constant, and they were always very slightly raised above the surface of the apple. They are generally very small in the extreme north and become quite constantly larger as one goes south, being largest in the southwest and in Colorado. Almost all specimens showed some dots with russet and some without. Aside from this they are generally lighter in the north and more gray or yellowish toward the south.

Cavity.

The variation in the size of the cavity was marked. It was small and very shallow in the extreme northeast, of medium depth in the central and south central States and very deep in the Ozarks and in Colorado and California. It was very narrow in the Ozarks and generally wide in other localities. In cross-section there was little significant variation except that the cavity was generally more smooth and regular in southern-grown specimens.

Stem.

The stem presented little of interest. It was extremely variable in length and size, but the variation was nearly as great between specimens of almost any one lot as between those of different lots. The variability was perhaps greater in northern-grown apples than in those grown farther south.

Basin.

The remarks concerning the variation of the cavity will apply almost as well to the basin. A noticeable variation was the tendency towards a five-crowned fruit in Nova Scotia and to a less degree in neighboring regions. This was also seen in some degree in specimens from British Columbia, but was less pronounced. This tendency towards a pentagonal form extends more or less to the whole apple, giving somewhat of a pentagonal outline to the fruit as a whole. In the more southern localities, and particularly in the Ozarks and neighboring regions, the basin is remarkably smooth and regular and the sides abrupt, which make the basin one of the surest means of identifying specimens of this variety that may chance to be off type.

Calyx.

The calyx was generally more or less distorted by handling, and it was difficult to make very much out of it. The most striking thing about it was that in the small, poorly developed specimens it was nearly always closed, while in large, well-grown specimens it was at least partly open and sometimes a little separate at the base.

Calyx Tube.

The calyx tube was extremely variable, being sometimes very short, not more than one-fourth as long as wide, as in some of the Quebec specimens, and sometimes extremely long, extending almost to the cells, as in some of those from Arkansas and Colorado. This variability lay mostly in what may be called the stem of the funnel, this being very long in some apples and varying all the way to complete suppression, leaving a conical tube, in others. As a rule it was longer in the fully developed specimens and short in the poorly developed apples from northern regions.

Core.

The variation of the core closely followed that of the general form of the apple. In the elongated specimens it approached an oval form, and in the roundish and oblate apples it was turbinate. Likewise, in the elongated specimens it was usually abaxile, often strongly so, and in the more oblate ones it became axile or nearly so. The size as compared with that of the whole fruit varied but little, being possibly a little larger in the ill-developed apples, and it was always central and the core lines generally clasping.

Cells.

The variation of the cells very closely followed that of other parts of the core, being wide open and asymmetrical in the northern-grown apples and closed and symmetrical in those from the south. It was most open and asymmetrical in the larger apples. The carpels were never tufted but often were a little slit, especially in those from the north; they varied considerably in form, following pretty closely the general form of the apple. The concavity of the carpels was chiefly dependent on the development of the seeds.

Seeds.

The seeds showed little variation worthy of note. The number was somewhat variable; they were usually plump and of medium size. The color varied with the degree of maturity of the fruit, being generally lighter in poorly developed, northern-grown specimens.

Causes of the Variation.

The most interesting and significant variation is found (1) in the form of the apple and its parts, both external and internal; (2) in size, and (3) in the quality of the flesh. The variation in color is that usually found, being darker in the higher latitudes.

Form.

It appears beyond question that, speaking generally, and possibly excluding the extremes of distribution, Ben Davis apples become gradually more elongated as one goes from its Southern range northward, and this elongation is much more pronounced near large bodies of water. This is probably somewhat affected by local influences, but in general it appears to hold. That these differences are caused by climate, and not by different soils, sites, fertilizers or methods of cultivation, the writer has no doubt. Just what factor or factors of climate bring this change about is not so clear. It would seem probable that humidity has something to do with it, but the writer has been unable thus far to secure conclusive evidence on this point. The available records of humidity have been unsatisfactory, and more exact knowledge of this at the stations where the apples are grown and more data on their variation are needed. It is also possible that temperature may have an influence, either direct or through its influence on humidity.

It is entirely possible that other factors enter in, but a careful consideration of latitude, altitude, amount and intensity of sunlight, rainfall and other considerations fail to show anything that can be demonstrated as having any constant effect. To determine just what the cause is will require much patient investigation.

Size.

The size of the apples appears to be largely governed in any locality by the summer temperature. This is shown by the larger apples in the warmer season of 1908. In only two cases has a higher temperature failed to produce larger apples, and in one case the apples are larger while the temperature remains the same. The other eight comparisons in Table 4 show a higher temperature and larger apples. It may also be noted that a comparatively low temperature in the north produces as large or larger apples than a much higher temperature farther south. It is of course to be understood that methods of cultivation have an effect on size sometimes greater than temperature, and this fact, together with some possible selection on the part of the shipper, probably accounts for the above exception to the general rule.

Flesh.

During the winter of 1907 careful notes were kept on the quality of the apples from the different localities. In the judgment of the writer the various lots would rank in quality about in the following order with a notable difference between 9 and 10: —

	Degrees F.		Degrees F.
1. Colorado,	63.0	11. Connecticut,	55.3
2. Indiana,	63.2	12. Pennsylvania,	56.9
3. Bentonville, Ark.,	–	13. Massachusetts,	55.9
4. Oklahoma,	68.9	14. Guelph, Ont.,	–
5. Lincoln, Ark.,	69.0	15. Nova Scotia,	50.4
6. California,	65.9	16. British Columbia,	49.5
7. Kentucky,	66.3	17. Maine,	53.8
8. West Virginia,	60.4	18. Prince Edward Island,	48.9
9. Delaware,	61.8	19. Vermont,	53.0
10. Belleville, Ont.,	52.4	20. Quebec,	49.9

Accompanying the list is given the average monthly mean temperatures for the growing season of 1907, March to September, inclusive, as compiled from the records of the United States Weather Bureau and Canadian Meteorological Service.

It appears from this that an average monthly mean temperature for the growing season of at least 60° is required for the satisfactory development of the Ben Davis apple, and if grown where a lower temperature prevails the product is likely to be inferior.

That the poor quality of these northern-grown apples, as shown by their acidity, and dry, tasteless flesh, is due to lack of sufficient heat to fully develop the fruit is indicated by the results of certain work of the Bureau of Chemistry of the United States Department of Agriculture on the development of the Ben Davis,[1] where is shown the constant increase of sugars and decrease of acids with the development of the apples. It is also shown that the tannin which is present in the partially developed apples gradually disappears, and it is doubtless this substance that gives the apples their astringent taste.

Summary.

1. Apples vary greatly in response to the widely varying conditions of soil, and, more especially, climate, in the apple regions of North America. The Ben Davis variety seems to be especially variable.

2. This variability may be accurately measured and studied by means of statistical methods.

3. The most striking variation is in the external form of the apples, and this is accompanied by corresponding changes of the internal structure.

4. The cause of this variation is some factor or factors of climate, which are closely related to latitude and the proximity of large bodies of water. It is probable that humidity or temperature, or both, may be the controlling factors.

5. The differences in warmth of different growing seasons definitely affect the size of the apples for that season.

6. The most favorable temperature for development in size

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[1] Bureau of Chemistry, Bulletin 94, p. 44.

varies with the locality. It is lower in the north than in the south.

7. The cause of the variation in quality is chiefly the varying amount of heat prevalent during the growing season.

8. In order to develop satisfactorily in quality the Ben Davis should have an average monthly mean temperature of not less than 60° F. for the growing season, March to September, inclusive.

FUMIGATION DOSAGE.

I. TOMATOES.

BY W. V. TOWER, B.S.

Introduction.

BY H. T. FERNALD.

Tomatoes are extensively grown in Massachusetts in greenhouses. Unfortunately, they are subject to the attacks of several kinds of insects which under glass seem to be more than ordinarily destructive. The most important of these enemies are the greenhouse white fly (*Aleyrodes vaporariorum* West.) and thrips, and as these are most successfully controlled by fumigation with hydrocyanic acid gas, this treatment should be familiar to tomato growers. Unfortunately, however, this is not the case, many growers seeming to be afraid to use it for fear that when the gas is generated in sufficient quantity to destroy the insects it will also injure the plants.

The amount of hydrocyanic acid gas to which tomato plants can be exposed without injury, under varying conditions of light, temperature, humidity, age, variety, etc., has never been investigated, so that there has hitherto been some reason for this fear. To determine, therefore, just what tomato plants could withstand in the way of treatment, under all conditions likely to be met with in commercial work, the experiments which follow were planned by the writer and were carried out in the greenhouse of the department of entomology of the Massachusetts Agricultural Experiment Station during the winter of 1905–06, by Mr. W. V. Tower, then a graduate student in entomology at the Massachusetts Agricultural College. The experiments had just been completed when Mr. Tower accepted an appointment in Puerto Rico and was obliged to leave before the results were ready for publication. It is therefore desirable, for the sake of placing responsibility, to state that the experiments were planned largely by the writer, assisted to some extent by Mr. Tower; that the entire care of the plants, the fumigations and the observation of the results were the work of Mr. Tower; while most of the conclusions and the duty of editing the work for publication have fallen upon the writer. In fact, the original work herein contained should be regarded as Mr. Tower's, while for the planning of the experiments and the editorial work the writer should be held responsible.

Three varieties of tomato — Livingston, Lorillard and Freedom — were selected, these being the ones most generally raised under glass in Massachusetts. Two plants of each variety were used in each test. In the tabulations which follow, factors common to the entire set are given before the tabulation itself. The abbreviations indicating the results are as follows: —

B, burned.
BB, badly burned.
BC, burned and leaves curling.
BI, badly injured.
C, leaves curling.
I, injured.
K, killed.
N, normal (uninjured).
SB, slightly burned.
SI, slightly injured.
TI, temporarily injured.
TK, top killed.
VBI, very badly injured.

Wilted leaves are the first indication of injury. If this is not too severe they gradually become normal again. Curled leaves indicate more serious effects, but plants thus affected frequently become normal later.

The fumigation in all cases was with 98 per cent. to 99 per cent. potassic cyanide, the proportions of the cyanide, acid and water used being 1, 2, 4. The column marked "Time of exposure" gives the time at which the treatment began. Temperatures are given by the Fahrenheit scale.

The first two sets of experiments were carried on in direct sunlight. In the first set periods of ten, twenty, thirty, forty-five minutes' and one hour's exposure quickly showed that it was not necessary to make any long exposures with the greater strength of cyanide, and, accordingly, exposures of ten, twenty and thirty minutes only were made, even the shortest of these being too severe a treatment for the plants.

Experiment I.

Day Exposures with Direct Sunlight.

First four sets treated March 14; fifth set treated December 14.

Fumigation with .005 gram KCN per cubic foot; plants six weeks old; humidity for first four sets, 65°; for fifth set, 60°; amount of sunlight (March 14) for first four sets, four hours; for fifth set (December 14), five hours; plants of first four sets, watered the morning of the test; of the fifth the day before; all sets dry when treated; conclusions drawn five days after treatment with the first three sets, eight days afterward with the fourth set and about three weeks afterward with the fifth set. The sunlight was not as strong for the fifth set as for the others, it being December, while the other tests were in March.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	2.28	3.00	3.30	4.10	8.30
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature of house (degrees),	68	65	63½	65	67
Livingston,	B	BB	BB	BB	VBI
Lorillard,	N	B	SB	BC	VBI
Freedom,	B	B	BB	BC	VBI

Experiment II.

Day Exposures with Direct Sunlight.

First two sets treated December 14; third set March 14.

Fumigation with .01 gram KCN per cubic foot; plants six weeks old; humidity, 79°; amount of sunlight for first two sets five hours; for third set four hours; all plants watered at 8.30 A.M. the day of the test, but dry when treated; one plant of each variety placed under a bench in the house for fourteen to nineteen hours before treatment; conclusions drawn after three weeks for the first and second sets and after one week for the third set.

	Set Numbers.		
	1	2	3
Time of exposure,	11.20	12.00	1.45
Length of exposure,	10 m.	20 m.	30 m.
Temperature of house (degrees),	70	70	71
Livingston normal,	K	K	BI
Livingston under bench,	I	K	K
Lorillard normal,	K	K	BI
Lorillard under bench,	K	K	BI
Freedom normal,	K	K	BI
Freedom under bench,	K	K	BI

This experiment would seem to indicate that the plants placed under the benches before treatment were not benefited in this way.

Experiment III.

Cloudy Day Exposures, December 19.

Fumigation with .02 gram KCN per cubic foot; plants six weeks old; humidity not taken till 8 P.M., when it was 81°; good sunlight for four days before the test and for two hours in the morning that day; all plants watered at 8.30 A.M. the day of the test, but dry when treated; half the plants of each variety were sprinkled just before the test; conclusions drawn after seventeen days' observation. It was dusk when the fourth set was fumigated.

	Set Numbers.			
	1	2	3	4
Time of exposure,	2.45	3.15	4.00	5.00
Length of exposure,	10 m.	20 m.	30 m.	45 m.
Temperature of house (degrees),	68	67	65	65
Livingston normal,	TI	TI	TI	TI
Livingston sprinkled,	TI	TI	TI	TI
Lorillard normal,	TI	I	TI	I
Lorillard sprinkled,	SI	I	TI	K
Freedom normal,	TI	I	TI	I
Freedom sprinkled,	I	I	K	TK

In addition to the effects noted, the sprinkled plants developed white spots where the drops of water stood, and in general were in worse condition than the others.

Experiment IV.

Day Exposures during Rain, Snowstorm and Cloudy Weather, January 12 and 13.

Fumigation with .02 gram KCN per cubic foot; plants nine weeks old; set 1 treated during a rainstorm; sets 2 and 3 during a snowstorm and set 4 during cloudy weather; no direct sunlight either day; plants of set 1 watered the day before the test; the others, the morning of the test, but dry when treated; conclusions drawn after three days for the first set; after six days for the second and after nine days for the third and fourth sets.

	Set Numbers.			
	1	2	3	4
Time of exposure,	10.30	9.00	11.00	1.15
Length of exposure,	1.30 m.	1.30 m.	1 h.	1 h.
Temperature of house (degrees),	65	65	55	68
Humidity before (degrees),	62	55	65	57
Humidity after (degrees),	80	84	82	80
Livingston,	K	BI	BI	I
Lorillard,	K	BI	BI	I
Freedom,	K	BI	BI	I

Experiment V.

Night Exposures, December 13.

Fumigation with .005 gram KCN per cubic foot; plants six weeks old; house humidity, 60°; six hours of sunlight the day of treatment, but cloudy the previous week; weather cloudy during the treatment of the first three sets; moonlight during the other two; treatment began on set 1 as soon as it was really dark; plants watered at 9 A.M., dry when treated; half the plants of each variety had been placed under benches for thirty hours before treatment; conclusions drawn three weeks after treatment.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	5.25	7.10	8.00	9.00	10.00
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature of house (degrees),	66	66	66	65	65
Livingston normal,	N	N	N	SI	SI
Livingston under bench,	N	N	N	N	SI
Lorillard normal,	N	N	N	SI	SI
Lorillard under bench,	N	N	N	SI	N
Freedom normal,	N	N	SI	SI	SI
Freedom under bench,	N	N	N	N	N

In this experiment it would seem that plants which had been shaded for a time before the treatment, by being placed under the benches, were at a slight advantage.

Experiment VI.

Night Exposures, December 14.

Fumigation with .01 gram KCN per cubic foot; plants six weeks old; house humidity, 79°; five hours of sunlight the day of treatment; dark during treatment of first two sets, moonlight during the last three; treatment began on set 1 as soon as it was really dark; plants watered at 8.30 A.M., dry when treated; half the plants of each variety had been placed under the bench for twenty-four hours before treatment; conclusions drawn three weeks after the treatment.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	5.20	7.20	8.30	9.30	10.45
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature of house (degrees),	55	58	62	60	58
Livingston normal,	C	TI	C	C	K
Livingston under bench,	N	N	N	C	BI
Lorillard normal,	N	C	C	C	K
Lorillard under bench,	N	N	N	N	I
Freedom normal,	N	C	C	K	K
Freedom under bench,	N	N	N	N	BI

Experiment VII.

Night Exposures, December 15 and March 15.

Fumigation with .015 gram KCN per cubic foot; plants six weeks old; house humidity, 83°; dusk during treatment of first set, cloudy during second and third sets, starlight during the last three sets; plants watered at 8 A.M.; half of each variety sprinkled before treatment, the others dry; conclusions drawn one week after treatment for set 5, three weeks after treatment for the others.

	Set Numbers.					
	1	2	3	4	5	6
Time of exposure,	4.45	5.45	7.20	8.30	7.30	9.55
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.	2 h.
Temperature of house (degrees),	65	65	64	65	58	65
Livingston normal,	SI	N	SI	C	C	K
Livingston sprinkled,	N	SI	SI	C	C	K
Lorillard normal,	SI	SI	SI	C	C	K
Lorillard sprinkled,	N	SI	SI	C	C	K
Freedom normal,	N	SI	SI	C	C	K
Freedom sprinkled,	N	SI	SI	C	C	K

The sprinkled plants showed spots on the leaves where the drops of water stood, as a result of the treatment; otherwise little difference in the two lots was noticeable.

Experiment VIII.

Night Exposures, January 8.

Fumigation with .015 gram KCN per cubic foot; plants eight weeks old; house humidity, 84°; amount of sunlight that day, four hours; plants watered at 10 A.M., dry when treated; night cloudy during the treatment; conclusions drawn after one week.

	Set Numbers.	
	1	2
Time of exposure,	8.30	9.30
Length of exposure,	30 m.	45 m.
Temperature of house (degrees),	58	65
Livingston,	SI	SI
Lorillard,	SI	SI
Freedom,	SI	SI

Experiment IX.

Night Exposures, January 9.

Fumigation with .015 gram KCN per cubic foot; plants eight weeks old; house humidity, 49°; amount of sunlight that day, six hours; plants watered at 8 A.M., dry when treated; treatment during moonlight; conclusions drawn after one week.

	Set Numbers.		
	1	2	3
Time of exposure,	5.15	7.00	8.30
Length of exposure,	30 m.	45 m.	1 h.
Temperature of house (degrees),	58	68	65
Livingston,	SI	SI	C
Lorillard,	SI	SI	C
Freedom,	SI	SI	C

Experiment X.

Night Exposures, January 31.

Fumigation with .015 gram KCN per cubic foot; plants eleven weeks old, rather weak, tall and spindling; amount of sunlight that day, one hour; plants watered at 8.30 A.M., dry when treated; moonlight during the treatment; conclusions drawn after four days.

	Set numbers.	
	1	2
Time of exposure,	5.30	7.30
Length of exposure,	1½ h.	2 h.
Temperature of house (degrees),	62	62
Humidity before (degrees),	58	62
Humidity after (degrees),	76	76
Livingston,	C	I
Lorillard,	C	I
Freedom,	C	I

Experiment XI.

Night Exposures, December 16.

Fumigation with .02 gram KCN per cubic foot; plants six weeks old; house humidity, 63°; amount of sunlight that day, four hours; plants watered at 9.30 A.M., dry when treated, except that half of the plants of each variety were sprinkled just before the treatment; first set treated at dusk, other sets treated in starlight; conclusions drawn after three weeks

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	4.30	5.40	7.05	8.20	9.50
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature of house (degrees),	68	60	65	66	64
Livingston normal,	N	N	C	BI	BI
Livingston sprinkled,	SI	N	C	BI	BI
Lorillard normal,	N	N	C	BI	K
Lorillard sprinkled,	N	N	C	K	K
Freedom normal,	SI	N	C	K	K
Freedom sprinkled,	SI	N	C	K	K

The sprinkled plants developed spots on the leaves where the drops of water stood during the treatment.

EXPERIMENT XII.

Night Exposures, January 10.

Fumigation with .02 gram KCN per cubic foot; plants nine weeks old; house humidity, 61°; amount of sunlight that day, four hours; plants watered at 8 A.M., dry when treated; sets treated in moonlight; conclusions drawn after five days.

	Set Numbers.			
	1	2	3	4
Time of exposure,	7.15	8.15	9.15	5.05
Length of exposure,	20 m.	30 m.	45 m.	1 h.
Temperature of house (degrees),	65	67	67	65
Livingston,	N	SI	C	C
Lorillard,	SI	SI	C	I
Freedom,	SI	SI	I	1

EXPERIMENT XIII.

Night Exposures, January 12 and 13.

Fumigation with .02 gram KCN per cubic foot; plants nine weeks old; weather cloudy the day of treatment of first two sets, clear the day of treatment of the third set; plants watered at 8.30 to 9 A.M., dry when treated; first set treated at dusk, the other two in starlight; conclusions drawn after five days.

	Set Numbers.		
	1	2	3
Time of exposure,	5.30	7.30	7.25
Length of exposure,	1½ h.	2 h.	2 h.
Temperature of house (degrees),	60	62	65
Humidity before (degrees),	65	65	46
Humidity after (degrees),	80	80	77
Livingston,	SI	BI	BI
Lorillard,	SI	BI	BI
Freedom,	TI	BI	BI

Experiment XIV.

Night Exposures, December 18.

Fumigation with .04 gram KCN per cubic foot; plants six weeks old; house humidity, 82°; eight hours of sunlight the day of treatment; plants watered at 8.15 A.M., dry when treated; clear, starlight night during the treatment; set 4 fumigated twenty-five minutes, aired and then treated ten minutes longer; conclusions drawn after two and a half weeks.

	Set Numbers.			
	1	2	3	4
Time of exposure,	8.00	9.00	10.00	5.05
Length of exposure,	10 m.	15 m.	20 m.	35 m.
Temperature of house (degrees),	68	70	68	68
Livingston,	N	C	C	C
Lorillard,	TI	SI	C	C
Freedom,	TI	C	K	K

The Freedom plants in sets 3 and 4 were weak and not in good condition.

Experiment XV.

Night Exposures, January 11.

Fumigation with .04 gram KCN per cubic foot; plants nine weeks old; house humidity, 73° six hours of sunlight the day of treatment; plants watered at 8 A.M., dry when treated; first three sets treated in dim moonlight, set 4 at dusk; conclusions drawn after four days.

	Set Numbers.			
	1	2	3	4
Time of exposure,	7.05	8.00	9.30	5.00
Length of exposure,	20 m.	30 m.	45 m.	1 h.
Temperature of house (degrees),	65	65	65	60
Livingston,	SI	SI	SI	BI
Lorillard,	SI	SI	SI	BI
Freedom,	SI	SI	SI	BI

Experiment XVI.

Night Exposures for Temperature and Humidity, February 26, 27, 28, March 5, 6.

Fumigation with .01 gram KCN per cubic foot; plants about seven weeks old; first two sets treated in starlight, third and fourth on a cloudy night, fifth and sixth in starlight, seventh and eighth in moonlight, ninth and tenth in a darkened box at night; plants watered at 8.30 A.M., dry when treated; all the plants vigorous; conclusions drawn after nine days.

	Set Numbers.									
	1	2	3	4	5	6	7	8	9	10
Time of exposure,	7.15	8.15	7.00	8.15	7.00	8.20	7.15	10.00	7.00	9.30
Length of exposure,	45 m.	45 m.	45 m.	1 h.	1 h.	2 h.	2 h.	2 h.	2 h.	2 h.
High temperature (degrees),	68	64	-	-	-	-	-	67	-	63
Low temperature (degrees),	-	-	58	55	58	56	57	-	52½	-
Humidity before (degrees),	45	58	50	55	50	51	52	70	45	60
Humidity after (degrees),	65	75	64	67	74	63	59	80	65	77
Livingston,	SI	SI	SI	SI	C	C	C	C	C	C
Lorillard,	SI	SI	SI	TK	I	C	I	C	I	C
Freedom,	SI	SI	SI	I	TI	C	C	C	I	C

Comments and Conclusions.

BY H. T. FERNALD.

The experiments were planned so that only one factor should vary at a time. It quickly became evident, however, that many of the factors were beyond control, and therefore entire certainty as to the cause of differences in results could not always be obtained. Thus, the treatment itself had the effect of increasing the humidity of the fumigator, and sometimes this change was quite considerable.

Morrill's experiments on the white fly (Technical Bulletin No. 1, Hatch Experiment Station, Massachusetts, p. 50, 1903) indicated that fumigation with from .007 gram to .01 gram KCN per cubic foot for three hours should control most stages of this insect, and that three such treatments at intervals of about twelve days would probably clear an infested house. Hinds's experiments on Thrips (Bulletin No. 67, Hatch Experiment Station, Massachusetts, p. 11, 1900), though less complete, indicate that these insects would probably be also controlled by this treatment.

An examination of the first two experiments given in this paper shows at once that under the conditions stated serious injury or the destruction of the plants would result long before the above-named insects were killed, and a comparison of the data in Experiments II., V. and VI. indicates that daylight treatment was, at least in part, responsible for this. Fumigation in cloudy weather, as shown in Experiment III., sustains this view, the injury being less than with plants treated in sunlight. Experiment IV. gives the results of treatment during rain and snowstorms with longer exposure, showing that even in bad weather daylight treatment is unsafe.

Comparison of the experiments carried on at night is also suggestive. Those treatments which were made on moonlight nights were always more injurious than those made in starlight, while slightly better results were obtained on cloudy nights. From the data at hand it would seem probable that the safest treatment for the plants would be on a cloudy night following a dark day; and the night experiments with plants which had been kept under the benches for a day or so before treatment, thus giving them partial shade, sustain this view.

The results of variation in temperature of the house during fumigation were by no means as noticeable as had been anticipated; indeed, as a result of these tests it would seem to make little difference whether treatment should be given in a warm or a cool house. Much the same can be said of humidity, though here it would appear probable that with high humidity — 75 degrees or over — there is more chance of injury than would be the case where the humidity is rather low.

It may be stated as a general conclusion that prolonged exposures to weak strengths of the gas are more liable to cause injury to the plants than are shorter exposures to greater strengths. As this does not entirely meet Morrill's directions for the control of the white fly, which would come under the head of prolonged exposure to a rather weak strength of gas, it would seem desirable to determine whether short exposures to greater strengths would be effective against the insects. Until this is determined it is probable that the best treatment for the white fly on tomato plants is to fumigate them with a strength of .015 gram of KCN per cubic foot for a period of from forty-five minutes to one hour, on a dark — moonlight, or perfectly cloudy — night, in a house where the humidity is below 70 degrees at the beginning of the treatment. Fumigation in this way will probably slightly injure the plants and may cause curling of the leaves; but the injury will be less than would be that caused by the insects if there were no treatment given, and three such treatments at intervals of twelve days should not prove serious to the plants, while they should reduce the white fly to a negligible quantity for quite a period, — probably until after the crop has been gathered from the plants concerned.

II. CUCUMBERS.

BY CHARLES W. HOOKER, PH.D.

Introduction.

BY H. T. FERNALD.

The experiments on cucumbers which follow were made during the year 1907 by Dr. Charles W. Hooker as a portion of his graduate work at the Massachusetts Agricultural College. More time being available for the purpose than was the case with the tomato tests, it was possible to make the tests more exhaustive, but the general ideas were the same for both series of experiments.

The two most common varieties of cucumber grown under glass in Massachusetts were used, viz., Rawson's Hothouse and White Spine. The latter variety seemed, on the whole, to produce the better plants. Two plants of each variety were used for each test.

The supervision of this work fell upon the writer of this introduction, but the work itself, the daily care and observations were made by Dr. Hooker, and the conclusions drawn are mainly his. For some editorial work on all the parts the writer is responsible. Abbreviations indicating the results are the same as those used for the tomato, which are explained on page 215. All the plants used were watered the day of the experiment, but their leaves were dry in all cases unless otherwise noted.

Experiment I.

Day Exposures with Direct Sunlight, April 4.

Fumigation with .01 gram KCN per cubic foot; plants nine days old; amount of sunlight the day of treatment, ten hours; conclusions drawn after three days.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	9.00	9.25	10.00	10.50	12.00
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	94	94	108	107	115
Humidity (degrees),	47	40	41	45	47
White Spine,	N	BB	B	B	BB
Hothouse,	N	BB	VBI	BB	BB

It is evident that, under these conditions, treatment long enough to be of any value against insects would seriously injure the plants.

Experiment II.

Cloudy Day Exposures, May 6, 7.

Fumigation with .01 gram KCN per cubic foot; plants of sets 1 to 5, ten days old; of set 6, seventeen days old; no sunlight the day of treatment; conclusions drawn after one week.

	Set Numbers.					
	1	2	3	4	5	6
Time of exposure,	9.40	10.05	10.40	1.25	2.25	2.10
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.	2 h.
Temperature (degrees),	59	59	60	62	69	67
Humidity (degrees),	70	84	90	85	81	98
White Spine,	N	N	N	N	N	N
Hothouse,	N	N	N	N	N	N

A comparison of the last two experiments shows how much less sensitive cucumbers are in cloudy weather.

Experiment III.

Cloudy Day Exposures with Older Plants, April 26, 29, May 8, 16.

Fumigation with .01 gram KCN per cubic foot; sunlight a portion of each day, but not during treatment; plants watered the day before the treatment; conclusions drawn after one week.

	Set Numbers.						
	1	2	3	4	5	6	7
Age of plants (days),	45	45	48	48	48	31	41
Date of treatment,	April 26	April 26	April 29	April 29	April 29	May 8	May 16
Time of exposure,	8.30	8.55	8.05	8.45	9.45	9.00	9.30
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.	2 h.	2½ h.
Temperature (degrees),	70	75	73	73	72	74	61
Humidity (degrees),	73	76	74	79	79	94	98
White Spine,	N	N	N	N	N	N	K
Hothouse,	N	N	N	N	N	N	K

Experiment IV.

Cloudy Day Exposures with Stronger Fumigation, May 23, 27.

Fumigation with .015 gram KCN per cubic foot; plants of first two sets sixteen days old, fumigated May 23; of the other sets twenty days old, fumigated May 27; amount of sunlight the day of fumigating first two sets, seven hours; on day of fumigating the other three sets, none; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	8.40	9.15	8.25	9.30	2.30
Length of exposure,	20 m.	30 m.	45 m.	1 h.	1½ h.
Temperature (degrees),	56	71	60	61	60
Humidity (degrees),	86	78	95	92	89
White Spine,	N	N	N	SB	SB
Hothouse,	N	N	N	SB	SB

Experiment V.

Cloudy Day Exposures with Older Plants, April 30, May 3, 6.

Fumigation with .015 gram KCN per cubic foot; amount of sunlight April 30, six hours; May 3, seven hours; May 6, none; plants of sets 2 and 5 watered the day before treatment; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Age of plants (days),	38	41	41	41	44
Date of treatment,	April 30	May 3	May 3	May 3	May 6
Time of exposure,	9.30	8.00	8.35	10.00	8.15
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	73	65	72	57	59
Humidity (degrees),	80	97	97	93	90
White Spine,	N	N	SB	SB	SB
Hothouse,	N	N	N	SB	SB

Experiment VI.

Cloudy Day Exposures with Stronger Fumigation, May 16.

Fumigation with .02 gram KCN per cubic foot; plants nine days old; amount of sunlight the day of treatment, four hours; plants watered the day before treatment; conclusions drawn after one week.

	Set Numbers.			
	1	2	3	4
Time of exposure,	8.30	8.55	9.30	10.10
Length of exposure,	10 m.	20 m.	30 m.	45 m.
Temperature (degrees),	69	67	67	76
Humidity (degrees),	91	81	81	83
White Spine,	N	N	SB	K
Hothouse,	N	N	SB	K

Experiment VII.

Cloudy Day Exposures with Older Plants, May 8.

Fumigation with .02 gram KCN per cubic foot; plants forty-seven days old; amount of sunlight the day of treatment, eight hours; plants watered the day before treatment; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	8.25	8.35	9.15	10.00	11.00
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	63	64	66	63	63
Humidity (degrees),	90	84	88	91	87
White Spine,	N	N	N	SB	SB
Hothouse,	N	N	N	SB	SB

Experiment VIII.

Moonlight Night Exposures, March 20.

Fumigation with .01 gram KCN per cubic foot; plants eight days old; amount of sunlight the day of treatment, nine and a half hours; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	7.00	7.25	8.00	8.45	9.45
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	62	59	58	60	65
Humidity (degrees),	58	52	44	43	51
White Spine,	N	N	N	N	SI
Hothouse,	N	N	N	N	N

Experiment IX.

Moonlight Night Exposures with Stronger Fumigation, March 20, 21.

Fumigation with .015 gram KCN per cubic foot; plants eight days old; amount of sunlight the day of treatment of the first three sets, nine and a half hours; of the last two sets, eleven hours; slightly hazy the evening the first three sets were treated; conclusions drawn after two weeks.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	11.00	11.25	12.00	6.35	7.35
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	76	75	73	63	70
Humidity (degrees)	36	40	44	55	61
White Spine,	N	N	N	SI	SB
Hothouse,	N	N	N	SI	SB

Experiment X.

Moonlight Night Exposures with Stronger Fumigation, March 21, 22.

Fumigation with .02 gram KCN per cubic foot; plants nine days old; amount of sunlight the day of treatment of first four sets, eleven hours; of fifth set, five and a half hours; conclusions drawn after two weeks.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	8.30	9.15	9.50	10.35	6.45
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	69	68	66	64	64
Humidity (degrees),	51	54	59	54	64
White Spine,	N	N	SB	SB	B
Hothouse,	N	N	N	SB	B

A comparison of the last three experiments would indicate that, under these conditions, an increase of .005 gram KCN was about equivalent to fifteen minutes' exposure.

Experiment XI.

Starlight Night Exposures, April 3.

Fumigation with .01 gram KCN per cubic foot; plants eleven days old; amount of sunlight the day of treatment, twelve hours; conclusions drawn after one week.

	Set Numbers.		
	1	2	3
Time of exposure,	7.25	8.10	9.10
Length of exposure,	30 m.	45 m.	1 h.
Temperature (degrees),	64	62	62
Humidity (degrees),	58	65	66
White Spine,	N	N	N
Hothouse,	N	N	N

Experiment XII.

Starlight Night Exposures with Older Plants, May 21, 23, 24, 1907; May 4, 14, 1908.

Fumigation with .01 gram KCN per cubic foot; conclusions drawn after one week.

	Set Numbers.						
	1	2	3	4	5	6	7
Date of treatment, ...	May 21	May 21	May 23	May 24	May 4	May 4	May 14
Age of plants (days), ...	14	14	16	18	13	20	25
Time of exposure, ...	7.35	9.00	8.00	7.30	9.20	7.15	7.15
Length of exposure, ...	1¼ h.	1½ h.	1¾ h.	2 h.	1½ h.	2 h.	2 h.
Temperature (degrees), . . .	56	56	55	57	61	65	69
Humidity (degrees), ...	90	81	80	76	100	96	94
White Spine, ...	N	N	N	N	SB	SB	N
Hothouse, ...	N	N	N	N	N	SB	N

Experiment XIII.

Starlight Night Exposures with Still Older Plants, April 15, October 7, November 4.

Fumigation with .01 gram KCN per cubic foot; plants of first five sets, five weeks old; of the sixth and seventh sets, four weeks; of the eighth and ninth sets, thirty-two days; conclusions drawn after one week.

	Set Numbers.								
	1	2	3	4	5	6	7	8	9
Time of exposure, ...	7.10	7.35	8.10	8.55	9.55	6.30	8.15	6.30	8.45
Length of exposure, . . .	10 m.	20 m.	30 m.	45 m.	1 h.	1½ h.	1¾ h.	2 h.	2½ h.
Temperature (degrees), . .	63	63	59	60	62	61	66	56	53
Humidity (degrees), . . .	70	71	76	70	76	50	80	79	84
White Spine, ...	N	N	N	N	N	N	N	N	N
Hothouse, ...	N	N	N	N	N	N	N	N	N

Experiment XIV.

Starlight Night Exposures with Old Plants, May 20, 23, 31, June 7, 17.

Fumigation with .01 gram KCN per cubic foot; entire greenhouse full of plants used in each exposure; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Age of plants (days),	69	72	80	87	97
Time of exposure,	8.10	8.15	8.20	8.00	8.00
Length of exposure,	1 h.	1½ h.	1¾ h.	3 h.	3 h.
Temperature (degrees),	63	63	62	62	-
Amount of sunlight for day,	10 h.	3.8 h.	2.7 h.	6.8 h.	12 h.
White spine,	N	SB	SB	SB	SB
Hothouse,	N	SB	SB	SB	SB

Experiment XV.

Starlight Night Exposures with Stronger Fumigation, April 11.

Fumigation with .015 gram KCN per cubic foot; plants nineteen days old; amount of sunlight the day of treatment, eleven and a half hours; conclusions drawn after one week.

	Set Numbers.		
	1	2	3
Time of exposure,	7.00	7.45	8.45
Length of exposure,	30 m.	45 m.	1 h.
Temperature (degrees),	70	69	69
Humidity (degrees),	59	63	63
White spine,	N	N	N
Hothouse,	N	N	N

Experiment XVI.

Starlight Night Exposures with Older Plants or Longer Exposures.

Fumigation with .015 gram KCN per cubic foot; amount of sunlight May 13, nearly twelve hours; not taken on the other days; conclusions drawn after one week.

	Set Numbers.								
	1	2	3	4	5	6	7	8	9
Age of plants (days),	24	24	24	24	24	21	21	16	16
Date of treatment, .	May 13	May 13	May 13	May 13	May 13	Nov.11	Nov.11	Nov.12	Nov.12
Time of exposure, .	7.25	7.50	8.25	9.05	10.00	6.30	8.15	6.30	8.45
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.	1½ h.	1¾ h.	2 h.	1½ h.
Temperature (degrees), . . .	70	65	62	61	58	63	63	60	60
Humidity (degrees),	75	73	73	75	72	79	81	71	73
White Spine, . .	N	N	N	N	N	N	N	SB	SB
Hothouse, . . .	N	N	N	N	N	N	N	SB	SB

Experiment XVII.

Starlight Night Exposures with Still Older Plants, May 1.

Fumigation with .015 gram KCN per cubic foot; plants five weeks old; amount of sunlight the day of treatment, 8.7 hours; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure, ...	7.00	7.25	8.00	4.45	9.45
Length of exposure, ...	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees), ...	60	56	56	54	53
Humidity (degrees), ...	90	87	90	82	87
White Spine, ...	N	N	N	N	N
Hothouse, ...	N	N	N	N	N

Experiment XVIII.

Starlight Night Exposures with Old Plants, May 14.

Fumigation with .015 gram KCN per cubic foot; plants seven weeks old; amount of sunlight the day of treatment, 11.5 hours; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	7.15	7.35	8.10	8.55	9.55
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	68	65	60	59	59
Humidity (degrees),	78	71	83	84	84
White Spine,	N	N	N	N	N
Hothouse,	N	N	N	N	N

Experiment XIX.

Starlight Night Exposures with Stronger Fumigation, May 17.

Fumigation with .02 gram KCN per cubic foot; plants ten days old; amount of sunlight the day of treatment, 2.3 hours; night slightly hazy, with the moon in the first quarter; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	7.20	7.40	8.10	8.55	9.45
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	58	58	58	60	60
Humidity (degrees),	71	71	88	86	86
White Spine,	N	N	N	BB	BB
Hothouse,	N	N	N	BB	BB

Experiment XX.

Starlight Night Exposures with Older Plants, April 18.

Fumigation with .02 gram KCN per cubic foot; plants thirty-seven days old; amount of sunlight the day of treatment, twelve hours; slightly cloudy just at the beginning of the experiment; conclusions drawn after one week.

	Set Numbers.			
	1	2	3	4
Time of exposure,	7.00	8.25	9.10	10.10
Length of exposure,	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	65	63	63	65
Humidity (degrees),	71	71	80	76
White Spine,	N	N	N	SB
Hothouse,	SB	SB	SB	N

Experiment XXI.

Starlight Night Exposures with Stronger Fumigation, May 20, June 4.

Fumigation with .03 gram KCN per cubic foot; plants of first three sets, three weeks old, treated May 20; of last two sets, twenty-six days old, treated June 4; amount of sunlight May 20, 10 hours; June 4, 6.6 hours; small amount of moonlight during sets 1 and 4; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	7.35	8.55	9.50	8.00	9.00
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	56	54	52	65	62
Humidity (degrees),	75	88	82	83	80
White Spine,	SB	SB	B	BB	B
Hothouse,	SB	SB	B	B	B

Experiment XXII.

Starlight Night Exposures with Older Plants, May 28.

Fumigation with .03 gram KCN per cubic foot; plants thirty-two days old; amount of sunlight the day of treatment, 3.8 hours; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	7.30	7.55	8.30	9.10	10.10
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	54	50	52	54	55
Humidity (degrees),	90	95	85	89	83
White Spine,	N	SB	SB	BB	BB
Hothouse,	N	SB	SB	BB	BB

Experiment XXIII.

Starlight Night Exposures with Strong Fumigation, April 22.

Fumigation with .04 gram KCN per cubic foot; plants five weeks old; amount of sunlight the day of treatment, 11.5 hours; small amount of moonlight during the first three sets; moon and stars nearly obscured during the last two sets; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	7.00	7.25	8.00	8.45	9.45
Length of exposure,	10 m	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	81	68	67	65	65
Humidity (degrees),	63	72	78	78	72
White Spine,	N	N	BB	BB	BB
Hothouse,	SB	B	BB	BB	BB

Experiment XXIV.

Cloudy Night Exposures, April 8.

Fumigation with .01 gram KCN per cubic foot; plants two weeks old; amount of sunlight the day of treatment one-half hour; conclusions drawn after one week.

	Set Numbers.		
	1	2	3
Time of exposure,	7.05	7.50	8.50
Length of exposure,	30 m.	45 m.	1 h.
Temperature (degrees),	69	66	65
Humidity (degrees),	63	70	60
White Spine,	N	N	N
Hothouse,	N	N	N

Experiment XXV.

Cloudy Night Exposures with Plants of Various Ages, May 6, Nov. 19, 1907; April 27, 1908.

Fumigation with .01 gram KCN per cubic foot; no sunlight any of the days when treatment was given; conclusions drawn after one week.

	Set Numbers.						
	1	2	3	4	5	6	7
Age of plant (days),	10	10	10	10	10	33	16
Time of exposure,	7.00	7.25	8.00	8.45	9.45	9.10	7.00
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.	1½ h.	2 h.
Temperature (degrees),	57	56	54	56	57	69	75
Humidity (degrees),	91	89	91	88	88	72	91
White Spine,	N	N	N	N	N	N	BB
Hothouse,	N	N	N	N	N	N	BB

Experiment XXVI.

Cloudy Night Exposures with Stronger Fumigation, May 10, 1907; April 27, 1908.

Fumigation with .015 gram KCN per cubic foot; plants of first five sets, two weeks old; of sixth set, sixteen days old; amount of sunlight the day of treatment of the first five sets, 7.4 hours; not taken for the sixth set; conclusions drawn after one week.

	Set Numbers.					
	1	**2**	**3**	**4**	**5**	**6**
Time of exposure,	7.10	7.40	8.15	9.00	10.00	9.10
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.	2 h.
Temperature (degrees),	65	61	57	57	55	72
Humidity (degrees),	79	77	83	78	84	93
White Spine,	N	N	N	N	SI	BB
Hothouse,	N	N	N	N	SI	BB

Experiment XXVII.

Cloudy Night Exposures with Older Plants, April 16.

Fumigation with .015 gram KCN per cubic foot; plants five weeks old; amount of sunlight the day of treatment, 11.5 hours; conclusions drawn after one week.

	Set Numbers.				
	1	**2**	**3**	**4**	**5**
Time of exposure,	7.00	7.25	8.00	8.45	9.45
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	71	71	72	74	76
Humidity (degrees),	55	60	63	68	68
White Spine,	N	N	N	N	N
Hothouse,	N	N	N	N	SB

Experiment XXVIII.

Cloudy Night Exposures with Plants of Various Ages, April 25, May 13, 28.

Fumigation with .015 gram KCN per cubic foot; dim moonlight during treatment of the first three sets; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Date of treatment,	April 25	April 25	April 25	May 28	May 13
Time of exposure,	8.00	8.45	9.45	8.00	7.20
Length of exposure,	30 m.	45 m.	1 h.	1½ h.	2 h.
Temperature (degrees),	81	81	78	68	69
Humidity (degrees),	62	66	68	93	92
White Spine,	N	N	SB	SB	BB
Hothouse,	N	B	SB	SB	BB

Experiment XXIX.

Cloudy Night Exposures with Stronger Fumigation, May 15, Nov. 12, 1907; May 13, 1908.

Fumigation with .02 gram KCN per cubic foot; conclusions drawn after one week.

	Set Numbers.								
	1	2	3	4	5	6	7	8	9
Date of treatment,	May 16	May 16	May 16	May 16	Nov. 13	Nov. 13	Nov. 13	May 13	Nov. 19
Age of plants (days),	9	9	9	9	17	17	17	20	23
Time of exposure,	7.45	8.10	8.50	9.40	6.30	7.45	9.30	9.30	6.30
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.	1½ h.	1¾ h.	2 h.	2½ h.
Temperature (degrees),	66	63	63	61	58	58	56	66	71
Humidity (degrees),	90	90	91	95	74	56	76	95	73
White Spine,	N	N	N	N	N	N	N	K	BB
Hothouse,	N	N	N	N	N	N	N	K	BB

Experiment XXX.

Cloudy Night Exposures with Older Plants, April 26.

Fumigation with .02 gram KCN per cubic foot; plants five weeks old; amount of sunlight the day of treatment, five hours; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	7.00	7.25	8.00	8.45	9.45
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	64	62	63	68	74
Humidity (degrees),	75	73	80	72	72
White Spine,	N	N	N	N	N
Hothouse,	N	N	N	N	N

Experiment XXXI.

Cloudy Night Exposures with Still Older Plants, May 9, 13.

Fumigation with .02 gram KCN per cubic foot; plants of the first five sets, fifty-one days old; of sixth set, thirty-eight days old; conclusions drawn after one week.

	Set Numbers.					
	1	2	3	4	5	6
Time of exposure,	7.00	7.25	8.15	8.55	9.55	9.30
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.	2 h.
Temperature (degrees),	61	58	55	54	53	66
Humidity (degrees),	81	88	91	91	92	95
White Spine,	N	N	SI	SB	B	K
Hothouse,	N	N	SI	SB	B	K

Experiment XXXII.

Cloudy Night Exposures with Stronger Fumigation, May 27.

Fumigation with .03 gram KCN per cubic foot; plants twenty days old; no sunlight the day of treatment; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	7.15	7.40	8.15	9.00	10.00
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees)	60	60	59	62	58
Humidity (degrees),	95	95	94	85	88
White Spine,	N	SB	SB	SB	SB
Hothouse,	N	SB	SB	SB	SB

Experiment XXXIII.

Cloudy Night Exposures with Older Plants, April 19.

Fumigation with .03 gram KCN per cubic foot; plants thirty-eight days old; amount of sunlight the day of treatment, four hours; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	7.00	7.25	8.00	8.45	9.45
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	64	64	66	68	68
Humidity (degrees),	74	74	73	73	72
White Spine,	SB	N	N	N	N
Hothouse,	N	N	N	SB	N

Experiment XXXIV.

Cloudy Night Exposures with Strong Fumigation, March 23.

Fumigation with .04 gram KCN per cubic foot; plants eleven days old; amount of sunlight the day of treatment, ten hours; conclusions drawn after two weeks.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	6.55	7.25	8.00	8.45	9.45
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	73	68	65	66	67
Humidity (degrees),	60	62	60	59	61
White Spine,	N	SI	SB	BB	VBI
Hothouse,	N	SI	SB	BB	VBI

Experiment XXXV.

Cloudy Night Exposures with Electric Light, April 29.

Conditions in this series of experiments were about like those of the preceding set, except that a 16 candle-power incandescent bulb hanging near the fumigating box was left turned on during the exposures.

Fumigation with .01 gram KCN per cubic foot; plants thirty-seven days old; amount of sunlight the day of treatment, 4.6 hours; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	7.00	7.25	8.00	8.45	9.45
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	72	70	72	68	67
Humidity (degrees),	55	58	78	82	82
White Spine,	N	N	SB	BB	BB
Hothouse,	SB	N	N	BB	BB

Experiment XXXVI.

Cloudy Night Exposures with Electric Light, Stronger Fumigation, May 2.

Fumigation with .015 gram KCN per cubic foot; plants seven weeks old; amount of sunlight the day of treatment, 8.2 hours; conclusions drawn after one week.

	Set Numbers.			
	1	2	3	4
Time of exposure,	8.00	8.25	9.00	9.45
Length of exposure,	10 m.	20 m.	30 m.	45 m.
Temperature (degrees),	65	60	59	59
Humidity (degrees),	85	72	85	83
White Spine,	N	N	SB	SB
Hothouse,	N	SB	SB	SB

Experiment XXXVII.

Cloudy Night Exposures with Electric Light, Still Stronger Fumigation, May 7.

Fumigation with .02 gram KCN per cubic foot; plants seven weeks old; amount of sunlight the day of treatment, 3.1 hours; rather cloudy and with a heavy mist during the treatment of the first three sets; cloudy during the last two treatments; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	7.00	7.25	8.00	8.45	9.45
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	65	63	63	63	62
Humidity (degrees),	72	84	84	86	86
White Spine,	N	SI	SB	BB	BB
Hothouse,	N	SI	SB	BB	BB

From the last three experiments it is evident that even an electric light near the plants which are being fumigated has an effect upon them.

Comments and General Conclusions.

BY C. W. HOOKER.

1. Day fumigation in direct sunlight is unquestionably unsafe, as the plants are badly injured or killed.

2. Fumigation on a cloudy day is unsafe at best, the plants being generally more or less injured.

3. Fumigation on a bright moonlight night is also unsafe, often causing much burning of the foliage.

4. The best results are obtained by fumigating on clear starlight nights, with little or no moonlight, and on dry, cloudy nights.

5. A clear, dry evening without moonlight, with a temperature in the house of from 55 degrees to 65 degrees, or a cloudy evening with the same temperature, offer the best conditions for fumigation. This should be followed by a thorough ventilation for at least fifteen minutes, and the temperature should be kept rather low for twenty-four hours thereafter.

6. A general survey of the experiments seems to indicate that a small amount of KCN with a longer exposure is preferable, to a large amount for a shorter exposure.

7. Individual results obtained here and there in the course of these experiments which seem to contradict the others may, in general, be accounted for by the condition of the plants,

which frequently, at least, in such cases were not as vigorous as the others, though this was avoided whenever possible.

8. Comparison of the results of these experiments on cucumbers with those of Mr. W. V. Tower on tomatoes shows that the former are much the hardier, successfully resisting more cyanide and longer exposures.

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TWENTY-SECOND ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

PART II.,

BEING PART IV. OF THE FORTY-SEVENTH ANNUAL REPORT OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

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PART II.

GENERAL REPORT OF THE EXPERIMENT STATION.

CONTENTS.

PART II.

MASSACHUSETTS

AGRICULTURAL EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

TWENTY-SECOND ANNUAL REPORT.

PART II.

SUMMARY OF LEADING CONCLUSIONS.

WM. P. BROOKS, DIRECTOR.

The papers presented in this part of the report treat a wide variety of subjects. These will be found in the table of contents. Many of the articles are of such a character that it is impossible briefly to summarize them. The articles themselves are concise, and those interested in the subjects should refer to them. Some of the more important of the conclusions may be stated as follows: —

1. A combination of fine-ground bone and low-grade sulfate of potash appears to constitute a satisfactory fertilizer for apple trees. The low-grade sulfate is much superior as a source of potash to the muriate, and basic slag meal seems likely to prove well adapted for use in the apple orchard as a source of lime and phosphoric acid.

2. Dried beet pulp at prevailing prices is not an economical food. The farmer should make it a rule to produce starchy or carbohydrate feeds, rather than to purchase them.

3. Dried molasses beet pulp is a very palatable food for dairy stock. It seems to be nearly equal to corn meal in its value for such stock.

4. Beet residues should be moistened before being fed; but while their use may occasionally be necessary, it should be the rule to buy foods rich in protein whenever it is necessary to supplement home-grown supplies.

5. Beet leaves may be fed to dairy stock with fairly satisfactory results, and may be used either fresh or in the form of silage; but they should not be largely used as food for cows producing milk for infants.

6. The factors which enter into the cost of milk are stated, and estimates based upon them show that the cost may be expected to vary (according to the quantity of milk yielded by the cows) from 3.86 to 5.18 cents per quart. The food cost of milk produced at the station during two years has been from 3 to 3.3 cents per quart. If other items of cost are added, it is believed that the total cost has amounted to a little more than 5 cents per quart, and that the cost of producing milk satisfactory in sanitary quality, and containing from 4 to 5 per cent. of butter fat, will usually be found to amount to from 4 to 5 cents per quart.

7. The extravagant claims made for the condimental and medicinal stock and poultry foods are not justified by the facts. They possess neither the food nor medicinal value claimed for them. It is pointed out that the healthy animal does not need medicine, and that medicines should rarely be used without the advice of a competent veterinarian.

8. Figures showing the composition of peat are presented, and its value for composts, as an absorbent and for direct application to light soils is pointed out.

9. Among the principal causes of injury from spraying the following are the most important: improper preparation of the spraying fluid and the meteorological conditions. Injury is more likely when spraying is carried on in damp, cloudy weather than in bright, sunny weather.

10. Very many of the more serious greenhouse diseases appear to be caused by faulty environment. The most skillful growers avoid most diseases by suitable attention to the composi-

tion of the soil, temperature, light, ventilation, etc. Spraying is seldom necessary.

11. Calcium benzoate proves ineffective as a spray for the prevention of rot in plums.

12. Examination of a large number of commercial seeds shows that the percentage of impurities and weed seeds is relatively large. There appears to be danger that Massachusetts will become the dumping ground for inferior seeds, since most of the neighboring States have enacted seed laws.

13. Further experiments confirm the favorable estimate earlier formed as to the beneficial effects of separation of seed for the removal of impurities and light and imperfect seeds on the germination, size and vigor of the young plants.

14. Among the leading causes of sun scorch of the foliage of the white pine, frost injury to the feeding rootlets in winter, hot, dry weather and drying winds appear to be the most important; although burning of the foliage is occasionally due to the action of a fungus. The diseases affecting the pine do not appear to be as serious as has been often represented.

15. Among the insects which were most prominent during the season of 1909 may be mentioned the elm-leaf beetle, San José scale and various kinds of plant lice. The article on "Insects of the Year" calls attention to the introduction of the leopard moth, which promises to be a serious pest, and to the continued spread of the brown-tail moth. It calls attention further to the discovery of an egg parasite of the asparagus beetle, which it is hoped will prove of great assistance in checking the ravages of that insect.

WM. P. BROOKS,
Director.

MANURING AN APPLE ORCHARD.

BY WM. P. BROOKS, DIRECTOR.

This article is based upon the results of experiments on the station grounds originally planned by Dr. C. A. Goessmann, when director of the old State Experiment Station. They have been in progress for twenty years. The leading results and conclusions only will be presented; but in order that readers may have a basis for judgment as to their significance and value, a brief statement of the conditions and plan of the experiment must be given.

Location and Soil.

The orchard is located on a moderate and fairly uniform slope, lying just to the west of a forest composed chiefly of chestnut and hemlock which covers the northerly part of College Hill. The soil is a strong and retentive gravelly loam, with fairly compact subsoil. It was originally somewhat overmoist in some places. In preparation for the orchard tile drains were put in to carry off the excess of water. In preparing the area for the trees a catch-water was placed at the head of the slope, so that the orchard is protected from surface wash from higher land. There can be no doubt that the moisture conditions are exceptionally favorable, for the water absorbed by the forest soil on higher levels to the east must constantly work through the soil downwards towards lower levels, thus furnishing a constant supply of moisture to the roots of the trees.

The soil is of a character naturally well suited for apples, except that, in common with all the soils of this part of the State, it is naturally deficient in lime. It is, however, the type of soil commonly selected in almost all parts of the State as naturally well suited for fruit.

Plan of the Experiment.

The area originally included in the experiment was considerably larger than that now occupied by the apple trees. Pears, plums and peaches as well as apples were planted, but neither of the first three fruits did well. A considerable number of the trees died, and after a few years all were removed.

The area devoted to apples is divided into five plots, all equal in area (about one-third acre). The plots were laid out and manures and fertilizers applied in accordance with the plan adopted one year before the trees were set, in 1889, during which year a hoed crop was cultivated. Each plot contains twelve trees, three each of Gravenstein, Baldwin, Roxbury Russet and Rhode Island Greening. The trees were ordinary nursery stock, two years old, when set in the spring of 1890.

Fertilization.

Each plot has been continuously fertilized in the same way each year since the date (1889) above mentioned. The annual rates per acre are as follows: —

Plot.	Fertilizer.	Pounds.
1	Barnyard manure,	20,000[1]
2	Wood ashes,	2,000
3	Nothing,	-
4	Bone meal,	600
	Muriate of potash,	200
5	Bone meal,	600
	Low-grade sulfate or potash (sulfate of potash magnesia),	400

All manures and fertilizers have invariably been applied broadcast in early spring. They were mixed with the soil so long as the orchard continued under cultivation, but since it has been in grass they have necessarily been left upon the surface.

[1] About 3⅓ cords.

Care of the Trees.

The entire orchard was carefully cultivated for the first five years after the trees were set, the area between the trees being occupied by hoed crops. Since 1895 the orchard has been kept continuously in mixed sod, grasses and clovers, except that during the first few years after it was seeded small circles immediately about the trunks of the trees were kept free from grass by hand culture. The product was cut, usually twice each season, made into hay and removed every year until 1902, when the trees first bore a large crop of fruit.

In 1902 the first crop was made into hay and removed, but the second crop was cut and left upon the ground. This practice has been followed annually since 1902. In seasons when rainfall is normal we cut over the orchard twice with the mowing machine; but during the past two seasons, which have been exceptionally dry, a single cutting has appeared to be sufficient. The orchard has been well cared for as regards pruning and spraying. The San José scale, however, obtained a foothold in it in 1901. It was discovered before serious damage had been done, and annual thorough spraying in spring with the lime and sulphur mixture has been sufficient to protect it from any serious injury from this pest.

Condition and Size of the Trees.

The trees have maintained for the most part a thoroughly healthy and normal growth. They have broad, low heads, well adapted for modern orchard methods. One tree has been lost in each of two plots, — a Gravenstein in plot 1 and a Russet in plot 4. These trees were promptly replaced, but the young trees have not yet come into bearing. The trees of all varieties exhibit considerable individual variations in size within each of the plots. To what these differences are due it is impossible to say. Possibly it may be attributed to differing individual characteristics in the trees themselves, for, as has been stated, they were ordinary nursery stock, and not known to have come in the case of any of the varieties from scions from the same parent tree. Variations in the amount of fruit produced would undoubtedly affect the growth of the trees, while it is of course possible that variations in the soil are responsible for the differences in growth. In spite of the fact of these individual variations, the trees of any particular variety in a given plot exhibit a fair degree of uniformity, and the averages presented below afford a good indication of the relative effects of the different systems of fertilization followed.

Average Circumference of the Trees.

Autumn, 1909.

	Inches.
Plot 1,	38.25
Plot 2,	33.23
Plot 3,	27.98
Plot 4,	32.27
Plot 5,	37.02

Yields of Fruit.

As has been previously indicated, the first fairly full crop of fruit was produced in 1902. Since that date the amount of fruit in different years has varied quite widely. The Baldwins have usually exhibited a strong tendency to produce fruit only in alternate years, the other varieties producing more moderate crops, as a rule annually. The following tables exhibit the nature of the results: —

Total Yield of All Trees to Date, including 1909.

Plot.	Pounds of Fruit.	Equal to Barrels per Acre.
1	24,934	556.3
2	12,841	286.6
3	3,940	87.9
4	14,453	322.6
5	21,863	488.0

Total Yield to Date for Each Variety.

Plot.	Gravensteins.		Baldwins.		Russets.		Greenings.	
	Pounds per Plot.	Barrels per Acre.	Pounds per Plot.	Barrels per Acre.	Pounds per Plot.	Barrels per Acre.	Pounds per Plot.	Barrels per Acre.
1	3,644.25	325.4	7,060.0	630.4	6,190.00	552.8	8,185.0	730.8
2	1,905.00	170.1	3,197.0	285.4	3,827.00	341.7	3,893.5	347.6
3	999.25	89.2	564.5	50.4	1,281.00	114.4	1,086.0	96.9
4	3,578.25	319.5	1,962.5	175.2	5,272.75	470.8	3,674.5	328.1
5	2,996.50	267.5	9,174.0	819.1	6,341.25	566.2	3,822.0	341.3

Yields of Each Variety in 1909.

Plot.	Gravensteins.		Baldwins.		Russets.		Greenings.	
	Pounds per Plot.	Barrels per Acre.	Pounds per Plot.	Barrels per Acre.	Pounds per Plot.	Barrels per Acre.	Pounds per Plot.	Barrels per Acre.
1	1,179.75	105.3	2,590.0	231.3	1,719.00	153.5	2,157.0	192.6
2	284.00	25.4	695.0	62.1	547.00	48.8	1,165.0	102.2
3	223.75	19.9	132.0	11.8	90.00	8.0	140.0	12.5
4	1,217.50	108.7	682.0	60.9	991.00	88.5	604.0	53.8
5	1,189.50	106.2	2,443.0	218.1	1,172.00	104.6	1,087.0	97.1

Attention is called to the fact that while the total yield of fruit upon plot 5 is materially greater than on plot 4, the yield of Gravensteins on plot 5 is inferior to that on plot 4. This may be in part accounted for by the fact that the Gravenstein row in plot 5 stood on the southern edge of the plot and within a comparatively short distance of a well-grown forest. It is believed that these trees were somewhat injuriously affected for a few years; but in 1908 this forest was cut back to a sufficient distance from plot 5 so that it is believed that this influence can no longer prove harmful. It will be noticed that in 1909 the yield of Gravensteins on plots 4 and 5 was practically equal.

The Quality of the Fruit.

In color and general attractiveness of appearance the fruit of the several plots has usually ranked in the following order: plots 2, 5, 4, 1 and 3. In the early years of the experiment the rank of the fruit in size was in the order: plots 5, 4, 1, 2 and 3. At the present time the apples on plot 1 take a higher relative rank, and in all cases where the quantity of fruit is not excessive the apples on plot 1 are usually larger than on any of the other plots.

A number of tests of keeping quality have been made, and in this respect the fruit has usually ranked in about the following order: plots 5, 4, 1, 2 and 3. The relatively low rank of the fruit from plot 2 in keeping quality appears to be connected with the fact that this fruit comes to maturity earlier than that on the other manured or fertilized plots. It will be noted that the fruit from plot 2 ranks highest in appearance. This is due to its superiority in coloring. This in turn is undoubtedly connected with the fact that the fruit is somewhat more mature. Such fruit might undoubtedly be kept if promptly put into cold storage; but in ordinary storage it is considerably inferior to the somewhat less thoroughly ripened fruit on the other manured plots.

The fruit from plot 5 has almost invariably been much superior in appearance to that produced on plots 1 or 4. Here again there have been individual variations in the product of the different trees of the same variety on all of the different plots. There has, however, been no doubt as to the fact that on the whole the product of plot 5 has been considerably superior in color and general attractiveness as well as in firmness of flesh to the product from plot 4; while the product from plot 1, which receives barnyard manure, ranks below either of the others in the qualities just mentioned. In general, the fruit produced on plot 5 shows a considerably brighter and clearer color than that on either plots 4 or 1. There can be no doubt that it would sell at a higher price in the general market than either of the others, although the difference between plots 4 and 5 is considerably less than between plots 1 and 5. The product of the unmanured plot, 3, shows good color and in some cases is of fair size, but in general is too small to command the best prices.

The Results discussed.

The most significant result of the experiment is the superiority of plot 5 as compared with plot 4. Reference to the tables will show that the trees are much larger and that they produce a much greater amount of fruit. It will be noted that both have annually received equal amounts of bone meal, and, since muriate of potash contains practically double the amount of actual potash contained in the low-grade sulfate, and is applied in one-half the quantity of the latter, it will be seen that both have received annually practically equal amounts of actual potash (at the rate of 100 pounds per acre). These two plots, therefore, have received annually applications supplying equal amounts of the three most essential elements of plant food, — nitrogen, phosphoric acid and potash. There is, however, one important difference in the applications made to the two plots. The low-grade sulfate of potash contains a large amount of magnesia; muriate does not supply this element. Whether the superior growth and fruitfulness of the trees on plot 5 is due to the magnesia supplied we cannot, unfortunately, feel certain. We know, indeed, that magnesia is an essential element of plant food. It is, however, an element which ordinarily appears to be supplied in sufficient quantities from natural sources. It is of course possible that there may be a natural difference in the soil of the two plots, although this is not believed to have been the case; or that the sulphuric acid combination with potash (sulfate) is better suited to the trees than the hydrocholoric acid of the muriate.

Experiments upon a larger scale to test the questions raised by the result of this experiment are now in progress.

This experiment shows most decisively that apple trees must be fed to grow well and bear well. The inferior results obtained on plot 3, which has been unmanured throughout the entire period of the experiments, strikingly establishes this point.

The manure used in this experiment is undoubtedly furnishing too large a proportion of nitrogen. The growth of the trees is rank; the foliage is heavy; the fruit is overgrown, coarse and inferior in color. In this particular experiment the combination of bone meal with low-grade sulfate of potash has produced results which, on the whole, must be regarded as the most satisfactory.

Cost of the Fertilizers.

The prices of the different materials used in this experiment have been subject to some variation from year to year. On the average the total cost has been at the rate of about $12 per acre for the materials applied to plots 2, 4 and 5. Barnyard manure, which is a home product, may be variously estimated. If purchased, the quantity applied would have cost somewhat more than either of the combinations of fertilizers employed. It may be that the cost of the fertilizers used in this experiment is excessive. For the twenty years it would, of course, amount to a large sum per acre; but in this connection it should be kept in mind that the crops produced (hoed crops and hay) up to the year 1902 were probably sufficient to cover the cost of the materials applied. The weights of hay were not at first taken; but from 1897 to 1901 the total product of the five plots, 1⅔ acres, amounts to about 27 tons, which must have had a value, when standing, of at least $6 per ton, or a total value of $162. During these five years the value of the manure and fertilizers applied to the four plots amounted to about $28 annually, or $140 for the five years. On this basis the fertilizer cost appears to have been lower than the value of the hay crops. Certainly it will not be the opinion of those qualified to judge that the fertilizer cost is excessive for a bearing orchard. The product of single trees this year on each of the manured plots was worth more than the entire cost of the fertilizers applied per plot.

How an Orchard should be fertilized.

No one familiar with such matters will for a moment believe that any one selection of materials can always be best. Certainly the writer is not disposed to claim that he knows what is the best selection of materials. The combination of bone meal with low-grade sulfate of potash in this experiment has produced satisfactory results. It seems likely that in many cases similar results would be obtained. It is the writer's belief, however, supported not alone by his own work, but by results obtained by some well-known private growers, that on soils naturally deficient in lime, basic slag meal might wisely be used in place of the whole or a part of the bone. It should be remembered, however, that the bone furnishes some nitrogen as well as phosphate of lime, while basic slag meal contains no nitrogen. It does, however, supply lime in a considerably larger proportion than the bone, and this is likely to prove valuable on the class of soils under consideration. In some cases it might be advisable, in connection with basic slag meal and low-grade sulfate of potash, to give an occasional very light dressing of manure, to furnish nitrogen; although it is probable that by the introduction of a legume as a cover crop the necessary nitrogen may be obtained from the air.

Practical Suggestions.

For orchard top-dressing the following fertilizer formulas are recommended. In each case the amounts given are intended for an acre.

Formula.	Fertilizer.	Pounds.
No. 1,	Bone meal,	600–800
	Low-grade sulfate of potash,	350–400
No. 2,	Basic slag meal,	800–1,000
	Low-grade sulfate of potash,	350–400
No. 3,	Basic slag meal,	600–800
	Low-grade sulfate of potash,	300–350

The materials recommended should be mixed and applied in early spring. In the case of trees ten or more years of age the mixture should be applied broadcast, covering the entire surface, with the exception of circles about the trunks of the trees equal in diameter to one-third to one-half of the spread of the branches. There will be few feeding roots within such circles. The practice of piling manure or spreading fertilizers close to the trunks of trees is not to be recommended. Manure in contact with the base of the trunk increases the probability of injury from insects or vermin, and neither manure nor fertilizer so placed is in position to exert its fullest influence in feeding the trees.

Formula No. 1 is likely to prove most valuable on the lighter orchard soils. It supplies a little nitrogen, in which such soils are often deficient and which they have little capacity to hold. If these soils are deficient also in lime, as is likely to be the case, an application at the rate of 1,500 to 2,000 pounds per acre before the trees are set, and a further application at the rate of 600 to 800 pounds per acre once in five or six years, will prove useful.

Under this system clover will become abundant in the orchard kept in sod, while such cover crops as soy beans, vetches or clovers will thrive if tillage is practiced. Under either the sod or tillage system, therefore, a sufficient supply of nitrogen will be brought within the reach of the trees.

Formula No. 2 will prove well suited for use on the medium or heavy soils. It supplies no nitrogen, but creates soil conditions peculiarly favorable for the coming in of clovers in the sod, or nitrogen-gathering cover crops in tilled orchards. Under these conditions it seems likely that sufficient nitrogen will be brought within reach of the trees. If, however, the growth of the trees is not satisfactory, a small amount of nitrate of soda, 100 to 125 pounds, may be added.

Formula No. 3 differs from No. 2 only in supplying the slag and low-grade potash in smaller amounts. This formula is suggested for use in those cases where it is convenient and regarded as desirable to employ some manure in the orchard. It is not the writer's belief that it will usually pay to purchase manure for such use, but in so far as it is available as a home product its use in moderate quantities may be advisable. Manure, however, supplies nitrogen in relative excess for fruit trees. It seems wise, therefore, to supplement it with materials like slag meal and low-grade sulfate of potash, which will supply additional phosphoric acid, lime and potash. It is not the writer's belief that it will usually be best to use manure in top-dressing orchards in annual amounts in excess of about 1½ cords per acre.

Sod or Tillage.

The fact that the orchard in which the experiments upon which this article is based have been tried has been kept in sod since 1895 should not be regarded as indicating that the sod system is held to be always superior to the tillage system. Both systems have their advocates. The question whether sod or tillage is better cannot be regarded as settled; indeed, as an abstract question it never will be settled. Each has earnest advocates; but the fact undoubtedly is that neither system is always best. The best must vary with conditions. Neither system possesses all the advantages.

It is not proposed to enter upon a full discussion of the subject here, but simply to present such statements as seem necessary to guard against misunderstanding.

The experiments here reported do not directly bear upon the question. No comparison of the two systems has been made. It will be admitted that the trees in this orchard have made good growth and produced a fair amount of fruit. In estimating the significance of these facts the character of the soil must be kept in mind. It will be remembered that it is strong and retentive, and that the moisture conditions are good. Under such conditions, trees as well as grass find their need of water abundantly supplied.

Whether or not the trees will be abundantly supplied with moisture must, in the writer's judgment, determine in any particular case whether an orchard should be kept in sod. On the lighter or gravelly soils there is always danger that the grasses will rob the trees of needed water. It is an easy matter to supply plant food both for grass and trees, but not so with water. On soils inclining to be dry the moisture must be carefully conserved for the trees, and such tillage as will maintain a dust mulch during the spring and early summer (Hale's horse leg irrigation) is necessary for good results.

It is of course true that allowing the grass and clovers to remain on the ground when cut, as has been the practice in our experiments, will provide a partial mulch which will help retain moisture in the orchard soil; but, even if this course be followed, there is danger of water shortage at critical times in orchards upon light or gravelly soils with subsoils of open texture, provided they are kept in sod. This danger is much reduced if the grass produced in the orchard is gathered and spread under the trees, thus providing a heavy mulch; but, while this fact is everywhere admitted, a large proportion of the most progressive orchardists practice tillage in spring and early summer, sowing a cover crop in late summer to furnish organic matter and nitrogen, and in many cases to protect from injurious soil washing during the late fall, winter and early spring rains.

BEET RESIDUES FOR FARM STOCK.

BY J. B. LINDSEY.

1. Dried Beet Pulp.

Dried beet pulp represents the residue in the manufacture of sugar from sugar beets. It is first run through presses to reduce its water content as much as possible, and then put into kilns where it is thoroughly dried by direct heat.

Composition of the Product.

The prepared product is very dry, coarse and of a grayish color. It contains substantially 9 to 12 per cent. of water, about 4 per cent. of ash, 8 per cent. of protein, 18 to 20 per cent. of fiber, 60 per cent. of extract matter and less than 1 per cent. of fat. The fiber is quite soft, being free from incrusting substance and hence quite digestible.

Digestibility of the Dried Pulp.

No digestion experiments made in this country are recorded. German experiments show it to have a digestibility of 77 per cent.; corn silage made from mature dent varieties shows an average digestibility of 66 per cent.; and corn meal 88 per cent.

Dried Pulp as a Substitute for Corn Silage.

Wing[1] compared the wet pulp with corn silage, feeding 50 to 100 pounds daily, together with 8 pounds of grain and 6 to 12 pounds of hay, and concluded that the dry matter in the pulp was of equal value, pound for pound, with the dry matter found in the silage. The milk-producing value of wet beet pulp as it

[1] Bulletin, No. 183, Cornell Experiment Station.

comes from the factory [1] is, pound for pound, about one-half that of corn silage.

Billings [2] compared the dry pulp with corn silage, and concluded that the pulp ration gave 10.2 per cent. more milk than did the silage ration; but, because of the cost of the dried pulp, it was more economical to feed silage. In his trial the cows receiving the pulp ration lost in flesh.

The fact must not be overlooked that the dried pulp is a carbohydrate, similar in chemical composition to corn silage and corn meal. It is believed that 5 tons of silage is substantially equivalent in feeding value to 1 ton of the dried pulp. Putting the value of the 5 tons of silage at $20, the ton of pulp should be bought for the same money, whereas its present cost is some $26. It is believed, under present conditions, not to be good economy for farmers to buy pulp to be used in place of home-grown corn silage, the farm being the place for the production of carbohydrate food stuffs.

Beet Pulp as a Substitute for Corn Meal.

On the basis of digestible dry matter in dried pulp and corn meal, the former is worth 90 per cent. of the latter. According to Kellner the dried pulp has substantially 80 per cent. as much value as corn meal.

2. Dried Molasses Beet Pulp.

Beet pulp, after it has been pressed to remove the excess of water, is mixed with residuum beet molasses and the mixture put into driers where it is thoroughly dried by direct heat. This product, similar to the plain pulp, is quite dry, coarse, and resembles in its appearance ordinary black tea.

Composition and Digestibility.

The molasses beet pulp does not vary much in the percentages of the several fodder groups from ordinary pulp. It usually tests slightly higher in protein and ash and a little lower in fat.

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[1] Only those living in the immediate vicinity of the factory can afford to use the wet pulp. It is worth not over $2 a ton on the farm.

[2] Bulletin, No. 189, New Jersey Experiment Station.

The average of three analyses of molasses beet pulp made at this station is as follows: —

Composition.	Molasses Beet Pulp (Per Cent.).	Corn Meal for Comparison (Per Cent.).
Water,	8.00	14.00
Ash,	5.40	1.30
Protein,	9.50	9.80
Fiber,	15.40	1.90
Extract matter,	61.30	69.20
Fat,	.40	3.80

The pulp differs from corn meal in having rather more of its protein in the form of amids, in containing more ash and less fat. Its carbohydrates are in the form of fiber, gums and sugar, while the carbohydrate of corn meal is practically all starch.

Our own experiment [1] on the digestibility of the molasses beet pulp carried out with two sheep is the only one on record. It shows it to be 85 per cent. digestible, as against 77 per cent. for the plain pulp. These results, however, are hardly comparable, as the latter figure represents the average of German experiments. In any case the molasses pulp has a high relative digestibility, and is not very much inferior in this respect to corn meal.

Molasses Pulp for Dairy Stock.

Billings [2] compared the dried molasses beet pulp with the plain dried pulp, and secured a trifle more milk with the former. He likewise compared it with hominy meal, and secured some 4 per cent. more milk as a result of its use.

Our own experiment, made in 1903,[1] comparing it with corn meal, resulted in an increase of 5 per cent. of milk when the corn meal was used. It is believed, however, to be a satisfactory carbohydrate food, slightly superior in its nutritive effect, as well as in palatability, to the plain dried pulp.

[1] Bulletin 99, Hatch Experiment Station.
[2] Already cited.

3. How Beet Residues should be fed.

Dried beet pulp absorbs a great deal of water, and in case it is fed dry, this absorption will take place in the mouth and stomach, and is likely to cause choking, indigestion and stomach irritation. It should be first moistened with two to three times its weight of water, and the dry grain mixed with it.

Daily Grain Rations containing Dried Beet Residues.

(*a*) *Dairy Cows.*

I.	II.
3 pounds distillers' grains. 4 pounds dried plain or molasses pulp.	1.5 pounds gluten feed. 1.5 pounds cotton-seed meal. 4.0 pounds dried beet pulp.
III.	**IV.**
2 pounds gluten feed. 2 pounds flour middlings. 3 pounds dried beet pulp.	2 pounds wheat bran. 2 pounds cotton-seed meal. 4.05 pounds dried beet pulp.

(*b*) *To supplement Pasturage.* — By weight one-half of dried beet pulp and one-half gluten feed; or one-third dried beet pulp, one-third gluten feed and one-third wheat bran; or two-thirds beet pulp and one-third distillers' grains would prove desirable combinations (feed from 3 to 7 pounds daily depending upon requirements).

(*c*) *For fattening Stock.* — It should prove satisfactory for fattening beef animals, in the proportion, by weight, of two-thirds beet pulp and one-third cotton-seed meal. The material is hardly to be recommended for swine and horses.

The Place of Dried Beet Residues in the Farm Economy.

Farmers who are in position to produce their own feed cannot afford, as a rule, to purchase starchy feed stuffs; they should be produced upon the farm, in the form of corn, oats and barley. For milk production it is much more desirable to purchase materials rich in protein, such as cotton-seed and linseed meals, dried distillers' and brewers' grains, gluten feed, malt sprouts, fine middlings and even bran. These feed stuffs are not only very helpful in milk production, but likewise supply large amounts of nitrogen in the resulting manure. When the supply of home-grown corn is exhausted or limited, beet residues may be substituted for fattening stock and as one-third of the grain ration for dairy purposes. Milk producers who purchase all of their grain will find the dried pulp a satisfactory component (one-half) of the daily ration.

4. Beet Leaves.

Every autumn the station is in receipt of inquiries concerning the value of beet leaves for feeding purposes. In order to answer these inquiries the following information is submitted: —

Composition and Digestibility.

The leaves have the following average composition:[1] —

	Per Cent.
Water,	89.30
Ash,	1.80
Protein,	2.30
Fiber,	1.50
Extract matter,	4.70
Fat,	.40

From the above analysis it is evident that the leaves contain a great deal of water and on the basis of dry matter are relatively rich in protein and ash and poor in fiber. The leaves contain 20 to 37.7 per cent. of their nitrogen in the form of amids. The ash contains a large amount of oxalic acid (3.5 per cent. of the dry matter), and in the extract matter varying amounts of dextrose and lævulose have been recognized.

According to F. Lehmann,[2] sheep digest 61 per cent. of the crude protein, 52 per cent. of the fat and 75 per cent. of the extract matter.

How to feed the Leaves.

Beet leaves are best suited for dairy cows and for fattening cows and steers. They are less suited for young stock, swine, horses and sheep. Fed in too liberal quantities they have a decidedly laxative effect, and likewise cause indigestion. This is due to the oxalic acid and inorganic ash constituents. The same bacteria which in the paunch of the bovine produces lactic

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[1] E. Pott, Handbuch der Thier. Ernährung, etc. Zweite Auflage, II. Bd. S. 201.

[2] See E. Pott, already cited, p. 202.

acid act to an extent upon the oxalic acid and partially decompose it. It is advisable to feed not over 50 pounds daily of the green leaves to dairy cows, together with dry hay and grain. In case of cows that are near to calving one-half of this amount is preferable. It is stated that dry cows and thin steers will take larger amounts without bad effect.

German observers have found it helpful, in order to guard against the unfavorable action of the oxalic acid, to feed 1 ounce of precipitated chalk to every 50 pounds of leaves. It is not advisable to feed the leaves when the milk is intended for young children. Before feeding, the leaves should be made as free from soil as possible. This can in a measure be accomplished by shaking off the dirt with the aid of a fork, or by placing them in slatted drums or on sieves made of slats. It is not economical to wash them, as too much of the water-soluble nutrients is lost.

Beet leaves may be ensiled, and thus treated have been found to be less laxative in their effect. The oxalic acid is also partly decomposed. The leaves should be allowed to wilt, freed from excessive earth or sand, and then placed in pits in the earth or in ordinary wooden silos and thoroughly tramped. Excess of moisture is to be avoided. In case of necessity the leaves may be placed in small piles, and will keep very well for from one to two weeks. The ensiled material contains approximately 76 per cent. of water, and E. Wildt[1] has shown it to have the following percentages digestible: —

	Per Cent.
Protein,	65
Fat,	60
Extract matter,	54

It is not advisable to feed to cows over 25 pounds daily of the ensilage, together with hay, straw and grain. Larger amounts frequently act unfavorably on the animal, and are likely to produce a strong taste in the milk. German authorities are inclined to prefer the ensiled to the fresh leaves, especially if the latter are at all frosted or decayed.

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[1] *Loco citato*, p. 207.

THE COST OF PRODUCING MARKET MILK.

BY J. B. LINDSEY.

It is impossible to determine just how much it costs to produce a definite amount of milk, as so many factors enter into the problem. Among such factors may be mentioned fertility of the farm, skill in management, kind of buildings and utensils employed, quality and care of dairy stock and care of the resulting product. It is the belief of the writer that in the past a great deal of milk has been made and sold for less than the cost of production. In making an attempt to gain a temporary livelihood from dairying, many have sacrificed the fertility of their farms, employed the most primitive methods of housing and caring for the dairy stock, and the family has cared for the milk and for the dairy utensils without credit. Now that the health authorities are demanding better dairy methods, the dairyman is indeed confronted with a serious problem, namely, how can he conform to these requirements, and produce milk at a reasonable profit? The writer sees no way out of the dilemma other than to teach the public to appreciate the highly nutritious character of milk, and to educate it to pay a price commensurate with the increased cost of producing a reasonably sanitary article. An attempt has been made, in the figures which follow, to estimate the cost of producing a definite amount of milk containing 4 per cent. of butter fat, which will meet the ordinary requirements of the city boards of health. The figures per quart mean the wholesale price at the farm, and do not include profit to the producer, other than the fact that he sells all of his roughage and whatever grain he may produce upon his farm at market rates. If he cares for his own cattle, he is allowed a reasonable compensation. It would probably be no more than fair to add to the cost per quart 10 per cent. for actual profit. In order to determine the retail price to the consumer, the cost of delivery to wholesale centers as well as the cost of retail distribution should be added.

Estimated Cost of Milk Production per Cow.

Basis 20 Cows.

1. Building for housing cow and feed (per cow),	$75 00	
Interest, taxes, depreciation, repairs and insurance, 10 per cent.,	–	$7 50
2. Value of cow,	75 00	
Interest and taxes, 6 per cent.,	–	4 50
Depreciation, 20 per cent.,	–	15 00
3. Value of carpenter's tools (per cow),	80	
Interest and depreciation, 15 per cent.,	–	12
4. Value of barn tools (per cow, — farm scale, shovels, forks, trucks for grain, manure, etc.),	2 28	
Interest and depreciation, 15 per cent.,	–	34
5. Value of dairy implements (per cow, — milk pails, scale, Babcock tester, strainers, hot water heater, cleaning brushes, etc.),	3 35	
Interest and depreciation, 15 per cent.,	–	50
6. Value of perishable tools and supplies (per cow, cards, brushes, record sheets, soap, salt, ice, bedding, bull service, veterinary, etc.),	–	11 86
7. Value of food consumed for one year: —		
40 pounds of silage daily for 224 days (7½ months), at $3.75 a ton,	16 80	
12 pounds of hay daily for 224 days (7½ months), at $17 a ton,	22 85	
8 pounds of grain daily for 224 days (7½ months), at $32 a ton,	28 67	
20 weeks' pasturage, at 30 cents per week,	6 00	
One-third cost of food (basis of winter feeding) while at pasture,	14 93	
		89 25
8. Care of cow and milk for one year,		30 00
		$159 07

Credits.

5 cords manure,	$20 00	
1 calf each year,	2 00	
		22 00
Net cost of one cow for one year,		$137 07

Cost of Milk per Quart.

$137.07 ÷	2,660 quarts	(6,000 pounds)	= 5.15	cents per quart.
137.07 ÷	2,930 quarts	(6,500 pounds)	= 4.68	cents per quart.
137.07 ÷	3,100 quarts	(7,000 pounds)	= 4.42	cents per quart.
137.07 ÷	3,330 quarts	(7,500 pounds)	= 4.12	cents per quart.
137.07 ÷	3,550 quarts	(8,000 pounds)	= 3.86	cents per quart.

It must be remembered that the above figures are intended only as an estimate. The value of the barn for housing 20 cows is estimated at $1,500; some may consider this a low estimate, others a high one. The cost of food for one year is intended for cows weighing from 1,000 to 1,200 pounds and producing at least 7,000 pounds of milk yearly. The food cost for smaller cows, weighing 750 to 900 pounds and producing 6,000 pounds of milk, would be $6 to $8 less.

The care of the cow and the milk for one year has been estimated by different individuals at from $18 to $45. It is believed that $30 represents a fair average.

It will be noted that the food is by far the largest cost item. Thus, the food is estimated at $89.25 and the other expenses at $47.82, after an allowance of $22 for manure and calf. Otherwise expressed, the housing and care of the animal and its products represents substantially 50 per cent. over the cost of food. The figures show that the cost of producing a quart of average milk varies from substantially 4 to 5.15 cents.

Food Cost of Milk produced by Station Herd.

The station keeps from ten to twelve cows, mostly pure-bred or grade Jerseys, for the purpose of carrying out a variety of experiments in studying the value of different foods for milk production, and for noting the effect of foods upon the composition of milk and butter fat. An exact record of the cost of the milk produced by this herd has been kept since 1895. In this connection a résumé of the record is presented for the years 1907 and 1908. At this writing the 1909 cost has not been tabulated.

1907.

No. of Cows.	Total Yield (Pounds).	Per Cent. Fat.	Per Cent. Solids.	Cost of Food consumed.	Cost of 100 Pounds of Milk.	Cost of 1 Quart Milk (Cents).
12	56,492.0	5.37	14.85	$766 01	$1 44	3.2
7[1]	41,120.9	-	-	547 35	-	3.0

1908.

No. of Cows.	Total Yield (Pounds).	Per Cent. Fat.	Per Cent. Solids.	Cost of Food consumed.	Cost of 100 Pounds of Milk.	Cost of 1 Quart Milk (Cents).
12	64,238.6	5.00	13.98	$932 74	$1 45	3.30
9[1]	50,755.6	4.98	13.91	739 85	1 46	3.30

During each year twelve cows were kept, but only seven and nine respectively remained during the entire year. The average yield per cow for the seven cows in 1907 was 5,874.4 pounds, the food cost per cow was $78.19 and the cost of a quart of milk 3 and 3.2 cents. In 1908 the yield per cow in case of nine cows was 5,639.5 pounds (2,564 quarts), the food cost per cow $82.21 and the food cost per quart of milk 3.3 cents. It will be remembered that these were grade and pure-bred Jerseys, producing 5 per cent. milk. Seven of the cows were pastured about two months each, *i.e.,* during the time they were dry. The remainder of the summer they, in common with the others which did not go to pasture, were fed hay, soiling crops and grain. It was obviously not possible for us to keep an exact record of the cost of care of cow and milk, for the reason that these animals were not kept for producing market milk, but for experimental purposes.

If to the yearly cost of food ($82.21) is added $47.82, representing the estimated cost of housing and caring for the animal and her product,[2] we have $130.03, which, divided by the number of quarts of milk produced (2,564), gives 5.07 cents as the cost of one quart of 5 per cent. milk. Another way of getting at substantially the same result is to add 50 per cent. (representing the cost of housing and care) to 3.3 cents, the food cost of a quart, which makes 4.95 cents, or, in round numbers, 5 cents. The general statement may be made that it is

[1] Kept during the entire year.

[2] $39.82 + $30 = $69.82 — $22 = $47.82. (See previous page.)

likely to cost the average producer from 4 to 5 cents a quart to produce milk of satisfactory sanitary quality, testing from 4 to 5 per cent. of butter fat.

Milk produced under more than average sanitary conditions, or certified milk, will naturally cost considerably more than the figures presented in these estimates.

CONDIMENTAL AND MEDICINAL STOCK AND POULTRY FOODS.

BY J. B. LINDSEY.

Several years ago the station made quite an exhaustive study of the composition of this class of feeds, and published its results in Bulletin No. 106, the edition of which has long since been exhausted. It is intended in what follows to give a résumé of the most important points made in the bulletin, in order to answer the frequent inquiries which come to the station concerning them.

It is not thought advisable to publish in this connection the detailed composition of each brand as it was given in the bulletin, as it may have been modified to some extent since the examination was made. It is believed, however, that the following statements will prove sufficient to enable every one to form a correct opinion concerning their general character, commercial value and utility.

Basic or Food Ingredients.

The chemist and microscopist have found these foods to consist principally of ordinary grains and concentrates, such as wheat by-products (bran and middlings) and corn meal. In some cases a few hundred pounds to the ton of linseed, cottonseed and occasionally meat and bone meal have been added, obviously to increase the amount of protein; such mixtures contained from 10 to 20 per cent. of that nutrient. Occasionally the presence of considerable quantities of mustard hulls, cocoa shells and weed seeds are noted, used evidently as a filler.

The poultry foods more frequently reveal the presence of from 10 to 50 per cent. of ground oyster shells or noticeable quantities of ground bone, which accounts for the exceptionally high ash percentage.

Nutritive and Commercial Values of the Food Ingredients.

It having been shown that the bulk of these foods is made up of ordinary ground grains and by-products, it must be evident to all that they cannot have a greater nutritive value than is to be found in the materials of which they are composed. The extravagant claims made by the manufacturers concerning their wonderful nutritive properties is in no way substantiated by the analytical results. It also must be clear that their commercial value from a nutritive standpoint cannot exceed 1 to 1½ cents a pound. Certainly no one would entertain the idea of purchasing these mixtures, at the prices asked, because of any particular nutritive value they may possess.

CHARACTER OF MEDICINAL INGREDIENTS.

In addition to the various cereals and by-products, these foods contain small quantities of a variety of substances, most of which possess simple medicinal qualities, to which it is understood is attributed the wonderful nutritive and curative properties claimed for them. The *condition powders,* so called, generally contain larger quantities of these medicines than the stock and poultry mixtures. The medicinal substances are described as follows: —

Fenugreek and *fennel* are the ground seeds of plants grown in southern Europe, known botanically as *Trigonella Fœnum Græcum* and *Fœniculum vulgare.* They are aromatic substances, used to excite the action of the stomach, thereby relieving indigestion and gas, and also to impart an agreeable flavor. It was formerly believed that fenugreek increased the quantity and improved the quality of milk, but such ideas are now largely exploded. The quantity used is comparatively small.

Anise or Aniseed (*Pimpenella Anisum*) is the seed of a plant cultivated in Spain and Malta. It has a pleasant warm taste and an agreeable odor, and is used for much the same purpose as fenugreek.

Gentian, occasionally recognized, is the dried root of the plant known as *Gentiana lutia,* and is grown in central and southern Europe. It is very bitter, and is used as a stomach tonic, promoting an increased secretion of the gastric juice.

Ginger is the powdered underground stem of *Zingiber officinale,* grown principally in India and the West Indies. It stimulates the various membranes with which it comes in contact, and is used as an appetizer and to reduce the griping effects of purgatives.

Pepper, the common black form, is obtained from the brown berries of an East India climbing plant, *Piper nigrum.* Cayenne pepper consists of the dried ripe fruit of *Capsicum fastigiatum* and *annum.* Both kinds are used as a stomachic and to increase the activity of the reproductive organs.

Salt, of which many of the mixtures contained from 2 to 20 per cent., was used as an appetizer.

Sulfates of magnesia and soda, in the form of Epsom and Glaubers salts, are purgatives, and are frequently spoken of as "salts."

Saltpeter, nitrate of potash or niter, is used in medicine to excite the action of the kidneys and to reduce fever.

Sodium bicarbonate is employed to neutralize an undue acidity of the stomach.

Sulphur is used as a laxative, alterative, and as a stimulant of mucous surfaces.

Iron found as the oxide — Venetian red or Princess metallic[1] is not used medicinally, but is employed to color or disguise the real character of the food. Sulfate of iron used as a restorative and tonic was seldom identified.

Charcoal. Its medicinal value consists in its ability to check fermentative changes, and to absorb undesirable gases. In most cases it appears to have been ground fine and mixed with the other ingredients to conceal their identity.

Tumeric, the powdered root of an East Indian plant, the *Curcuma longa,* is a stomachic, but is used principally as coloring matter.

Quantity of Medicinal Ingredients.

No attempt was made to determine the exact quantity of each of the several drugs employed. Most of the foods contained from 5 to 40 per cent. of ash. Ordinary grains and by-products rarely contain more than 5 per cent. of ash; the excess in the

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[1] Dry paints.

present cases was made up of such mineral substances as oyster shells, bone, sand, common salt (2 to 20 per cent.), Epsom or Glaubers salts (about 5 per cent.), niter (1 or more per cent.) and Venetian red. The vegetable drugs — fenugreek, fennel, anise, gentian, ginger and pepper — were employed in sufficient quantities to produce an agreeable odor and smart taste, probably in quantities varying from 5 to 10 per cent. of the whole mixture. In some cases the total quantity of mineral and vegetable drugs constituted from one-sixth to one-third of the mixture, while in other cases the amount of such substances was very much less.

Cost and Selling Price compared.

None of the mineral drugs, excepting niter, cost much over 1 cent a pound; the vegetable drugs vary in price from 3 to 12 cents a pound. Judging from all the data at hand, the cost of the entire mixtures — grains and drugs — could rarely have exceeded 3 to 4 cents a pound. In many cases it could not have been more than 2 cents a pound.

The initial cost of the condition powders is probably somewhat greater than the ordinary stock foods. The retail prices of the latter vary from 6 to 25 cents a pound, depending on the brand and quantity purchased. Condition powders are much higher priced, varying from 30 cents to $1 a pound. Is it not strange that many are willing to pay extravagant prices for materials possessing such ordinary feeding and medicinal values? It is hoped that poultrymen have sufficient common sense to purchase bran, corn meal, salt, oyster shells, charcoal and meat scraps separately, rather than pay from 10 to 20 cents a pound for such mixtures put up in attractive packages, for which the manufacturers make the most astounding and unreasonable claims.

Utility of these Foods.

Their food value cannot be greater than the ordinary grains, of which they are largely composed. Their medicinal value depends largely upon the aromatic seeds and roots used as a tonic for the stomach, on charcoal as an absorbent and on the purgative effect of the Epsom or Glaubers salts. The quantity recommended to be fed daily is usually so small (1 ounce or less) that very little if any effect can be expected unless the material is fed for a considerable length of time. While it is probably true that some of these stock foods may prove beneficial under certain conditions, it is also true that most of them are heterogeneous mixtures, and evidently put together by parties quite ignorant of the principles of animal physiology, pathology and veterinary medicine.

Claims made by Manufacturers.

The following are the principal claims made by one of the largest manufacturers of stock and poultry foods: —

Horses. — Gives greater speed endurance. Imparts new life and strength. Makes colts grow very rapidly and keeps brood mares and colts healthy. Guaranteed to save corn and oats. Makes horses fat, gives glossy coat and fine appearance.

Cattle. — Increases the milk yield 15 to 25 per cent. and increases the richness of the milk. Removes taint from milk, cream and butter, and makes milk more healthful for human use. Such milk will convey some of the beautiful elements of the vegetable ingredients we use into the systems of your children, and they will be stronger to ward off disease. Makes calves grow as fast as new milk. Saves thirty days' time in fattening cattle, and 15 to 25 per cent. of the grain usually required.

Hogs. — Cures and prevents hog cholera, and is the quickest hog grower ever discovered. Makes juicy and tender meat.

Poultry. — It prevents disease and cures chicken cholera. It greatly increases egg production and makes chickens grow very rapidly.

The amount advised to be fed daily to horses and cattle to accomplish these marvelous results is two-thirds of an ounce! The material costs 14 cents a pound in 25-pound lots.

The Connecticut, Pennsylvania, Rhode Island, Virginia, Iowa, South Dakota and Massachusetts stations have found this stock food to consist principally of wheat (bran and middlings), to which has been added fine charcoal, a bitter substance resembling gentian, cayenne and common salt. Another large manufacturer makes essentially the same claims as above, and the material sells at 6 cents a pound in 25-pound lots. The same experiment stations found it to be composed largely of corn meal, with small quantities of fenugreek, gentian, charcoal and salt.

Farmers, dairymen and poultrymen: What would be your opinion of any experiment station worker who would make such statements concerning the nutritive, medicinal or commercial value of corn meal, wheat bran, charcoal, gentian and salt? Do you think there is any humbug in the claims made by the manufacturers of such goods? *The question is left for you to decide. You may be the judge.*

Do Healthy Animals need Medicine?

Dr. Paige, the veterinarian at this college, very pointedly expresses the most advanced views of the profession when he says, "Animals in a state of health do not need condition powders or tonic foods. There is in the body of a healthy animal a *condition of equilibrium of all body functions.* The processes of digestion and assimilation are at their best. All that is required to maintain this condition of balance is that the animal be kept under sanitary conditions, and receive a sufficient supply of healthful, nutritive food and pure water. While tonics may improve the appetite so that the animal will temporarily consume and digest more food, should this increased quantity of nutrients consumed not be appropriated by the tissues of the body, harm may result from thus overloading the lymphatic system, or from an increased action of the excreting organs."

Treatment of Sick Animals.

The writer believes it unwise to give drugs to animals when it can possibly be avoided. Even such simple substances as "salts," ginger, gentian and the like should be used as sparingly as possible. If an animal is out of condition, and it is believed a tonic will be helpful, try the following, suggested by Bartlett of the Maine station: "pulverized gentian, 1 pound; pulverized ginger, ¼ pound; pulverized saltpeter, ¼ pound; pulverized iron sulfate, ½ pound. Mix and give one tablespoonful in the feed once a day for ten days, omit for three days, then give ten days more. Cost of the above, 20 cents a pound."

In exceptional cases, when skilled medical treatment appears absolutely necessary, it is far wiser to employ a reliable veterinarian than to attempt home doctoring by the indiscriminate use of patent medicines or powders recommended to cure everything.[1]

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[1] This bulletin does not decry the various veterinary medicines put up by pharmacists and veterinary surgeons for the use of stockmen. The claims made for them are, as a rule, quite reasonable, and they unquestionably have their proper sphere of usefulness.

THE UTILIZATION OF PEAT IN AGRICULTURE.

BY H. D. HASKINS.

Peat is composed largely of partially decomposed vegetable matter. In its natural condition, when found in the swamp, it is very dark or nearly black in color and contains about 80 to 90 per cent. of water. The limited use of peat dates back many years, before the introduction of the commercial fertilizer, but in the early history of its use little was known regarding its chemical composition. It was used as a supplement to farmyard manure and to improve the mechanical condition of light, sandy and gravelly soils. If we should measure the value of peat for agricultural purposes from the standard of a chemical analysis, the standard by which the worth of all commercial manurial substances is established, we would find that its greatest value lies in its organic nitrogen-containing constituents, which means the organic combinations commonly known as humus.

During the past fifteen years there have been many analyses of peat made at this laboratory. These analyses, 55 in number, and representing products from every county in the State, have been averaged, and will serve to illustrate fairly well the chemical composition of the peats found in Massachusetts. A discrimination has been made between peat and muck samples; those containing a relatively high percentage of insoluble matter or ash, and which are commonly known as muck deposits, have been excluded from the average.

Average Chemical Composition of 55 Samples of Peat made at the Massachusetts Experiment Station Laboratory.

Moisture,	60.85
Dry matter,	39.15
	100.00

100 parts of dry matter contain: —

	Parts.
Organic matter,	58.00
Nitrogen,	2.19
Ash,	28.12

100 parts of peat ashes contain, on the average: —

	Parts.
Potassium oxide,	.44
Phosphoric acid,	.99
Calcium oxide,	2.53
Silicious material soluble in dilute hydrochloric acid,	88.12

There can be only a very small agricultural commercial value to the mineral constituents found in peat, as may be seen by the small amount of potash, phosphoric acid and lime given in the average analyses. The greater part of the ashes of peat is composed of insoluble silicious material possessing little or no value as plant food. The commercial value of the potash, phosphoric acid and lime in 1 ton of peat ashes, provided they were all in a highly available form, which is probably not the case, would be less than $2. It might be mentioned in this connection that it would take 7,115 pounds of peat of the above composition to make 1 ton of ashes. If peat has any pronounced value as a fertilizer, therefore, it must lie in the organic portion, — that portion which contains the humus and nitrogen.

In selecting the most valuable peat for fertilizing purposes we would, therefore, choose the product which contains the smallest amount of mineral matter; in other words, that portion that appears to be purely organic vegetable matter. In this connection a question suggests itself to the mind: is there any difference in the availability of the nitrogen contained in peat taken from various depths? Upon first thought one would expect that the lower layers of peat would be in a more advanced state of decomposition, and its nitrogen would, therefore, be more available. Several years ago the writer was able to make an interesting experiment regarding the availability of the nitrogen in peat taken at various depths. The samples were procured from a deposit averaging about 5 feet deep. One sample was taken from the first 18 inches of the surface layer, the intermediate layer was sampled between 18 inches and 3 feet below the surface, and the lower layer was sampled at a depth of 3 feet. A fourth sample was procured from the same locality, but was taken from a pile of air-dried peat which had been excavated several months previous and had been allowed to lie exposed to the oxidizing agencies incidental to the weathering process.

The table of analyses has been prepared on the basis of 100 parts of dry matter, the method used for the determination of the availability of the nitrogen being the alkaline permanganate method.

Peat.	Total Nitrogen.	Per Cent. of Nitrogen Available.
Weathered peat,	1.72	28.4
Top layer (first 18 inches),	2.29	28.3
Intermediate layer (18 inches to 3 feet),	1.83	26.2
Lower layer (below 3 feet),	1.25	23.2

In case of the samples examined it will be seen that the lower layers contained less nitrogen, which was probably rather less available than that in the upper layers. It may be seen, further, that the weathered peat, although showing a smaller nitrogen content than even the intermediate layer, apparently has a slightly higher availability. These results seem to me very significant. The weathered sample was a mixture of the peat taken from the same locality to a depth of from 4 to 5 feet, and yet we find that it leads in the availability of its nitrogen. This indicates the possible beneficial effect of the weathering or oxidizing process.

It should not be understood that the above figures represent the actual amount of nitrogen in the peat that is immediately available as plant food. There is no certainty that laboratory methods accurately indicate availability. They are as yet arbitrary, and much work needs to be done along the lines of vegetation experiments before we can definitely say just how much of the nitrogen in any organic substance is available as plant food. The results, however, are comparative.

Peat is found in such immense quantities and is so widely distributed throughout the country that it may not be out of place to give it a careful study from an economical standpoint.

We should realize that it is not the nitrogen alone that gives peat or any other organic manurial substance its superior value as a fertilizer. We depend upon these substances to furnish valuable organic matter and humus, without which it is impossible to successfully grow a crop, even with the most concentrated mineral fertilizers. We depend upon these substances further to improve the mechanical condition of soils, to make the heavy compact clay soils more open and porous, and to make the light sandy soils more retentive of moisture, and to furnish conditions whereby the soluble plant food may be retained near the surface of the ground, within easy reach of the rootlets of growing vegetation. We acknowledge the value of barnyard manure as a fertilizer, and yet a glance at its chemical analysis reveals only a small amount of nitrogen, potash and phosphoric acid. The average of 38 analyses of barnyard manure made at the Massachusetts experiment station shows only .42 per cent. of nitrogen, .53 per cent. of potash and .31 per cent of phosphoric acid. The calculated commercial value of the plant food contained in 1 ton of the average barnyard manure would be about $2. The agriculturist recognizes the value of the organic matter furnishing humus, and expects and is willing to allow a reasonable amount for the same. It is well known that peat carries a relatively high percentage of humus, and this fact, in no small degree, enhances the value of this material as a fertilizer. Aside from the consideration of the humus in peat it is of interest to study the value of peat as based upon its content of nitrogen and the availability of this most expensive element of plant food.

But little work has been done by the scientific agriculturist to establish the relative value of peat as a fertilizer. A few analyses have been made in various experiment stations, by the alkaline and neutral permanganate methods, which show the better grades of peat to have a nitrogen availability of 21.4 per cent. as compared with blood and fish having a nitrogen availability of 65 per cent. or over, but this is only comparative. These figures do not actually show the true amount of nitrogen which is available; this can only be accomplished by vegetation experiments. The Massachusetts experiment station has for several years been carrying on such experiments by growing millet in pots under conditions which can be absolutely controlled in every detail. The experiments in question were not instituted for the sole purpose of studying the availability of nitrogen in peat, but rather to make a detailed investigation regarding the availability of nitrogen from every well-known source, whether of a mineral or organic nature. The duplicate investigations were conducted in galvanized iron pots holding 38.75 pounds of soil. Each pot was fertilized with an abundance of potash and phosphoric acid, and the same amount of nitrogen was applied in each instance (5.4 grams) a few days before planting the millet seed. Five millet plants were allowed to grow and reach maturity in each pot. Care and watering were so regulated as to maintain uniform conditions. The results for the year 1908 show that sulfate of ammonia leads, with a percentage increase over the nothing pots of 74.17 per cent. of seed and 91.03 per cent. of straw. The peat ranks low, giving an increase of only 5.44 per cent. seed and 10.53 per cent. straw. These results are, of course, not conclusive, as they show only one year's investigation.

It is claimed that garbage tankage of our large cities can be economically made into a fertilizer, commonly known to manufacturers as base goods, by treating the tankage with sulphuric acid, the resulting product showing a high degree of availability of its nitrogen. The writer has successfully made a fertilizer from wool waste, the resulting product of which showed nearly 100 per cent. of nitrogen availability. Some such process may be applied to peat, and it is not improbable that the time will come when the nitrogen in peat will be utilized as a source of plant food by treatment with strong mineral acids as in the manufacture of base goods. It is questionable, however, if it would be at present on account of the large variety of other more concentrated and easily accessible ammoniates, both animal and vegetable that may be used in this process.

The use of commercial fertilizers is increasing enormously, and in a comparatively few years every source of plant food will be taxed to supply the demand for available ammoniates. As our western States become obliged to use more and more fertilizer each year, attention must sooner or later be turned towards our immense peat deposits.

The present seems to be a period of investigation and discovery. The manufacture of cyanamid compounds from the nitrogen in the atmosphere has furnished a most valuable economical source of nitrogen. This fact may retard somewhat the development of our peat industry from an agricultural standpoint, although the fact that peat furnishes valuable humus directly, while the mineral forms of plant food can only furnish it indirectly by growing a green crop to be subsequently ploughed under, will always be an incentive to its use in the natural or modified condition. The manufacturers of commercial fertilizers have recognized the value of peat as a drier, an absorbent and a source of humus in which many chemical formulas are deficient, and some are already using peat as a drier, and to improve the mechanical condition of fertilizer mixtures. How far this can be done legally and still comply with the fertilizer laws of our various States is an open question. If the manufacturer does not count the nitrogen which the peat carries in his guaranteed composition, but simply uses the material to improve the physical condition of his goods, it would not be undesirable, but the practice would offer a chance to the unscrupulous manufacturer to load his fertilizer with low-grade ammoniates.

There can be no question but what the nitrogen in dried peat has a much lower availability than the nitrogen in the high-grade animal and vegetable ammoniates, and for this reason its use as a *source of nitrogen* in mixed fertilizers must be excluded in order to comply with many State laws.

It is, of course, desirable to utilize peat as a fertilizer on as large a commercial scale as is possible, and the introduction of some process whereby this material may be made available for extensive use will be welcomed. In the mean time, however, there is no reason why peat should not be utilized to improve the chemical and physical condition of soils. It is a well-known fact that dry peat is a most wonderful absorbent. Experience teaches us, however, that it is rather slowly decomposed. If we can compost peat, therefore, with something that is teeming with bacteria and is easily decomposed there is a gain in two ways. For instance, if air-dried peat is composted with manure from the horse stable, the manure aids in disintegrating the peat, while the peat retards the too rapid decomposition of the manure, at the same time absorbing any plant food in form of ammonia compounds or other soluble plant food elements that may be made available. This is a very practical and economical manner of utilizing peat, and it will be found that the resulting compost will prove a very valuable manure. It may be necessary to make a frequent application of lime to soils on which such a mixture is constantly used, and it may be found necessary, in some cases, to use lime in making the compost.

The application of air-dried peat to light sandy or gravelly soils often results in their material improvement. Such applications can best be made by a manure spreader, and the peat may be applied to a depth of 2 inches. Freshly slaked lime should be used at the rate of 5 or 6 bushels to each cord of peat. The whole should be thoroughly harrowed into the soil and subsequently ploughed to a depth of from 4 to 5 inches. As an absorbent and deodorizer in the stable, dry peat has few equals.

Many of our peat lands make our most productive soils when properly drained and reclaimed, and especially is this true when the crops selected are particularly adapted to that class of soils. *Natural peat soils are deficient in available mineral plant food which has become washed out through successive years of leaching. Such soils, therefore, need an abundant application of potash, phosphoric acid and lime before they become productive.*

SPRAYING INJURIES.

BY G. E. STONE.

In recent years injury from spraying has become more common; at least, it appears to be more noticeable than formerly. This injury is more prevalent some seasons than others, and it is known that certain crops can be treated at one time without being injured and at other times precisely the same treatment may be given with bad results.

The causes underlying injury from spraying are complex and require attention from the best-equipped investigator. Already enough is known in some special cases concerning the nature of the injury to explain its occurrence at one time and not another. It is also well known that some plants are more susceptible to injury from spraying or fumigation than others, a wide range of susceptibility existing in plants.

Investigations have shown that meteorological conditions have an important bearing on the problem, but the data which have been collected are not sufficient, either in kind or quantity, for practical use.

Spraying injury to fruit and foliage has been noticeable the past season, especially on apple foliage. The fruit has also been injured to quite an extent by Bordeaux mixture, which causes the so-called " russeting " of the fruit.

Some cases have come to our notice during the past year of burning of foliage by arsenate of lead, and our attention was called in one case to the heavy loss of foliage on plum trees, due to spraying with this poison. It is well known that when spraying mixtures are not carefully prepared they are likely to cause burning, and in some of the cases observed by us it is not unlikely that the chemical nature of the arsenate of lead may have been responsible for the burning. A number of firms are now putting this on the market, and it is presumable that their products vary considerably as regards chemical composition. It is imperative for manufacturers of spraying mixtures or other remedial substances used on plants to demonstrate that their products are thoroughly trustworthy before putting them on the market. It is true that a spraying mixture can be used on one crop safely and not on another. It is also known, as previously mentioned, that meteorological conditions play an important role in this connection. It is safer to spray when the sun shines than during cloudy weather, for severe injury has often been noticed from spraying with various fungicides and insecticides in cloudy periods when no injury would have occurred had the sun been shining.

It is therefore important in spraying that attention should be given to the weather conditions, since if the spray is allowed to remain on the foliage in a moist condition for too long a time burning is likely to result. On the other hand, if the sun is bright and the spray mixture dries on the foliage very quickly, no such injury is likely to occur.

Burning of maple tree foliage has also been noticed as resulting from spraying with arsenate of lead, at the rate of 13 pounds to 100 gallons of water, and our attention has been called to a number of cases of severe burning of beech trees sprayed with this after standard formulas.

CONTROL OF CERTAIN GREENHOUSE DISEASES.

BY G. E. STONE.

One occasionally finds growers of greenhouse crops spraying for mildews and other diseases, and even contributors to the florists' journals sometimes recommend such treatment, perhaps because they know of no other. One at least of the objections to the practice of extensive spraying is that it is too likely to be considered a universal remedy or panacea for all the diseases plants are heir to. Any one attempting to control the diseases of greenhouse crops by spraying is wasting his time, and has much to learn concerning the fundamental principles of pathology. The most skilled florists and market gardeners discovered the true cause of disease many years ago, not from any particular experiments, but from intelligent reasoning out of the problem.

No one can long grow crops under glass before realizing that environment is a factor very largely under his control. He also discovers that many, if not all, of the blights with which he has to contend are caused by conditions of environment, and that if these conditions are modified properly the blights are checked. Considerable skill is required to manage the greenhouse in such a way that blights may be controlled, but it has been accomplished very successfully in many cases. In others, they are controlled to such an extent that only a minimum amount of damage occurs.

The important factors to which the grower of greenhouse crops must pay attention are heat, light, moisture, circulation of the air, and the chemical and mechanical conditions of the soil, and a knowledge of their effects upon plant development enables him to grow healthy plants. The influence of moisture in the air is alone an important, perhaps the most important, factor in controlling disease, and is very plain in the case of outdoor diseases also. In wet seasons certain diseases are common which may be entirely absent in dry seasons. The presence of dew, even in dry periods, may bring about infection by furnishing favorable conditions for spore germination. If the moisture conditions out of doors could be controlled as easily as they are inside, a very large percentage of so-called blights could be eliminated.

Cucumbers and Melons.

Experiments made with melons and cucumbers, covering a period of many years, have demonstrated that by proper regulation of the moisture in well-ventilated houses *Anthracnose* (*Colletotrichum*), downy mildew (*Plasmopara*), *Alternaria* and powdery mildew (*Erysiphe*) can be held absolutely in check.

At the time some of our experiments were being carried on, melons which were growing out of doors, within a few feet of our greenhouse, were infected with all of the above diseases except powdery mildew, but not a trace of infection could be found from any of these diseases inside. During the many years we have grown cucumbers and melons under glass we have never had any infection from the above diseases except the powdery mildew, which was introduced into our house at one time and encouraged to spread for a special purpose. All of these diseases are more or less common each year in cucumber houses, and cause much injury.

Downy mildew affects cucumbers during July and August, and *Anthracnose* in the spring. Most greenhouses growing cucumbers are kept too moist and are often poorly ventilated. There is no reason whatsoever why these crops cannot be grown without infection from the above-mentioned diseases. Experience has shown us that in order to control blights it is necessary that the air moisture should be held down, and if syringing of the foliage becomes necessary, it should be done only on bright, sunshiny mornings, when the foliage will dry off quickly, thus preventing the spores from germinating and affecting the crop.

Tomatoes.

There are a large number of troubles associated with tomatoes under glass which arise from improper handling of the crop.

The tomato leaf blight, caused by *Cladosporium,* often termed scab, can be perfectly controlled by paying attention to the air moisture and to details of syringing the foliage. The same attention to syringing, ventilation, etc., should be paid in the case of tomatoes as with melons and cucumbers.

When tomato plants are crowded, and there is an insufficient amount of light and circulation of the air, the lower leaves are frequently attacked by a leaf blight, known as *Cylindrosporium,* but this will give no trouble if the conditions are kept normal. This leaf blight occasionally occurs in commercial houses, although we have never had a trace of it in our many years' experience in growing tomatoes under glass, both summer and winter. It is more common in winter, when the light is poor, than in the spring and summer.

The blossom end rot of tomatoes is often a very troublesome disease and furnishes a good illustration of a trouble brought about by neglect of certain details necessary for the normal development of the crop. This disease is caused by bacteria, one or more fungous growths (*Fusarium, Cladosporium,* etc.) occasionally accompanying the bacteria. Lack of water in the soil when the fruit is maturing, especially if the atmosphere of the house is more or less dry, will cause the rot, and a liberal supply of moisture, preferably supplied by irrigation, will prevent it. Moisture plays an important role here because a too dry atmosphere causes the fruit to crack at the blossom end and become imperfectly developed, and infection follows. This rot is more common near steam pipes, where the air is drier, and in the spring, when the sunlight is more intense and prolonged, than during the late fall or winter. In the spring transpiration is more active, hence the necessity for more soil moisture and more attention to wetting down the house. Sunshine and transpiration are important factors in causing the rot, and our experiments have shown that slight shading in the spring months is of great value in holding back the trouble. In our experiments in the greenhouse we obtained over 30 per cent. more blossom end rot on plants which were watered on the surface than on those subirrigated, and a very material decrease in the amount of rot occurred from the shading afforded by the plants.

Lettuce.

Many years ago lettuce growers were troubled with a disease known as top-burn, and amateur growers have it to contend with at the present time. The disease is characterized by the margins of the young leaves becoming wilted and dying from a collapsing of the tissue. The older and more skilled lettuce growers early learned that the trouble was not associated with fungi, and it could be easily controlled by the adjustment of the day and night temperature to the conditions of the weather. It has been found that if the night temperatures are kept too high, — 50° or more in cloudy weather, — top-burn will follow, if the following day is clear and the day temperature reaches as high as 70° or 80°. By carefully maintaining low night temperatures, 40° or 45°, during cloudy periods, and holding the day temperature down, top-burn can be prevented. On the other hand, in bright, sunshiny weather, higher day as well as night temperatures may be maintained without running the risk of getting top-burn.

Lettuce as well as other indoor crops must be grown according to the weather, and as no two seasons are alike it follows that no two crops can be grown precisely alike. Every successful greenhouse grower realizes this and handles his crop accordingly.

Chrysanthemums.

The chrysanthemum is affected with three diseases, which can be controlled if attention is given to proper methods of culture.

Leaf blight (*Cylindrosporium*), similar to that on the tomato, occasionally affects more or less badly the lower leaves of chrysanthemum plants when grown to a single stem close together. This leaf spot, like the one on tomatoes, is caused by too close planting, which shuts out the light and prevents the circulation of air. More open planting, or anything which would allow more light or freer access of air, will prevent it.

The chrysanthemum rust, which once caused considerable alarm, can be prevented by paying attention to watering. Some greenhouse growers are often troubled with this rust, while others have never had the least indication of it. Even if two growers buy their stock from the same concern, and it is identical as regards freedom from rust, one is likely to have it very severely and the other not at all, which proves that the method of handling the plant has everything to do with the occurrence of the rust. When plants are grown outside, as they occasionally are in summer, and are exposed to rains and dews, they are very likely to become infected, but when grown inside, and especial care given to watering the foliage, little rust is present.

Powdery mildew (*Erysiphe*), although occasionally seen on chrysanthemum foliage, has never been considered a serious trouble, and is seldom, if ever, severe enough to require treatment. Stem rot, occasionally caused by *Fusarium,* which is more likely to affect the weak stems on closely planted crops, is sometimes destructive, but the chrysanthemum is, as a rule, quite immune to stem rots.

Carnations.

The principal troubles peculiar to the carnation are the stem rots, termed the wet and dry rot, and the rust. There are other troubles which are not serious, however, such as leaf spot (*Septoria*), purple joint, stigminose, etc., the latter being caused by insects. The breeding and selection of new varieties of carnations has had a more important influence on the elimination of carnation diseases than anything else. Carnation rust, which a few years ago gave much uneasiness among the growers, is now fairly well handled by expert carnation men. Careful attention given to syringing the plants has been of great value in preventing the rust, as has also subirrigation, or applying the water below the surface.

The stem rots are more recent troubles and are more difficult to handle. Wet rot, caused by a sterile fungus (*Rhizoctonia*) can be easily controlled by sterilizing the soil with steam, and formalin is also good, being applied to the soil at the rate of 2 pints to 50 gallons of water. It can be applied with any sprinkling device. It is generally recommended that formalin be applied at intervals of a few hours, until the whole amount has been taken up by the soil, and frequent stirring of the soil is necessary. Since formalin is extremely poisonous to plants it is necessary to get it all out of the soil before planting, and the house must remain idle some days. One gallon of the solution of the strength given above to each square foot has been recommended.

The dry rot, caused by *Fusarium*, is more difficult to handle, and the methods employed for the control of the wet rot appear to be of little use for this disease. *Fusarium* rots in general have increased during the last decade. In the case of carnations this is due possibly to the more extensive forcing common in recent years. Too extensive forcing, too close planting and shading have a tendency to weaken the stem, and undoubtedly render it more susceptible to attacks from fungi. On the other hand, low temperatures and exposure to the light harden the plant tissue, rendering it less susceptible to disease. There are authentic cases known where certain plants subject to stem rots, when transplanted and raised out of the ground slightly, become hardened and perfectly immune.

Damping-off Fungi.

There are two serious damping-off fungi which cause trouble to the greenhouse grower by affecting seedlings and cuttings. The damping fungus *Botrytis* is the most common, and affects plants in a low state of vitality. The *Botrytis* propagates freely by spores, and therefore does not yield to treatment by sterilization. The most healthy plants will become affected with the damping-off fungus if they remain in an abnormal condition for brief periods, and if cuttings are kept too moist or too warm, or lack sufficient light, they are likely to damp off. By paying close attention to cultural and sanitary conditions, damping-off can almost always be prevented.

Another damping-off fungus, known as *Pythium deBaryanum*, often gives considerable trouble to cucumber, tobacco and other seedlings when the conditions are not normal for their best development. Even sudden changes in the condition of the plant will cause the trouble. For example, when plants are taken from hotbeds where they have been forced too freely, and placed out of doors in damp, cold weather, they will damp off, and too much heat will cause the same thing in cucumber seedlings. Attacks of this fungus are confined almost entirely to the seedlings, and when the plant grows out of the seedling stage it generally becomes immune. *Pythium* can be easily eliminated from a soil by sterilizing with steam.[1] The formalin method of treatment, previously described, is beneficial.

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[1] Ohio Circular No. 57, Ohio Agricultural Experiment Station.

SPRAYING EXPERIMENTS WITH CALCIUM BENZOATE.

BY G. E. STONE.

Calcium benzoate has been recommended by manufacturers and dealers for a few years past as being a fungicide of some value, and samples of this substance have frequently been sent to us for trial by the manufacturers, with directions as to its proper use. We have previously tested sodium benzoate, an allied compound, on potatoes, and the results are reported elsewhere.[1]

It was desired that a test be made of this substance for the control of plum rot (*Monilia*), the claim having been made that it would completely control the rot. If true, the calcium benzoate would prove of inestimable value to the fruit grower, and would find a ready market.

In testing the material we selected half a dozen plum trees, leaving checks for comparison. The trees, which were laden with fruit and had always been susceptible to the rot, were given a very thorough spraying with the calcium benzoate, at the rate of 2 pounds to 50 gallons of water. The spray covered the foliage and fruit very thoroughly, and was applied at a favorable time to control any rot which might subsequently appear. As the season was very dry, and no rains occurred during the period of experiment, none of the substance was washed off.

Later in the season considerable rot was observed on both the sprayed and unsprayed trees, and a thorough examination showed absolutely no difference in the sprayed and unsprayed fruit as regards infection. We regard the experiment, therefore, as being purely negative in its results.

[1] Annual Report Hatch Experiment Station, 1908, p. 128.

Monilia rot of the plum and peach is a very difficult thing to control by spraying, and none of the spraying solutions or mixtures seems to have more than a partial effect. The best methods of handling the rot, in the absence of any suitable spraying mixture, particularly where it appears late in the season, on ripened fruit, consists in gathering the fruit just before it is mature and not allowing any overripe fruit to remain on the tree to become affected. When the rot occurs early in the season, as is sometimes the case, this method would be of little use, and spraying, even if only partially effective, might be resorted to tentatively.

SEED PURITY WORK, 1909.

BY G. H. CHAPMAN.

The testing of seeds for purity was not taken up at this station to any extent before 1908. In 1908 only about 12 samples of seed were sent in to this department for examination as to purity, but owing to other States having taken the matter up in a very decided manner, and some of them passing seed laws for the regulation of the sale of commercial seeds, the seedsmen and farmers of Massachusetts began to take interest in the matter.

The seeds found in the Massachusetts market are in general of very good quality, when purchased from well-known, reliable dealers, but since laws have been passed in other States suppressing the sale of impure seeds in those States, it has become customary with certain seedsmen to ship poor quality seeds out of the State, and place them for sale in States which have no such seed law. This has been brought to our attention more forcibly this year than ever in the past, and the farmers of this State are beginning to pay more attention to the matter, as is evidenced by the increased number of samples sent in for purity tests. In all, 100 samples have been examined this year, and it has been deemed advisable to make a report of the work done at this time.

Most of the seeds examined were offered for sale by reliable dealers in this and other States, and such can be bought with reasonable assurance, as these dealers are, in the main, careful to offer only a good grade of seed, and usually advise the purchase of their best grades. This is not because it brings them in a larger profit, but because the best grade of seed is usually purer than other grades of the same seed offered by them at a lower price. It is to their advantage to offer a good article, as well as to the farmer's advantage to buy a good article; but, as in any other business, if a man is not willing to pay the price of a first-class article he can be accommodated with something inferior.

One great mistake which the farmer makes is the buying of seed from the small country stores, as it has been found in many cases during the past year that these seeds were improperly cleaned, or not cleaned at all. We therefore strongly advise purchasing seed from a reliable dealer rather than buying them haphazard anywhere.

The table gives briefly the results of the seed purity tests carried on this year. This table is practically self-explanatory, and gives briefly the different kinds of seed examined, with the maximum, minimum and average percentage of purity, as well as the kinds of weed seeds found and the number of samples in which these were found. The most common impurities in the different kinds of seed examined were plantain, ribgrass, sheep sorrel and dock. Dodder might be mentioned as being among the most noxious of seeds found in the clovers and alfalfa, but it was present in only a small percentage of the samples submitted for examination.

In this table no mention has been made of the chaff, bits of stem and dirt which were found in the samples, as these were usually present only in small amounts.

It is believed that it would be advisable for Massachusetts to draw up a seed law governing the sale of commercial seeds, but this should not be done without great deliberation and the utmost care, as it appears to us that many of the laws drawn up by other States are either harmful, or unjust to the seed dealer, or to the purchaser of commercial seed. At the present time nothing can be done about this, but it is hoped that in the near future the seed dealers and farmers will take up the matter, and that some law may be passed which will protect both the farmer and the dealer. Justice should be done to both parties, and we do not believe that it will be a difficult matter to draw up a law which will not only protect the buyer from purchasing impure seeds offered for sale in this State which are grown outside of the State, and shipped in for sale, but would also protect the Massachusetts seed dealer as well.

According to some of the laws in our neighboring States, Massachusetts might easily become the dumping ground for impure seeds which could not be sold by dealers in other States. This is inimical to the Massachusetts seed dealer as well as to the buyer, and it is evident that something must be done to safeguard the interests of the farmer and the seed grower and dealer.

Showing Results of Seed Purity Tests, 1909.

Seed.	Number of Tests.	Per Cent. Purity.			Kinds of Weed Seeds found, and Number of Samples in which found.	
		Maximum.	Minimum.	Average.	Noxious.	Harmless.
Timothy,	14	100.0	96.0	98.9	Yellow daisy (1). Plantain (7). Dock (2). Five-finger (2). Sheep sorrel (3). Pepper grass (2). Hawkweed (1). Ox-eye daisy (1). Switch grass (1). Lamb's-quarters (2). Wild parsnip (1).	Red clover (4). Alsike clover (4). Redtop (6).
Red clover,	24	100.0	82.7	97.6	Sheep sorrel (2). Plantain (11). Rib grass (10). Curled dock (5). Sorrel (5). Dodder (5). Daisy (2). Lamb's-quarters (2). Foxtail (6). Wild turnip (1), Switch grass (2). Medicago sp.? (3). Parsnip (5). Wild carrot (2). Tumble weed (2). Mallow (1). Self-heal (1). Canada thistle (2). Dock (2). Lady's-thumb (4). Smartweed (1). Witch grass (1). Pepper grass (1). Melilotus sp.? (1).	Timothy (13). Alsike clover (7). White clover (6). Orchard grass (1). Redtop (4). Alfalfa (2). Fescue (1). Medic (1).
Redtop,	12	100.0	92.0	96.8	Daisy (3). Sorrel (2). Plantain (4). Five-finger (3). Smartweed (1). Chickweed (1).	Timothy (6). Red clover (2).
Oats,	1	98.6	98.6	98.6	- -	Wheat (1). Barley (1).
Alfalfa,	7	99.0	98.0	98.4	Medic (1). Bitter dock (1). Dodder (3). Sweet clover (1). Gum plant (1). Medicago sp.? (1). Plantain (1). Bur clover (1). Switch grass (1). Rib grass (2). Mustard (1). Lamb's-quarters (2).	Red clover (4). Timothy (1). Old seed (1).

Showing Results of Seed Purity Tests, 1909 — Con.

Seed.	Number of Tests.	Per Cent. Purity.			Kinds of Weed Seeds found, and Number of Samples in which found.	
		Maximum.	Minimum.	Average.	Noxious.	Harmless.
Alsike clover.	14	99.5	91.0	97.4	Sorrel (7). Dock (2). Plantain (4). Switch grass (2). Shepherd's purse (1). Dodder (3). Daisy (2). Pepper grass (2). Field sorrel (1). Medicago sp.? (1). Chickweed (1). Five-finger (1). Rib grass (1). Crab grass (1). Corn-cockle (1).	Timothy (14). Red clover (6). Redtop (3). White clover (2).
White clover.	6	99.0	84.0	96.2	Plantain (2). Sheep sorrel (4).	Timothy (1). Alsike clover (2). Henbane (1). Red clover (1).
Orchard grass.	2	94.0	91.0	92.5	Dock (2). Plantain (2). Corn-cockle (1). Ox-eye daisy (1). Sheep sorrel (1). Quack grass (1). Rib grass (1).	Timothy (1). Red clover (1). Redtop (1). Buttercup (1).
Agrostis, .	2	99.8	-	49.9	- -	Timothy (1). Old seed (1). Orchard grass (1).
Kentucky blue grass.	2	97.0	92.0	94.5	Shepherd's purse (2). Pepper grass (2). Plantain (1). Chickweed (1). Lamb's-quarters.	Clover (1). Timothy (1).
Meadow fescue.	10	100.0	97.0	98.7	Dock (4). Lady's-thumb (1). Foxtail (1). Mustard (3). Medicago sp.? (1).	Paspalum sp.? (1). Clover (1).
Alfalfa clover.	2	99.0	98.0	98.5	Dock (1). Bull thistle (1). Foxtail (1). Lamb's-quarters (1).	
Millet, . .	2	96.0	74.0	85.0	Ragweed (1). Yellow foxtail (1). Lady's-thumb (1). Tumble weed (1). Lamb's-quarters (1). Plantain (1). Barnyard grass (1).	
Italian rye grass.	1	99.0	-	-	Curled dock. Tall buttercup.	
Yellow oat grass.	1	99.8	-	-	Curled dock (trace). Tall buttercup (trace).	

SEED GERMINATION AND SEPARATION.

BY G. E. STONE.

The routine work in seed germination and separation has been carried on as in the past. Several methods were tried for the separation of mixtures of seeds, especially of grass seed, but work along these lines is not far enough advanced to warrant a report.

The number of samples of seed sent in for germination far exceeded those of the preceding year (see Table I.), 273 samples of different seeds being received, 92 of which were onion. Onion seed for 1909 seemed better than that of the preceding year, and the average germination of all the seed samples seemed to be a little higher than for 1908. The tobacco seed, especially, gave a higher germination percentage than ever before. Large seeds produce large plants, and if this characteristic is inherited it might be supposed that selection and separation would ultimately result in a better strain of seed and better crops.

TABLE I. — *Records of Seed Germination, 1909.*

Kind of Seed.	No. of Samples.	Average Per Cent.	Per Cent. of Germination.	
			Highest.	Lowest.
Onion,	92	82.2	97	25
Tobacco,	8	93.6	97	85
Corn,	4	78.0	97	50
Lettuce,	15	60.8	100	-
Pansy,	43	46.4	88	3
Celery,	8	69.0	85	25
Miscellaneous,	108	69.0	100	-
Total,	273	-	-	-

The work in seed separation also increased during the season of 1909 (see Table II.), the principal seeds separated being onion, tobacco and celery. This season about 1,440 pounds of onion seed were separated, against 720 in 1908, and 60 pounds of tobacco seed, against 56 pounds during 1908. In all, about 1,500 pounds of seed have been separated for the growers during the past year, and indications point to a still larger increase in the amount of seed separated next season.

TABLE II. — *Records of Seed Separation, 1909.*

KIND OF SEED.	No. of Samples.	Weight (Pounds).	Per Cent. of Good Seed.	Per Cent. of Discarded Seed.
Onion,	48	1,439.34	88.9	11.1
Tobacco,	88	59.08	89.9	10.1
Celery,	7	3.27	89.4	10.6
Total,	143	1,501.69	-	-

The per cent. of onion seed discarded was only 11.1 for all the samples, showing that the seed offered in 1909 was on the whole of slightly better quality than that offered in 1908. The average per cent. of seed discarded for tobacco was also less than in the past, only 10.1 per cent. being taken out, against 14 per cent. in 1908. Of course, in a great many samples a much larger percentage was taken out than was absolutely necessary, as some of the growers specifically requested that a certain percentage of the seed be blown. One grower, especially, asked that one-third of the seed be blown in order to insure practically perfect seed for planting.

We are occasionally requested to test the germination of seed both before and after separation, and the results of a few such tests have been published at different times in our annual report.

Table III. shows the results of tests made the past year. Two hundred seed were used in each test. The average amount discarded was 7.09 per cent., and the average germination of the seed before being separated was 74.7 per cent. and after separation 83.6 per cent., showing a gain of 8.9 per cent. as a result of separation.

TABLE III. — *Showing Increase in Germination of Seeds by Separation.*

KIND OF SEED.	PER CENT. OF GERMINATION.		Per Cent. discarded.
	Before Separation.	After Separation.	
Onion,	83.0	92.0	9.10
Onion,	85.0	85.0	7.60
Onion,	25.0	30.0	13.00
Onion,	82.0	87.0	9.00
Onion,	80.0	94.0	5.00
Onion,	82.0	96.0	3.30
Onion,	70.0	89.0	4.00
Onion,	91.0	93.0	9.00
Onion,	75.0	87.0	3.80
Average,	74.7	83.6	7.09

In some previous separations with onion seed, in which 7 samples of seed were used and an average of 14 per cent. blown out, we obtained an increase of 9 per cent. in the germination.

In Table IV. are shown the results of seed germination before separating, also the germination of the heavy and light seed. The average amount of seed discarded here was 8 per cent. The heavy seed showed an average increase of 5 per cent. in the germination, while the light or discarded seed gave an average of only 57 per cent., or 28 per cent. less than the heavy seed.

TABLE IV. — *Showing Increase in Germination of Seeds by Separation.*

KIND OF SEED.	No. of Experiment.	PER CENT. OF GERMINATION.			Per Cent. discarded.
		Before separating.	AFTER SEPARATING.		
			Heavy.	Light.	
Onion,	1	85.0	88.0	56.5	8.58
Onion,	2	76.0	83.0	59.0	7.60
Average,	–	80.5	85.5	57.7	8.09

In Table V. the per cent. of germination and the weight of celery seedlings are shown, the results being an average of two experiments. The amount discarded in this experiment was 15 per cent., and the difference in the percentage of germination between the heavy and discarded seed was 32 per cent., while there was a gain of 68 per cent. in the germination of the heavy over the light.

Table V. — *Showing Effects of Seed Separation on Germination.*

	Per Cent. of Germination.	Weight (Grams).	Per Cent. discarded.
Heavy,	43.5	.44	15
Light,	11.5	.14	-

It is becoming a recognized fact that under present conditions governing the sale of seed in Massachusetts and elsewhere separation is necessary in order to produce the best results, being particularly valuable in the case of such seed as tobacco, onion, celery, radish, lettuce, etc., as often a great deal of light or old seed, which is absolutely worthless and only a "makeweight," is mixed with the seed offered for sale. The grower, however, is beginning to realize that he is sometimes imposed upon, so is more careful about the quality of seed which he buys, and is consulting the station more and more frequently about the problems connected with the seed question and the growing of crops.

The station is always glad to receive seed for separation or germination from people residing in the State, and will do all in its power to assist them in any way possible. From the gratifying increase in the number of samples sent in for both germination and separation it is believed that people in the State are realizing more and more the benefits resulting from the gratuitous work done for the people at this station.

All samples of seed to be germinated or separated should be addressed to G. E. Stone, Massachusetts Agricultural Experiment Station, Amherst, Mass., and the express or freight on these seeds should be prepaid by the parties sending the seed.

SUN SCORCH OF THE PINE.

BY G. E. STONE.

Much interest, accompanied by an unusual amount of alarm, has been felt since 1905 in the so-called "pine blight," and, as is customary where more or less conspicuous injury to trees occurs, exaggerated reports have been made concerning it. This blighting of the pine is not new to Massachusetts as we have noticed it for at least twenty-five years. About twelve years ago it was quite prevalent in the eastern part of the State, being noticed by us and reported by others. Prof. B. M. Watson of the Bussey Institute and others have recently called our attention to a similar burning which occurred apparently at the same time.

Sun scorch of conifers in general is of common occurrence. Pines growing in very dry situations are often sun scorched, and frequently show yellow, inferior foliage; the needles are sometimes burned, and it is not unusual for fungi to attack the dead needles, but these fungi are never the primary cause of the trouble. This condition of the pines may be found here and there almost any season, but is more noticeable some seasons than others.

The present pine blight dates back to the winter of 1902-03, when the conditions were such as to cause much injury to vegetation in general. The following winter, that of 1903-04, was even more severe in its effects on vegetation, and caused extensive root killing of many trees and shrubs. The pine, as well as other trees, in many cases was killed outright, but the injury to the pine was largely confined to the smaller roots, or those less than 3/16 of an inch in diameter. It was not, however, until the very dry summer of 1905 that extensive burning was noticed, and this was very general throughout the State. The season of 1905 was the first to attract attention to this burning although in our annual report[1] we had already mentioned the condition of the pine roots, and stated that we anticipated trouble if this condition continued.

The blight was characterized by a burning of the needles, which was so severe in some cases as to cause the death of the tree; in others, burning was not so severe, affecting only parts of the tree, and in a large number of cases the trees recovered the following year (1906). In some cases the tips of the needles only were burned, while in others the whole leaf was involved. The branches bearing such leaves, and sometimes the whole tree would die. The trees which recovered in 1906, of which there were a large number, were not perfectly healthy as regards color or leaf development, but they were free from burning. Extensive burning occurred again during the summer of 1907, appearing simultaneously all over the State the latter part of July. It was much more noticeable than formerly, and occurred at a very dry period, when high winds were common, although the effects on the trees were not so disastrous. An examination of the root system in 1907 showed that about 90 per cent. of the small feeding roots had collapsed, and the micorhiza on the roots appeared to suffer the same fate as the roots themselves. The soil during part of the season was so dry that it was like powder. Many of the trees improved during the fall of 1907, and in 1908 they appeared much better.

The principal burning during 1908 occurred on the young tips of the needles, before they had expanded, and was much less severe than in the preceding year. Many trees which burned previously appeared perfectly green in 1908, and an examination of the root system showed that new feeding roots were forming.

In all the burning of the foliage we have never discovered any indication of fungi on the needles at first, although after the leaves had been dead a few weeks different fungi were found, being purely secondary. In the summer of 1908 considerable *Septoria* occurred on the dead leaves, but there has been no indication of infection at any time since the blight's appearance. Hundreds of instances may be noted where trees have remained

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[1] Annual Report, Hatch Experiment Station, 1905, p. 9.

perfectly healthy whose branches interlaced with those of blighted trees.

The number of pine trees affected with the so-called blight or sun scorch in Massachusetts is probably less than 1 per cent., and the number which have died is so insignificant that it is hardly worthy of mention. Most of the affected trees have periods of burning and periods of recovery. When new leaves form, the old, blighted leaves drop off; consequently, when a new crop of foliage appears the tree no longer shows the effects of blight. Trees which have blighted once have almost invariably been affected again; in other words, blighting has been confined each year to certain trees.

During the past five or six years the writer and his assistants have examined a great many hundreds of pine roots from different parts of the State, and have made many observations and notes on the affected trees. Sun scorch of the pine has been found to be associated with a very dry condition of the soil, aided by severe winds. The side of the tree corresponding with the direction of these winds is most severely affected, and many instances may be found to prove this assertion. Moreover, that part of a forest which is exposed to severe winds has shown the greatest amount of blight. There has been more blight of trees on the margins of forests than in the interior, and trees growing in the open under exceptional conditions seldom if ever blight. Small pines growing in the shade of older trees in the forest have proved to be more or less susceptible, but they have not been affected to such an extent by burning as by winter-killing of the roots. Pines growing under such conditions are not able to attain their best development in any season, and are more likely to die from any cause that would tend to weaken them than those growing in the open.

For the past five or six years the white pine has been looking badly. It has been unusually susceptible to attacks of insects of one kind or another, the pine borer killing the leaders in many cases, and a black, scurfy-like growth on the foliage, known as *Scorias,* has been more common than usual. Many trees which have shown no inclination to burn possess a poor root system which causes a yellow and sickly appearance of the foliage. These trees are also noticeable for their short needles and stunted growth.

Besides the typical burning of the pine, troubles of a different nature have occasionally been observed. In the season of 1906–07 there was considerable burning, caused by the fungus *Phoma*. This fungus attacked the young stems and branches, causing the death of the leaves. In this case the leaves die but remain on the branch. There was also a burning of pine foliage in the early spring months similar to that which occurs on arbor vitæs and various conifers, generally known as sun scald. This has been more or less common the last year or two, and is confined to certain branches. The effects of burning from contact with drifting snow have also been noticed from time to time in certain localities, and serious burning has been noted on the foliage of the pitch pine, which, according to Mr. T. H. Jones, a graduate student who specialized in entomology, is due in part if not wholly to the work of insects.

Occasional dying of the white and Scotch pines has been observed, and the Norway and other spruces have been dying to a greater extent than usual.

It should be pointed out that reports of the so-called pine blight have been exaggerated even by those who should have known better. Fortunately this exaggeration has had slight effect on owners of woodland, and the planting of young pine is still going on in this State, owing to the excellent work of State Forester F. William Rane.

Of all the trees peculiarly adapted to this region, the white pine stands at the head of the list, and it has been and is to-day one of the most valuable assets of our soil. So well adapted is this tree to our region, and so rapidly does it fill up old pastures and woodlands, that if Massachusetts should become deserted now, in one hundred and fifty years it would be densely covered with a magnificent growth of white pine. In the primeval forests of the State, pine and hemlock constitute the principal trees, but the hemlock has disappeared to such an extent, owing to the modification of soil conditions, that it would take several centuries for it to regain its former pre-eminence. On the other hand, the white pine is such a cosmopolitan tree in this region, adapting itself to such a variety of conditions, that if left to itself to propagate it would form from 50 per cent. to 75 per cent. of the entire tree growth in this State in a comparatively short time.

As to the treatment of the pine blight, in some cases spraying has been resorted to, with supposed beneficial results, but if such results followed spraying, it is very likely due, as Dr. G. P. Clinton of the New Haven station has pointed out, to the clogging of the stomata, which prevents excessive transpiration at a critical period. In the case of lawn pines, which are greatly prized, we have recommended as treatment for the blight mulching the soil with horse manure well diluted with straw, and applying to the tree fertilizers, such as wood ashes, ground bone, pulverized sheep manure, etc.

INSECTS OF THE YEAR.

BY H. T. FERNALD.

During the year 1909 insects were abundant, but no serious outbreak of any one species was noted. Average losses were the rule, and in some cases there was less destruction than usual.

For several years the elm-leaf beetle (*Galerucella luteola* Mull.) has been increasing in abundance and attracting more attention. During 1909 its work was evident over quite a large part of the State, and this has led to attempts to control it by legislation. Under these circumstances an outline of its history in the State may not be out of place.

Just when this insect reached Massachusetts is unknown, but as it came from the south, and was found in Amherst in 1895, it is probable that it entered the State by the Connecticut valley a year or two earlier. At first it was not abundant enough to attract much attention, but by 1899 it had begun to be noticeable on the elms there, had also reached the eastern part of the State and was working northward. Two years later it had become injuriously abundant in eastern Massachusetts, and in 1902 it was becoming a pest in the northeastern part of the State, though elsewhere its injuries seemed to be less, on the whole, than they had been the year before.

The beetles appeared abundantly the spring of 1903 and laid many eggs. About the first of May, however, a prolonged drought began, lasting nearly eight weeks. During this period many of the egg masses failed to hatch, and some, at least, appeared to dry up, while in many cases where the eggs hatched the tiny grubs could be seen biting at the leaves hardened by the drought, but failing to make any impression on them. The mortality of these insects under the circumstances was enormous, and the amount of injury comparatively small. The following winter — that of 1903–04 — was exceptionally cold, and in the spring of 1904 almost no elm-leaf beetles could be found.

How far the unusually cold winter was responsible for this destruction it is impossible to say, but it seems certain that the spring drought, causing the failure of eggs to hatch, and the starvation of the newly hatched young, were important factors in the destruction of this pest.

Many towns and cities sprayed their trees for the elm-leaf beetle in 1903, and it seems to have been too generally supposed that this was the reason so few of these insects were found the following year.

Since 1904 the elm-leaf beetle has been gradually increasing in abundance again, and in 1908 it had become so plenty as to cause considerable injury. In 1909 this was also the case, and a repetition of this may be expected each year hereafter, until some combination of natural or climatic conditions unfavorable to the insect shall appear.

The question of controlling the elm-leaf beetle is important under these circumstances, and two lines of action seem possible. Cities and towns may spray their trees if they see fit to do so, holding the insect in check in this way. There are many parts of the State, particularly on the west and north, as far east as Ashby, perhaps, where it is not probable that this insect will ever do serious injury, unless it acquires greater resistance to cold than it now has. For this reason local treatment would seem particularly desirable. The difficulty would be that trees not on town streets, but on private grounds, and those in the fields and woods would not be reached in this way, and each year these would restock the street trees. The other method would be by State law requiring all elms to be sprayed. This would be impracticable of enforcement, however, for there are not enough people in the business to spray one one-hundredth of the trees, and it is impossible to spray elms without power sprayers, with any degree of success, during the period when spraying must be done. If the State should take up the work, it would mean the expenditure of about half a million of dollars annually, for the entire State, except the western and north-western portions, would need to be treated during a period of five weeks for it to be of any value, and this would require at least fifty gangs of men and power pumps. Then, too, it must be remembered that the boundaries of Massachusetts are not impassible to these insects, and the work would have to be done every year. In other words, State treatment would mean an annual tax of about half a million dollars for this purpose, or else work of no lasting value and a waste of money.

The oyster-shell scale (*Lepidosaphes ulmi* L.) and several others of our common scale insects have been the cause of some correspondence, but nothing new has developed about them. The San José scale (*Aspidiotus perniciosus Coms.*) is becoming more abundant in orchards and on ornamental shrubs and trees, and in some cases may be found in wooded areas. The desire for legislation has included this pest also, but there is little chance of any law being passed which will accomplish much against it. In the end, those persons who will treat their trees will save them, while those who do not will lose them, and the burden will fall where it should, upon those who neglect their property.

The past spring was unusually favorable for the rapid increase of plant lice, and many kinds of them were extremely abundant. On the other hand, the cranberry fruit worm was very markedly less abundant than usual, losses by the attacks of this insect being much smaller than for several years.

The leopard moth (*Zeuzera pyrina* L.) has increased in the region around Boston and is another menace to our shade trees. The gypsy moth (*Porthetria dispar* L.) has also increased, and, in spite of a disease which attacked the caterpillars in many places, killing large numbers of them, there is no question that the general condition of eastern Massachusetts as regards this insect is worse than ever before.

The brown-tail moth (*Euproctis chrysorrhœa* L.) is spreading in the State, and nests have now been found as far west as Brookfield and Belchertown. It is only a question of a few years when the whole northeastern United States will be infested by this insect, in spite of all the laws and repressive measures which have been adopted against it.

The twelve-spotted asparagus beetle (*Crioceris 12-punctata* L.) has now been taken in Massachusetts. It was found fairly abundant at Concord and at Roslindale last summer, but has not yet been reported in the Connecticut valley. This pest passes its early stages in the asparagus berry.

On the 2d of June, 1909, a Chalcid parasite was captured at Amherst, laying its eggs in the eggs of the common asparagus beetle (*Crioceris asparagi* L.). The parasite was quite abundant, and was later discovered at Concord. It proved to be a new species, and was described by Mr. J. C. Crawford of the United States National Museum as *Tetrastichus asparagi*. This insect has two and probably three broods a year, corresponding to those of the asparagus beetle, and, to judge from its work last summer, it promises to be quite effective in controlling its host.

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