U. S. DEPARTMENT OF AGRICULTURE

WORK AND EXPENDITURES OF THE AGRICULTURAL EXPERIMENT STATIONS, 1919

PREPARED BY THE
OFFICE OF EXPERIMENT STATIONS
STATES RELATIONS SERVICE

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A. C. True, Director.

OFFICE OF EXPERIMENT STATIONS.

E. W. Allen, Chief.

RELATIONS WITH INSTITUTIONS FOR AGRICULTURAL RESEARCH.

Supervision of Work and Expenditures of the State Experiment Stations Under Federal Appropriations.

E. W. Allen, E. R. Flint, J. I. Schulte, W. H. Evans, W. H. Beal.

Experiment Station Record.

E. W. Allen, Ph. D., editor; H. L. Knight, B. S., associate editor; Sybil L. Smith, M. A., agricultural chemistry and agrotechny; W. H. Beal, A. B., M. E., and R. W. Trullinger, B. S. C. E., meteorology, soils, and fertilizers; W. H. Evans, Ph. D., and W. E. Boyd, Ph. B., agricultural botany, bacteriology and plant pathology; H. M. Steece, B. S., field crops; J. W. Wellington, B. S., horticulture and forestry; W. A. Hooker, B. S., D. V. M., economic zoology and entomology; C. F. Langworthy, Ph. D., D. Sc., and Sybil L. Smith, M. A., foods and human nutrition; F. J. Kelley, B. S., animal husbandry, dairying, and dairy farming; W. A. Hooker, B. S., D. V. M., and Sybil L. Smith, M. A., veterinary medicine; R. W. Trullinger, B. S. C. E., rural engineering; Eugene Merritt, A. B., and Louise Marbut, A. B., rural economics; E. H. Shinn, A. B., B. S., and Marie T. Spethmann, agricultural education; Martha C. Gundlach, A. B., indexing; William Henry, proof reading.

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Hawaii Experiment Station.

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Porto Rico Experiment Station.

D. W. May, M. Agr., agronomist in charge, Mayaguez; T. B. McClelland, A. B., horticulturist; W. V. Tower, B. S., entomologist; L. G. Willis, B. S., chemist; Thomas Bregger, B. S., plant breeder; J. O. Carrero, B. S. Ch. E., assistant chemist; W. P. Snyder, B. S., assistant in plant breeding; H. C. Henricksen, B. Agr., specialist in farm management, San Juan; J. A. Saldana, assistant in horticulture.

Virgin Islands Experiment Station.

Longfield Smith, Ph. D., agronomist in charge, St. Croix; C. E. Wilson, M. A., entomologist.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
States Relations Service,
Washington, D. C., January 20, 1921.

Sir: I have the honor to transmit herewith a report on the agricultural experiment stations in the United States for the fiscal year ended June 30, 1919. This is a part of a report prepared in accordance with the following provision of the act of Congress of March 4, 1915, entitled "An act making appropriations for the Department of Agriculture for the fiscal year ending June thirtieth, nineteen hundred and sixteen":

That hereafter there be prepared by the Department of Agriculture an annual report on the work and expenditures of the agricultural experiment stations established under the act of Congress of March second, eighteen hundred and eighty-seven (Twenty-fourth Statutes at Large, page four hundred and forty), on the work and expenditures of the Department of Agriculture in connection therewith, and on the cooperative agricultural extension work and expenditures of the Department of Agriculture and of agricultural colleges under the act of May eighth, nineteen hundred and fourteen, entitled "An act to provide for cooperative agricultural extension work between the agricultural colleges in the several States receiving the benefits of an act of Congress approved July second, eighteen hundred and sixty-two, and of acts supplementary thereto, and the United States Department of Agriculture"; and that there be printed annually eight thousand copies of said report, of which one thousand copies shall be for the use of the Senate, two thousand copies for the use of the House of Representatives, and five thousand copies for the use of the Department of Agriculture (38 Stat. L., p. 1110.)

This report embodies the information heretofore submitted in compliance with the provisions of 34 Statutes at Large, page 64, section 5.

Very respectfully,

A. C. True, *Director.*

Hon. E. T. Meredith,
Secretary of Agriculture.

CONTENTS.

WORK AND EXPENDITURES OF THE AGRICULTURAL EXPERIMENT STATIONS, 1919.

By E. W. Allen, E. R. Flint, and J. I. Schulte.

This report, prepared by the Office of Experiment Stations, States Relations Service, pertains to a period of readjustment which bore heavily upon the experiment stations. It affected the whole system, and because it brought to light the weakened condition of the stations and the necessity for strengthening them if they are to maintain their proper position, the situation became one of no little anxiety.

The report for 1918 dealt with the conduct of the experiment stations during the war, the part these institutions and their personnel played in war activities, and important contributions which they made to the general cause. The result was one to reflect great credit on the stations and to emphasize their importance, not alone to the agricultural industry but to the national welfare. The war inevitably interrupted the growth of the experiment stations and their work. It diverted attention and interest from them to some extent, as was natural, because the nature of their work is not spectacular and does not bring them into the public eye as does that of some other branches. The stations suffered from a combination of unusual circumstances which seriously handicapped them for the time being and reached a climax during the year. If these setbacks had been merely temporary they would not have been so serious, but the inability of the stations to recover from these handicaps and to resume their former position called attention to their real situation and the extent to which they had suffered. Numerous factors contributed to the general result and made speedy recovery most difficult.

EFFECTS OF THE WAR ON AGRICULTURAL RESEARCH.

The attention of the administrative officers of experiment stations was to an increasing extent diverted by other demands as the war progressed. Many took on engrossing special duties, several went out from the institutions altogether for a period, while others directed their attention quite largely to organizing the rapidly expanding extension work. So many emergency calls were made upon the time of these men that the station administration was reduced to a mini-

mum, and plans for the future development of its work could not receive attention. Quite naturally there was little forward-looking in that period, and there was a decrease not only of emphasis on investigation but of stimulating influence and support for it, which began to be felt by the station forces.

The situation was intensified by a large number of changes in directors. From 1914 to 1919 the directors of practically half the stations changed, in five cases twice. Eight of the former directors went into industrial positions. Furthermore, it may be noted that of the twenty-eight administrative changes which occurred, the vacancies were filled in all but three cases by persons who had not had previous experience in directing an experiment station; one-half of them were likewise new to station work, not having been connected with a station staff, and only a small part had been previously engaged in active investigation of any type.

This is a noticeable change in the system of administration during the past five or six years. Obviously it does not mark an advance in the provision of experienced leadership in the research field, and other reasons than the provision of such leadership evidently actuated the appointing powers. In part it may be ascribed to change in form of organization—a doubling up in administrative positions and duties. Thus, in nine cases the station directorship, formerly a separate office, was combined with some other office in the college, such as president, dean, or director of extension, whose exacting duties even in normal times would leave considerably less opportunity for attention to the station than formerly. In abnormal times the things which naturally suffer under pressure are those which require more intimate study and consideration, and in the case of an experiment station these are the ones on which effective supervision and advancement most largely depend. Consequently the war period brought a check to the stronger and more effective organization of these research institutions, which had seemed to be under way.

It is gratifying to note that several of the colleges have recently provided for a special officer under the dean, designated as director or vice director, to look particularly after the conduct and welfare of the stations, but the situation still leaves much to be desired in the provision for adequate administrative supervision and expert leadership.

CHANGES IN PERSONNEL.

A very serious effect on the progress of the experiment stations was exerted by change in the working forces. In addition to those who joined the war service in some form, many went into the industries or other branches more lucrative than station work. Others were unsettled by the conditions about them and the desire to render a more conspicuous service.

The loss of men was tremendous. For the six-year period from 1914 to 1919, the turnover in the personnel of the stations was no less than 80 per cent. That is to say, nearly 1,400 of those occupying technical positions, out of a total roster of approximately 1,700, left their positions for other openings, a large proportion of them outside the stations. By actual count there was a decline of about 250 persons in the combined station staffs. While the assistant grade was most largely represented in these separations, 370 department heads and leaders of special lines made a change, equivalent to an average of 7 leading workers for every station. Of this expert class, upward of 150 went into industrial or commercial lines, about 50 into extension work, an equal number to the National and State departments of agriculture, and nearly as many more into exclusively teaching positions.

While a small proportion, therefore, remained in agricultural investigation, the large majority were not only lost to the stations but to agricultural investigation as well. To this extent the stations were the poorer, because the difficulty in securing experts often led to filling the vacancies by advancement or appointment of persons less well qualified by training and experience. This difficulty in filling positions has necessitated the suspending of projects, and in some cases closing them out prematurely.

Almost everywhere there has been a decrease in the number of assistants now employed. As positions of this grade have become vacant they have often not been filled, partly because of the difficulty and partly because the funds could not be spared. In some places the only way to increase salaries and keep the work going has been through such economy. Leaders of projects have thus been required to do simple routine duties they were not accustomed to—a pathologist bugging his own potatoes, a plant breeder doing the ordinary cultural labor, a chemist making the routine determinations requiring skill but not imagination, etc. The spirit in which this has been accepted by such experts is fine, but it is false economy, and the effect on the amount and progress of research is none the less serious. It necessarily affects the character of the projects undertaken. It has been a frequent expression of men the past few years, in speaking of their future plans, to qualify by the provision that they might be able to have the needed assistance.

EFFECT ON THE WORK.

Naturally the more advanced research is the type of activity first affected by such changes in the personnel, particularly in a lowering of its grade. The effect is seen in a lower grade of inquiry, less skill and insight in devising means of advance along new lines, a performance of the simpler routine features with an omission of the

constructive inquiry essential in original research. There have been many evidences of this. The result is apparent also in the elementary character of the outlines of some of the new projects proposed for the research fund, suggesting limitation of training in the elements and the spirit of research.

The condition referred to is not isolated or highly exceptional. It is becoming so common that it raises a serious question regarding the ability of many stations to utilize any considerable additional funds in genuine research unless the staff is strengthened. This maintenance of a high-grade corps of investigators and its strengthening by the appointment of persons of advanced training is one of the most serious difficulties to be met, and the outlook in that direction is one of the gravest aspects of the situation. Apparently agricultural research as a career does not figure as prominently as it did, and the opportunities in other lines of agriculture calling for far less preparation seem more attractive to those who are coming on. The lack of special incentive to prepare for the service of the stations or any prospect of rank or salary corresponding to the high character of the work and qualifications will continue to act as a serious handicap unless it can be corrected. The standards which had come to be recognized in the past can not be lowered without distinct detriment to the character of the investigation.

EFFECT OF OTHER COLLEGE ACTIVITIES.

The return of peace brought greatly increased attendance to nearly all of the agricultural colleges, in some cases unprecedented. These students naturally had to be cared for, necessitating heavier teaching schedules and not infrequently pressing into service those assigned primarily to the stations. The time available for research by the part-time workers was materially diminished, sometimes entirely absorbed. This was a severe setback to the return of the stations to normal. It has by no means been overcome.

The practice of dividing the time of station workers with the college teaching or with the extension work is apparently on the increase. It is a result in part of straitened circumstances, the scarcity of experts, and expansion in other directions; but more often it is ascribable to the college than to the station. Pressure is laid upon the stations to carry a part of the salary of persons whose main business is teaching, and who may even be in another branch of the institution, on the assumption that they can render some service to the station. Frequently the real advantage of the arrangement lies with the college rather than the station. Where much teaching is involved, it is a source of questionable strength to the station and a tax on its slender resources. It is a reversion to a practice in which there had been marked progress in correcting.

There are indications that the attitude of some of the colleges themselves toward the advancement of research has not become increasingly favorable with the growth in other directions. Emphasis has been laid by them on certain other lines, the demands upon them have grown, and their program has continued to include more and more activities which take the college out to the people. With inadequate forces and deficient funds the result is reflected in the station, especially in the case of joint college and station employees.

These things serve to illustrate that our research is not yet on a wholly safe and secure basis. It is the first thing to be affected by an unusual condition. The teaching must go on; the extension work must not be interrupted, and there are increasing plans for outside activities. This is right and proper, but manifestly it should not be at the permanent expense of research.

With the growth of the colleges and with the dominant position they have attained, it is reasonable to expect that research should share in the general advancement when there has been time for adjustment, and that there should be active concern for its protection and stimulation—that the colleges will be insistent that their research departments grow. In the multiplicity and pressure of other interests there is some doubt whether the real condition of the stations and the consequent effects are always fully realized.

Appreciation of research is frequently of a somewhat academic or abstract character; its importance is accepted in a general way somewhat as a matter of course. As it is a mature effort and is less likely than some other branches to involve problems for the administrative head, it is easy to see that contact with the station and its needs might not always be as close as is desirable at this time. In a considerable number of cases, however, where the situation has been brought home to the authorities there has been a gratifying disposition to stress research and to make adequate support an active feature of the developmental program.

THE FINANCIAL SITUATION.

The total revenue of the experiment stations as reported for the fiscal year 1919 amounted to $7,192,912. This, compared with a total of $6,215,681 in 1918, indicates an apparent increase of nearly a million dollars. These figures, however, need to be interpreted to be properly understood, and unless such interpretation is made they are very misleading as to the support of research in the stations and the relative amount spent in its support as compared with the prewar period.

While special effort has been made in gathering the statistics of revenue, the support of the stations is so joined with other features of the colleges and their responsibilities are so diverse in many cases,

including features which have no direct relation to research, that it is very difficult to assemble figures actually representing the funds available or used for investigation and experiment.

Of the total sum reported by the stations for 1919, something over four million dollars was derived from Federal and State appropriations, while the remainder came from sales, fees, individual and community contributions, and miscellaneous sources. Though the total was nearly a million dollars larger than in 1918 and approximately two million dollars larger than in 1914, the difference is more apparent than real. The total appropriation for State stations from Federal and State sources has shown practically no increase in the six years from 1914 to 1919, inclusive. The Federal fund has remained stationary.

The State appropriation for the fiscal year 1914 aggregated $2,575,000; it was a little less for the three succeeding years, reached $2,716,000 in 1918, and was $2,734,000 in 1919. The increase in this six-year period therefore was less than $160,000, which is quite within the fluctuations in the total State appropriation from year to year.

The record shows, therefore, that with 1914 the States ceased adding to their station appropriations in marked contrast to the practice up to that time. In each of the three five-year periods immediately preceding 1914 the total State appropriation practically doubled, or increased in an even greater ratio. Thus, it grew from $168,000 in 1894 to $240,000 in 1899, to $522,000 in 1904, to $1,035,000 in 1909, and to $2,575,000 in 1914.

The present State contribution is not to be understood as wholly direct appropriation for the station maintenance. In several instances the amount reported is an estimate of the college revenues devoted to research, or the allotment made by the college to the station as a whole. The latter is not alone for investigation, but in several instances is in consideration of special services, such as the carrying on of control work, the soil surveys, marketing enterprises, the maintenance of the college farm, or other features. The direct State appropriations also include considerable amounts of money for inspection work, and in a number of cases funds for purposes largely on the border line between station and extension work. At several institutions the facilities for instruction, so far as the farm, dairy, live stock, and orchards are concerned, are provided and maintained by the stations out of their various funds, with little aid from the colleges. These conditions in the aggregate serve to reduce considerably the total budget under this head for experimental work.

Inspection and control work of various kinds still constitutes quite a feature of the station activities and accounts for a considerable part of the direct or indirect funds included in the total of $7,000,000. As the cost of the service comes out of this revenue

these inspection fees contribute but slightly, if at all, to the net revenues for experiment and investigation, considering the stations as a whole. To an increasing extent such regulatory service is provided for in State appropriations and hence goes to swell the total from that source. Only 8 stations reported fees for such work, the total being under $400,000 and fully two-thirds of it being received by two stations.

The sales fund has quite naturally increased in recent years by reason of the high prices of products and the larger areas involved. It usually includes the revenues from substations and from farms used in experiment, together with some tracts which at present are chiefly commercial. In the case of 16 stations, the amount reported covers the entire college farm rather than the portion or features devoted to investigation; and in several other instances it includes the revenues from farms which have been given to the institution and turned over to the station for management, largely as commercial ventures at present.

The growth of the sales fund has been quite steady for many years. In the fiscal year 1894 the amount returned from this source was only $47,300; by 1900 it had nearly doubled, and in 1906, when the Adams fund came, it was over $135,000. From that time it increased rapidly, doubling in the next four years, amounting to $307,000 in 1914, to a half million in 1915–16, and close to $700,000 in 1917. In 1918 it was over $900,000, and in 1919 upwards of $1,400,000. In several cases the amount is very large, ranging from $50,000 to $180,000 or over; in one case it is given as nearly $186,000.

With the possible exception of the last two or three years, the increasing size of the return from sales implies a larger scale of operations involving land, live stock, and farm products. Incidentally it serves effectually to acquit the stations of any possible charge that they are conducting their work increasingly on a laboratory scale, showing that on the contrary they are operating under conditions which very largely conform to those of practice. Nevertheless it is quite misleading as a source of net revenue for research.

The figures reported are for gross returns, and to a very large extent they represent merely a turnover and hence are not to be counted as additional revenue. Farms conducted for experiment or for instruction or demonstration are not ordinarily expected to be revenue producers, owing to the conditions under which they must be maintained.

It is evident therefore that this large item, representing approximately 20 per cent of the total station income, is only to a very slight extent to be regarded as a source of added revenue, the responsibility and time involved in the management of extensive enterprises to a great degree offsetting any net profit. It is true that the conduct of

these larger operations frequently places better facilities at the disposal of the stations, and enables them to carry out their practical experiments on a commercial scale. This advantage and the effect on the public are not to be overlooked.

Another large item of the revenues as reported falls under the head of "miscellaneous," amounting to approximately $1,159,000. This is a convenient repository for items not easily classified elsewhere, consisting in part of allotments or estimated expenditures of the colleges for station enterprises, and the Federal appropriations for the insular stations amounting to $190,000. It is found on investigation to include also balances brought forward from the previous year, aggregating nearly $700,000. These balances are due largely to differences in the fiscal year, the maintenance of a circulating or operating fund, and the like. They were of course included in the returns for the preceding year, and they are found to be almost exactly offset by unexpended balances at the close of 1919. Hence they are not to be counted in the year's revenue. Correcting this miscellaneous item for the balances and the insular station funds leaves less than $270,000 of it to be counted in the assets of the State stations for the year in question.

All things considered, therefore, the station revenues available for the administration and support of experiment and investigation in a fairly strict sense may be said to be limited practically to the Federal and State appropriations, and to less than $270,000 derived from miscellaneous sources. There may be occasional residues under other heads, but these can not safely be counted on as net revenues. The total of $7,000,000 shrinks therefore to a little over $4,250,000, and there are some considerations of late which tend to reduce this amount in its strict application to experimental inquiry.

THE NEED FOR INCREASED FUNDS.

The revenue of the stations, as stated above, has shown practically no increase since 1914, up to which time it was growing steadily. The research activities of the stations practically ceased increasing with the close of that fiscal year, and remained unchanged during the five years following. This is the more marked since in each of the three 5-year periods immediately preceding 1914 the total appropriations from the State had practically doubled or increased at an even higher ratio. The Adams fund was being added to year by year from 1906 to 1911, and between the latter date and 1914 the States kept up the increased appropriations from that source, doubling in the three years from 1911 to 1914.

It is evident, therefore, that the stations as a group came to the period of inflated prices with only a prewar revenue and with very unusual difficulties to face, not the least of which was the keen com-

petition for workers. Because the station funds were growing to a large figure, it apparently was not realized that the funds for investigation and experiment had become stationary in the face of ascending costs. Under the circumstances the stations could not even stand still; they must retrograde or retrench. This is more apparent with some than with others, and on the whole it is remarkable how well the stations have managed to overcome the effects of their straitened circumstances and keep their main lines of investigation going.

This halt in the station appropriations is not attributed to any marked change in public sentiment, and perhaps not primarily to the effects of the war itself. But new legislation diverted attention and placed new demands on the States which have doubtless had their effect. The passage of the Agricultural Extension Act in 1914 and the Vocational Education Act in 1917 called for offsets by the States which have increased from year to year. These charges have been added to by the Federal Road Act, which makes the largest demand of all. The total offset which these three acts call upon the States to contribute is a large one, amounting for the immediate future to about $50,000,000 a year. In some cases this may make it difficult to secure any considerably increased State appropriation for research in the near future.

No institution can hope at this time to maintain its position on a prewar revenue. With the increased cost of expert service, materials, labor, and everything that goes into research, it is manifestly impossible for an experiment station to do so. The price which is being paid for delay in meeting these higher costs is a heavy one, as becomes forcefully apparent when a study is made covering any considerable range of country. It is expressed in a slowing up of research, a diminished force of attack, attention to questions of smaller range or simpler character, and a falling off in publication.

THE OUTLOOK.

Reconstruction throughout the world must rest largely upon agriculture. In this the work of the experiment stations is of paramount importance. The stations must advance and grow, and unless they do inertia and retrogression will inevitably follow, with a diminishing equipment and a lower grade of investigation. The demand upon the stations is continually increasing. Changed conditions and developments in every State bring forward new problems which need to be solved through scientific investigation. The extension service now looks largely to this source for new information, and the farmers are seeking its advice and help more extensively.

Already the legislatures of several States have made noteworthy additions to the appropriations for support. Where the stations have had opportunity to go before the people of their States the

response has usually been excellent. Three States in the South which had not previously contributed to the support of the central stations have made generous initial appropriations, and in another State the representatives of the various agricultural interests were called together, with the assistance of the president of the university, and not only indorsed a biennial station budget for nearly $170,000, but formed a committee to press it actively before the coming legislature. Elsewhere plans for seeking larger State contributions are being laid and the feeling is generally optimistic. In cases where, for local reasons, the station does not have a separate budget or is not named in the estimates, and where it is not permitted to solicit public support for larger funds—and there are some such—relief will depend upon sympathetic and appreciative action by the college administration.

There is still need for a quickening of interest in agricultural research, led by the colleges and expressed in their plans. It is important that attention be given to publicity which will bring the stations and their requirements more definitely home to the public. In a considerable proportion of the States their condition is critical. The inequalities are one of the serious features of the situation at present. Some of the stations in position to do exceptional work are suffering most from shortage of funds. As a group they have reached the limit of their ability to maintain a satisfactory output and to keep step with the advance in the demands for teaching and extension.

The situation is not one for pessimism or discouragement, but rather for right understanding and for action. Never before has there been such a great body of sound public sentiment to support the growth of agricultural institutions, and this sentiment is rapidly growing in force and in understanding. Rightly informed and guided it will enable the present situation to be relieved and will restore the station system to a position for continued growth.

INVESTIGATIONS UNDER THE HATCH AND ADAMS FUNDS.

The Federal sources of support for the experiment stations known as the Hatch and Adams funds have tended to become quite clearly differentiated in their application in the course of time. The wording of the acts indicates the limitations of their purposes, the Hatch Act reading "to aid in acquiring and diffusing among the people of the United States useful and practical information on subjects connected with agriculture and to promote scientific investigation and experiment respecting the principles and applications of agricultural science," while the Adams Act states that the funds appropriated are "to be applied only to paying the necessary expenses of conducting original researches or experiments bearing directly on the agricultural

industries of the United States, having due regard to the varying conditions and needs of the respective States or Territories."

The Federal Department's interpretation of the use to which these funds may be put, having in mind the clear intention of Congress when the respective acts were passed, is embodied in the clause "original research" of the Adams Act, as distinguished from the broader provisions of the Hatch Act for "acquiring and diffusing * * * useful and practical information," through "scientific investigation and experiments." In other words, the later act attempted to reinforce the one passed nearly 20 years earlier by enlarging the amount of original inquiry along the fundamental lines of research, since experience had shown this to be essential to progress. The demands on the stations under the Hatch Act had been so heavy for strictly practical information and they had been called on for such a variety of popular activity that the attention they could give to thoroughgoing research was often very limited. Furthermore, research was not popular, because the need for it was not understood, and there was no extension service to make the contact with the farmer and supply his need for general information. The Adams Act aimed to relieve and sustain the stations, not only financially but in furthering their research; and to insure this it restricted the use of its funds and made them available gradually.

Such limitation is less necessary at the present time than when the Adams Act was passed, and the amount of original investigation and inquiry conducted under the other funds of the stations has vastly increased. There can be no doubt that the rather rigid interpretation of that act has greatly stimulated fundamental research in agriculture by directing attention to its qualities and requirements, encouraging students to prepare themselves adequately for it, and attracting to that field persons with taste and qualifications for it. Its influence on the personnel of the stations has been very marked, and the type of work it represents has been found both practical and necessary to intelligent advancement of the industry.

To properly discharge its function, an experiment station must of necessity carry on work of various grades and kinds, some of which will be relatively simple in method, aiming only at empirical results to answer local questions, or merely comparative or commercial, to meet the immediate need for advice. Such work has served a useful purpose and not all topics which arise call of necessity for thoroughgoing research at present. It is a question of the wise use of funds and facilities, having regard for what is of local importance. The station aims to advance the agricultural interests of its State, without implying the construction too narrowly, and hence it must be governed considerably by the kind of work that is needed. It can not wisely leave its results in the purely research or theoretical stage,

and it often needs to adapt to local conditions facts and theories which are not new or original with the station. But it must advance knowledge and understanding, and it must itself grow through its own efforts.

Although in selecting the lines of effort the stations are to have "due regard to the varying conditions and needs of the respective States," no station can afford to be held down by a local condition for which the extension service may be the real remedy. It must be in contact with the conditions and the needs of its State and it can not close its eyes and ears to appeals for aid, but it must do its work in its own way and meet the situation as seems best in its judgment.

The list of the projects of the stations, or the subjects to which they are addressing themselves, discloses the great variety of their effort, both as to kind and as to character, covering a scope as wide as the agriculture represented by the diverse conditions of the States.

PROJECTS OF THE EXPERIMENT STATIONS.

In response to widespread interest in having a list of projects of all the experiment stations, so arranged as to show what lines of work are in progress and where, such a list was prepared and has been distributed in mimeographed form. This is the first attempt to assemble such a catalogue of station activities. The list relates to projects in operation during the fiscal year 1919. The work of assembling and classifying the titles was done by E. R. Flint, of the Office of Experiment Stations.

The list includes about 3,750 projects. Of these 546 are in progress under the Adams fund, about 3,050 under the Hatch and State funds, and about 150 in the insular stations. Only projects relating to experiment and investigation were enumerated, those relating to purely administrative, inspection, and control work being omitted.

The list served to show how comprehensive is the combined program of the stations, and indicated the relative stress which is being laid on various departments of agricultural inquiry. By far the larger number of projects relate to crop production—soils, fertilizers, field crops, and horticultural subjects. Studies of plant diseases and insect pests have from the first constituted a prominent feature of station work, and cover a wide range. Animal husbandry, dairying, and dairy farming comprise about 700 projects, and diseases of animals add 150 more, accounting together for more than one-fifth of the total. There has been a growth in fundamental inquiry regarding animal nutrition. Rural engineering and rural economics embrace only about 100 and 75 projects, respectively. In both of these divisions there is opportunity for considerable profitable development of inquiry.

One result which should follow from the distribution of this list is to make possible a closer contact between workers on related topics. It should promote the interests of cooperation by making more evident the opportunity for it and the extent to which workers are laboring independently of one another. The information given largely removes the excuse for such duplication or repetition as may be unnecessary and not justified in the present status of experimentation. Such repetition as is frequently necessary can have more definite reference to the work of others and therefore be made more specific in its purpose.

The importance of making projects definite and of limited range has frequently been urged. The list discloses a large nunber of projects of broad, general character, although as actually conducted at present the work is frequently much more specifically directed at definite points. There is little call at this stage to perpetuate broad general topics of investigation which lack clarity of aim. Such projects may well be recast to put them in more definite form and thus bring them down to date.

There are some subjects on which comparatively little original research is now in progress, as the stations fully realize, and this situation is an indication of the need for growth. The total number of projects, however, averaging nearly 65 for each institution, is manifestly more than can usually be carried to advantage. Not infrequently workers are endeavoring to conduct more projects than they can keep up with adequately and more than can be properly supported with the present funds. They have been reluctant to discontinue these, the hope being that additional support might enable their more active prosecution. The list as a whole supplies renewed evidence of the wide usefulness of the stations and the importance of their adequate support.

COOPERATION IN EXPERIMENT STATION WORK.

The advantages of cooperation among the various agencies engaged in agricultural research are, in many cases, obvious. While not all problems lend themselves to cooperative work, a large number either present so many phases, or the value of an accumulation of data under varying conditions is so great, that cooperation is of distinct advantage. In other cases, where direct cooperation does not seem advisable, coordination of investigations along the same lines in order that results may be comparable or supplementary is of benefit. One advantage of cooperation lies in the prevention of useless duplication of work and equipment, and the opportunity for more intensive application to some particular phase by each investigator. With problems that are regional in their scope each section is brought in touch not

only with the main problem, but also with its local aspects. A further distinct advantage lies in cooperative planning, in that the combined experience and the discussions and suggestions of those who are to participate tend to a more complete grasp of the questions to be investigated. One of the obstacles in organizing a cooperative undertaking is the separation of workers and the difficulty of bringing them together around a common problem and eliciting their united effort.

It is encouraging to note that the experiment stations are extending their cooperative activities, not only among themselves, but with individuals, agricultural associations, and organizations, and with the United States Department of Agriculture in the various States. Nearly all of the stations have entered into projects carried on cooperatively with the various branches of the Federal Department of Agriculture, over one hundred such projects being reported. A number of war emergency lines of work were taken up cooperatively through the National Research Council, many of which are proving of such value that they will be continued, although the emergency that suggested them no longer exists.

Such problems as the protein requirements for growing calves and the requirements of adult animals for maintenance and milk production, entered into by a number of the stations under the leadership of the Pennsylvania Institute of Animal Nutrition; the composting of raw rock phosphate in order to increase its availability; and the relation of feeding peanuts and other factors to what is classed as "soft pork," conducted by a number of the southern stations, have yielded a greater accumulation of systematic data in a much shorter period of time and under varying conditions than could otherwise have been the case.

Not only is this type of cooperative work becoming more general, but the value of cooperation between the various departments within the stations themselves is being recognized. Many projects present a number of phases, the solution of which involves different departments, and only by their cooperation is it possible to obtain comprehensive results on the whole problem.

NEW LINES OF WORK.

Among the more recent problems that are engaging the attention of the experiment stations may be mentioned the study of the vitamines, which is modifying previously held theories on nutrition and the respective values of feeds. A number of the stations have entered this new field and are obtaining results of the greatest improtance bearing on the relation of the different forms of vitamines to growth, maintenance, reproduction, and preservation of health.

The gradual encroachment on the western ranges for farming purposes, with the resulting intensive grazing of the remaining areas which is threatening to kill out the native grasses, has led a number of the western stations to make a study of methods for their conservation. Closely connected with this study is the subject of poisonous range plants, which are causing increasing losses as the formerly abundant nutritious grasses are being used up, with the result that sheep and cattle are grazing on plants that would formerly have been passed over. A number of the western stations have taken up this line of work, and many plants formerly considered harmless have been found to contain poisonous principles. Studies of methods of eradication and of range management which will tend to prevent the grazing of live stock upon these plants promise a large reduction in losses from this cause.

Among recent results of work in entomology may be mentioned the discovery that the potato leaf-hopper is responsible for a form of the disease known as "tip burn," which in some sections has caused serious losses in this crop. The demonstration of the connection of this insect with the disease makes possible the application of effective methods of control. The timely discovery of the European corn borer by the Massachusetts station has allowed active steps to be taken for control before it becomes so firmly established as to make this impossible.

The study of the relation of peanut feeding and other factors to the production of soft pork, while not a new line of inquiry, has received a new impetus through the arrangement for cooperative study by a number of the stations in the Southern States. This will have a direct influence on a large and growing industry in that section of the country.

Years of drought, with consequent failure of crops as well as of the natural grasses on the ranges of the Southwest, take a toll of live stock that frequently results in a serious menace to the industry. Experiments by the stations in that section have demonstrated that this loss can be largely averted by feeding yucca or soapweed and some of the other desert plants when properly prepared, by which means range stock can be carried over such seasons until better conditions prevail.

The sunflower as a forage crop, introduced in the Northwest through the work of the Montana and other stations, has proved to be a valuable addition to the agriculture of that section. It has been found to be suitable for both dairy and beef cattle, makes an excellent quality of silage, and produces large yields.

Breeding and selection work, both with field crops and with horticultural plants, carried on by many of the stations, is producing higher yielding and more disease-resistant strains. Encouraging re-

sults are being obtained in the production and introduction of hardy fruits for the Northwest, by the South Dakota and other stations, which are utilizing plants found in colder climates for breeding stock for this purpose.

PERSONNEL OF THE STATIONS.

The change in personnel during the year was exceptionally large, and was due to numerous causes. In many instances, men who went into war service did not return to their former positions, and new appointments were necessary. An unfortunate contributary cause lay in inability to offer adequate salaries to compete with the opportunities offered in commercial lines, research men in all branches of science being more and more in demand for technical positions. In some instances, the station resources became relatively so restricted that a cutting down of the staff was necessary. A majority of the changes occurred among the assistants and in minor positions, but they affected heads of departments sufficiently to indicate the serious condition confronting the stations with regard to the stability of their organizations. Following are some of the more important changes:

A change in directorship occurred in eight of the stations. D. W. Working was appointed director of the Arizona station in March, 1919, succeeding President R. B. von Klein Smid, who succeeded R. H. Forbes in February, 1918. H. J. Webber assumed the directorship of the California station in May, 1919. At the Georgia station H. P. Stuckey succeeded J. D. Price as director. W. M. Jardine, director of the Kansas station, was elected president of the Kansas State Agricultural College and was succeeded in the directorship of the station by F. D. Farrell. W. P. Brooks resigned as director of the Massachusetts station in October, 1918, and was succeeded by F. W. Morse as acting director, Dr. Brooks retaining his connection with the station as consulting agriculturist. E. R. Lloyd, director of the Mississippi station, resigned and was succeeded by J. R. Ricks. L. Van Es, acting director of the North Dakota station, resigned to accept a position in the Nebraska station, and was succeeded by P. F. Trowbridge, formerly of the Missouri station. E. C. Johnson was appointed director of the Washington station, to succeed I. D. Cardiff.

A. W. Morrill, consulting entomologist, and D. C. George, consulting plant pathologist, resigned from the Arizona station.

At the Arkansas station W. L. Bleecker succeeded C. L. McArthur as head of the bacteriological and pathological department and J. B. Rather was succeeded by J. W. Read as head of the department of agricultural chemistry.

At the California station, J. B. Davidson, head of the department of agricultural engineering resigned and was succeeded by L. J.

Fletcher. J. C. Whitten, formerly of the Missouri station, was appointed head of the department of pomology.

Miss E. L. Ferry, research chemist at the Connecticut State station, died in October, 1919.

D. C. Dyer resigned as chemist of the Delaware station, and was succeeded by A. C. Whittier. C. C. Wiggens was appointed research horticulturist, but resigned at the close of the year. At the Georgia station T. E. Keitt, formerly of the South Carolina station, was appointed chemist and J. A. McClintock was placed at the head of the botany and plant pathology department during the absence of B. B. Higgins.

Paul Emerson, formerly bacteriologist at the Maryland station, was appointed bacteriologist of the Idaho station and later resigned. V. H. Young was appointed head of the botany department and C. W. Hungerford in the plant pathology department. R. E. Neidig was placed in charge of the chemical department. H. P. Davis was appointed vice director and head of the dairy department. R. K. Bennett, formerly of the Kansas station, was placed in charge of the farm crops department.

Cyril C. Hopkins, vice director and head of the agronomy department of the Illinois station, was away during the year on special agricultural work in Greece. N. W. Hepburn associate in dairy manufacture, resigned.

O. E. Reed was appointed chief in dairy husbandry at the Indiana station. A number of associates were appointed, including G. H. Roberts in the veterinary department, C. M. Vestal and F. G. King in the animal husbandry department, R. H. Carr in the nutrition department, and M. W. Gardner in the botany department. The resignations included R. E. Caldwell, acting chief of the dairy husbandry department; H. M. Weeten, associate in dairy bacteriology; and H. A. Noyes, associate in horticulture.

The principal changes in the personnel of the Iowa station included the appointment of E. D. Ball as chief of the department of entomology; the resignation of W. H. Pew, chief of the animal husbandry department, who was succeeded by H. H. Kildee; and the resignation of G. M. Turpin, chief of the poultry department, who was succeeded by H. A. Bittenbender.

In addition to the change of directors at the Kansas station, C. W. McCampbell succeeded W. A. Cochel as head of the department of animal husbandry. J. B. Fitch was appointed head of the department of dairy husbandry, Theodore Macklin head of the department of agricultural economics, and R. L. Hensel head of the department of range management. E. F. Ferrin was appointed associate in animal husbandry in charge of swine investigations and F. W. Bell of horse

investigations. B. V. Severson, associate in animal breeding, died of influenza in December, 1918, at the age of 31.

P. L. Blumenthal resigned as research chemist at the Kentucky station.

A. P. Kerr was appointed chemist at the Louisiana station, in charge of the fertilizer and feeding stuffs inspection laboratory, succeeding G. D. Cain, who was appointed assistant director in charge of the North Louisiana station at Calhoun.

Changes in the Maine station included the resignation of the biologist, F. M. Surface, and the chemist, H. H. Hanson.

E. M. Pickens was appointed animal pathologist at the Maryland station.

Some of the more important changes at the Minnesota station included the appointment of William Boss as chief of the division of agricultural engineering; C. H. Eckles, of the Missouri station, as chief of the dairy department, succeeding H. H. Kildee; L. I. Knight as plant physiologist; and J. D. Black as acting chief of the agricultural economics department. F. Jager, chief of the beekeeping division, returned from leave of absence in Serbia.

H. K. Gayle resigned as head of the animal husbandry department at the Mississippi station and was succeeded by D. J. Griswold.

M. F. Miller was acting director of the Missouri station during the absence of Dean F. B. Mumford, V. R. Gardner was appointed professor of horticulture, C. R. Moulton succeeded P. F. Trowbridge as head of the department of agricultural chemistry, and A. C. Ragsdale succeded C. H. Eckles as chief of the dairy department. H. O. Allison resigned as associate in animal husbandry and L. S. Palmer as dairy chemist.

At the Montana station M. H. Swenk was appointed chairman of the department of entomology.

M. R. Miller succeeded C. A. Jacobson as chemist at the Nevada station.

B. D. Halstead, associated with the department of botany at the New Jersey station since 1889, died in August, 1918, at the age of 66. His work had dealt extensively with the breeding of plants and improvement by selection; and he had conducted studies in various branches of plant physiology.

At the North Dakota station L. Van Es, veterinarian and acting director, resigned to go to the Nebraska station, and A. F. Schalk was put in charge of the department. P. F. Trowbridge assumed his duties as director in August. W. H. Peters, of the animal husbandry department, resigned to accept a position in the Minnesota station and was succeeded as head of the department by J. H. Shepperd. R. C. Doneghue, of the agronomy department, was succeeded by H. L. Walster. C. J. T. Doryland, the soil bacteriologist, resigned.

The head of the department of animal husbandry at the Oklahoma station, J. S. Malone, resigned and the position was filled during the year by W. L. Blizzard, as acting chief.

At the Oregon station J. S. Jones was appointed head of the agricultural chemistry department to fill the vacancy caused by the resignation of H. V. Tartar. M. B. McKay was advanced from assistant to associate plant pathologist, and W. S. Brown was appointed pomologist to take the place of V. R. Gardner, resigned.

S. M. Bain, of the botany department, and W. G. Shaw, of the veterinary department, at the Tennessee station, both died during the year. Prof. Bain had been associated with the institution since 1893 and professor of botany since 1901. His death occurred in January, 1919, at the age of 50. His experimental work dealt particularly with red clover and its diseases. Dr. Shaw, who died in April, 1919, had been with the station since 1915.

At the Utah station E. B. Brossard was appointed head of the department of farm management and R. L. Hill, head of the department of human nutrition. R. J. Becraft was placed in charge of the department of range management. W. C. Carroll, head of the department of animal husbandry, who was away on war work, returned.

C. E. Wilson was appointed entomologist at the Virgin Island station.

At the West Virginia station E. L. Anthony was appointed head of the dairy department and H. A. Jones as associate horticulturist. E. W. Sheets, of the animal husbandry department, resigned.

LEGISLATION AFFECTING THE STATIONS.

In many States no legislation affecting station work was enacted during the year. Following are notes on such legislative acts as are of particular interest in this connection:

Three special appropriations were made by the Arizona Legislature, including $10,000 for citrus investigations, $10,000 for the purchase of additional land at the Yuma date orchard, and $30,000 for irrigation investigations in Cochise County.

The 1919 Arkansas Legislature passed an act permitting the trustees of the university to draw upon the appropriation made to the university under the millage tax, to the extent of $75,000, for the purchase of land, the payments to be made as follows; $25,000 to be paid out of the appropriation for the biennial period ending June 30, 1920, and $25,000 to be paid out of each of the two succeeding biennial appropriations. Under the above act the trustees purchased approximately 425 acres of desirable land lying from $1\frac{1}{4}$ to $2\frac{1}{4}$ miles north of the university campus. No appropriations were made for branch station work, consequently the work in progress there had to be abandoned.

The last California Legislature provided for uniting the various agricultural activities of the State into the "State department of agriculture," which will have charge of all agricultural police powers in the State, including the fertilizer control and insecticide act, formerly in charge of the director of the experiment station.

In Connecticut a statute provides that the State forester and the State entomologist, both members of the station staff, with the station botanist, shall be a commission to examine, and, if found competent, to license those who undertake, for pay, the care of forest, shade, and fruit trees, and to issue certificates to them. A new and more satisfactory fertilizer law was passed which increases somewhat the income of the station. An appropriation of $100,000 was made for a new laboratory on the station grounds, for the joint use of the station and the State board of health. It is the development of a policy to concentrate in one place the laboratory research required by the State. The general assembly, at the session of 1919, increased the annual appropriation to the Storrs station from $7,500 to $12,500.

The Florida State station appropriation was cut down from $28,000 for the biennium to $10,000 for the same period.

The Idaho Legislature made an appropriation, for the first time, of direct State aid for the central station of $15,000.

In Massachusetts legislation consisted principally of interpretations and rulings by State officials based on a constitutional amendment forbidding State appropriations not fully under State control, and an old statute, to which the college and station are now amenable. These included the following rulings: No salaries in excess of $1,000 per year may be increased without the consent of the governor's council; no salaries nor wages may be increased between the first of December and the first of June, which is the usual period of the annual legislative session; apparatus and equipment may be repaired or renewed from the annual maintenance appropriations, but any addition to apparatus or equipment must first be approved by the legislature as a part of the annual budget; all cash receipts, including fertilizer fees, etc., must be remitted monthly to the State treasurer and any unexpended balances revert to the State at the end of the year. The last is an opinion based on a constitutional amendment which supersedes definite statutory provisions for the use of the fertilizer and other fees. Numerous minor rulings were made which apply to the control of station funds by other officers than those of the college.

The Minnesota Legislature passed a potato seed certification law.

Funds were appropriated for a horticultural building at the New Jersey station.

In New Mexico a pure-seed law was passed, and part of the work, according to this law, is to be done by the station, such as testing the different kinds of seeds.

The State laws of New York have made salaries of station workers statutory and imposed quite rigid control over other expenditures.

The South Dakota Legislature authorized the purchase of 240 acres of land, which will add greatly to the station's facilities.

A special appropriation of $15,000 per annum for two years was made by the Texas Legislature for the establishment of a wool and mohair scouring plant.

A feeding stuffs law and a dairy code, enacted by the Washington Legislature, require that the necessary analytical work shall be done by the station chemist, who is also State chemist. Similar agricultural and vegetable seeds legislation was enacted, but no special appropriation to the station for this work was made. An act passed establishing a division of apriculture at the State college, to regulate the importation, keeping, and sale of bees, and $4,000 was appropriated for the biennium to enforce this.

In West Virginia the legislature increased the appropriation by making the $10,000 annual war emergency fund a part of the annual appropriation. An act was also passed providing for the construction of a community fruit-packing plant, to be operated by the college of agriculture; an appropriation of $25,000 was made for building this plant and an annual sum of $4,000 to be used for operating it. The 1919 legislature appropriated an additional $30,000 to be used for farm buildings on the station farms and $15,000 for farm buildings on the Reymann Memorial Farms at Wardensville. These appropriations of $70,000 did not become available until July 1, 1919.

The only important legislation affecting the Wisconsin college of agriculture and station was the appropriation of funds for the establishment of an additional branch station in Door County. This provides $5,000 from State funds to be met by $5,000 from Door County funds for the present fiscal year, and $12,000 additional from State funds for the coming year. The sum of $15,000 was also appropriated for the purchase of land for the branch station at Marshfield.

The Wyoming Legislature passed an act placing all experiment farms and stations of the State, now existing or hereafter to be established, under the supervision, management, and control of the director of the experiment station. W. L. Quayle was appointed director of experiments. The farms at present are located at Lyman, Grover, Eden, Archer, Torrington, Jireh, and Sheridan, and an act of the last legislature calls for an additional one at Gillette.

STATISTICS OF THE STATIONS.

The detailed statistics of the experiment stations by States as to organization, working force, publications, revenues, etc., are given in the tables at the end of this report.

In the work of administration and inquiry the stations employed 1,881 persons, of which 944 were also members of the teaching staff of the coleges, and 410 assisted in the various lines of extension work. During the year the stations published 1,285 annual reports, bulletins, and circulars, aggregating 25,046 pages, and these were distributed to 959,068 addresses on the regular mailing list. A revision and reclassification of the mailing lists by many of the stations reduced the number of names listed as compared with the year before.

In the statistics of revenues here presented, all balances from the previous year, heretofore given under miscellaneous, are reported in a separate column under the heading "Balances from previous year"; while the funds received from individuals and communities, accounted for separately in earlier reports, are included in the miscellaneous items. This is believed to show the financial resources of the stations to better advanatge, as it is possible, under this arrangement, to arrive at the net total revenue of the stations for the year.

The total income of the experiment stations for the fiscal year ended June 30, 1919, was $7,192,912.41, comprising $715,287.99 derived under the Hatch Act, $710,125.93 under the Adams Act, $190,000 from Federal appropriations for the insular stations, $2,734,089.20 from State appropriations, $398,795.01 from fees, $1,439,817.92 from the sale of products, $491,551.75 from miscellaneous sources, and $688,658.53 carried over as balances from the previous year.

At present, six of the stations receive no State aid, two others receive appropriations for the branch stations only, and four others receive less than $5,000. Nine stations are receiving over $100,000 each from the State, the highest being $265,500.

The estimated value of additions to the equipment of the stations during the year was as follows:

Buildings	$433,694.26
Library	19,726.59
Apparatus	63,547.26
Farm implements	102,166.30
Live stock	184,646.81
Miscellaneous	157,046.54
Total	960,827.76

Additions to the building and equipment were not so extensive as in some years, because of the higher cost of material and labor. Some of the more prominent additions are noted as follows:

At the Delaware station a well-equipped research laboratory was added to the horticultural department.

An irrigation system was installed on a portion of the farm at the Florida station, to be used for forage crop experiments, and plans

are being made for starting experimental work at the new citrus substation at Lake Alfred.

A service building for the poultry department of the Idaho station, to cost $1,500, is nearing completion, and a greenhouse, 75 feet in length, was completed during the year, and is used by the various departments for experimental work.

A feeding plant was erected at the Caldwell (Idaho) substation providing for 144 head of cattle and 1,000 sheep, with a reserve water-storage tank holding 9,000 gallons, at a cost of $3,500. A superintendent's house, costing $2,700, and a barn costing $1,000 were built at the high altitude station at Felt.

At the Indiana station the Pinney-Purdue farm of 400 acres was purchased for $55,000, with 67 acres additional for $8,000. Live stock and equipment to the value of $12,490 were added to the station. At the Wilson farm, a house, barn, and shed were erected at a cost of $9,250. Improvements at the Moses Fell Annex included a house, shed, and poultry house, costing $7,090, with live stock and equipment, and 79 acres of additional land obtained at a cost of $2,370. Various additions to the equipment of the central station were made, to the value of $42,600.

Two glass houses and a foreman's cottage were built at the market garden field station in Massachusetts.

The new chemical building at the Montana station was completed during the year, the construction being fireproof throughout. The station will occupy three laboratories, a storeroom and two offices, and in the basement storage rooms and grinding rooms for soil and forage.

New laboratories were equipped for the veterinary and range management departments at the Nevada station.

A new wing to the dairy barn was completed at the New Jersey station.

At the New Mexico station a drying house to be used in nutrition studies was erected during the year.

Plans for a new insectary at the New York Cornell station were completed.

An office and laboratory were erected at the North Carolina trucking branch station, and a laboratory is under construction at the tobacco branch station, costing about $2,500 each.

At the North Dakota station a recent addition to Science Hall, while not used for experiment station work, relieves congestion in the old building. Stalls, harness, and other equipment have been installed for digestion investigations.

At the Ohio station a new range of greenhouses was completed, to replace the older buildings.

An underground cold frame serving as a greenhouse for the horticultural department was added to the equipment of the Oklahoma station.

Two large warehouses at the Army camp at Las Casas, Porto Rico, were transferred from War Department to the Department of Agriculture for the use of the Porto Rico station, and have been utilized for the construction of much-needed residences, laboratories, and stables.

The South Carolina station has added over $4,000 worth of pure-bred breeding stock to the dairy herd. A cotton gin was installed at the Pee Dee branch station.

The newly completed agricultural building at the South Dakota station is occupied in part by the station. A farm of 240 acres was purchased, available March, 1920.

Two large barns were nearing completion at the close of the year on the Cherokee farm at the Tennessee station, and at the newly established middle Tennessee substation an administrative building, stock, horse, dairy and implement barns, and four cottages for laborers were under construction.

A special appropriation of $15,000 per annum, for two years, was made by the Texas Legislature for the establishment of a wool and mohair scouring plant. The newly completed office and laboratory building, known as the Research Administration Building, was occupied.

An appropriation of $25,000 was made by the Utah Legislature for the purchase of additional land to be used for experimental purposes and for the erection of a seed house, a greenhouse, and a new horse barn, in addition to three new buildings provided by the last legislature.

Extensive repairs were made on several of the buildings already on the grounds at the Virgin Islands station, and a number of pieces of machinery were added to the equipment.

The rebuilding of the portion of the greenhouse which was destroyed by fire at the West Virginia station, was nearly completed by the end of the year. The new agricultural building, Ogleby Hall, was completed and occupied, as were two large barns on the new live-stock farm, and $1,200 was expended on the agronomy barn in fitting it up for special work.

A donation of 50 acres of land was received by the Wyoming station, with the necessary water, which will be a desirable addition to the agronomy farm. A new hog house was completed, and a contract made for the construction of a 12 by 30 foot hollow-tile silo. A number of items of valuable laboratory equipment were received.

SOME RESULTS OF STATION WORK.

The progress made in the various lines of investigation carried on by the experiment stations has been very satisfactory, notwithstanding the adverse conditions under which the work has been done. The increased cost of material and supplies as well as the difficulty of maintaining the staff made it increasingly difficult, in many instances, to pursue successfully the program already undertaken or to institute new lines of work.

Following is a brief summary of some of the more important lines of progress during the year:

AGRICULTURAL CHEMISTRY.

The Oklahoma station finds that a portion of the prussic acid that develops in grain sorghums is given off during the process of curing, the amount depending on the length of time required for curing and the condition of the plant. If dry, hot weather occurs at this time, a greater percentage of this compound is retained.

Studies on the deterioration of stored corn and corn meal at the Kentucky station show that if corn does not contain over 12 per cent of moisture it will keep in a dry atmosphere, and meal made from such corn will remain in good condition for a year or more, but if the moisture reaches 15 per cent molds develop and the corn spoils. The factors causing deterioration are moisture, enzyms, heat, and microorganisms. Aseptically prepared samples, free from moisture, at room temperature, gave a germ count of only 15 to 30 per gram after 34 days, and 30 to 120 after 94 days, while samples with 20 per cent of moisture were overgrown with molds after 34 days and contained millions of organisms per gram after 94 days.

Chemical studies of frosted wheat at the Montana station show that the earlier this occurs the less completely the proteins are built up. Normal wheat contains from 4 to 5 per cent of nonprotein nitrogen, while in frozen samples it runs as high as 12 to 14 per cent, the frozen samples showing an increase in reducing sugars also. This difference in composition makes an appreciable difference in the baking qualities.

The baking qualities of wheat were investigated at the Washington station also, with the conclusion that "quality" does not depend on the percentage of gluten alone, various other factors entering into it, particularly the basic nitrogen. Cultivation was found to have an influence on the nitrogen content of wheat, which can be increased as much as one-third by proper methods, although this is closely connected with moisture conditions. There was not much difference in this respect between winter and spring wheat under proper handling.

At the Montana station yellowberry was found to be high in wheat cut in the milk stage, dropping to a minimum with later cuttings, and then rising again.

A study at the Minnesota station of the chemistry of disease resistance in plants has led to an interesting theory of the possibility of something corresponding to the vitamines in animal nutrition, which are necessary for plant growth, the presence or absence of which may explain immunity to certain diseases.

Investigation of the clarification processes in cane sugar at the Louisiana station shows that it is possible to get more sugar out of the molasses than by the ordinary sulphitation process, by treating raw juice directly with kieselguhr and decolorizing the filtrate with carbon.

A number of the stations, notably those in Arizona, Colorado, Nevada, and Wyoming, made extensive studies on poisonous range plants. The toxic principles of three species of larkspur have been isolated and identified. These differ with each species, some containing more than one alkaloid, mostly crystallinic. These are poisonous to cattle, but less so to sheep, and horses do not eat the plant to any extent. Other poisonous plants, such as the woody aster and the whorled milkweed, have also been studied. The Mississippi station has isolated the toxic principle of ergot on paspalum. It occurs in the oil and apparently is not an alkaloid.

The North Carolina station in extensive studies of gossypol, the poisonous principle of the cotton seed, found it to be in the resin glands distributed throughout the entire kernel, both the meat and hulls containing from 0.6 to 0.8 per cent. Feeding experiments showed that the presence of an alkali or of iron salts reduces the toxicity to some extent, as does cooking the kernels.

An investigation by the Oklahoma station of the development of oil in cotton seed shows this to be continuous and uniform. No sugar is found previous to the formation of the oil, except a little glucose, which remains quite constant during growth.

A profitable method of making acetic and lactic acids from corncobs was perfected at the Wisconsin station.

A study of the chemical changes which take place in a lime-sulphur-lead-arsenate combination spray, by the Kentucky station, showed that if acid lead arsenate is used, a portion of the sulphur reacts with the lead salt to form a sulphid and soluble salts of arsenic, decreasing the efficiency appreciably. This can be largely corrected by adding lime at the rate of 10 pounds to 100 gallons of solution.

The Wyoming station has been very successful in alkali proofing cement. Among the salts commonly present in "alkali," magnesium chlorid had the greatest disintegrating effect, because of the action of hydrochloric acid produced by the hydrolysis of the salt. The

presence of sodium carbonate in solutions of the other salts retards the disintegrating effects. Calcium sulphate had no bad effects. The mixing of cement in weak solutions of sulphuric acid, di-sodium phosphate, magnesium fluorid, and oxalic acid is of advantage and increases the alkali-resisting qualities.

BOTANY AND PLANT PHYSIOLOGY.

Studies at the Montana station on the effect of arsenic on vegetation showed a general suspension of all physiological activities, such as translocation, etc., with a reduction in growth.

Permeability by a given salt, studied with peach trees at the Delaware station, may vary with soil treatment. Potash-treated trees do not behave as do those which receive nitrogen and phosphoric acid. Sulphates do not influence permeability to any extent, chlorids exert some influence, and nitrates much more.

Investigations conducted at the New Jersey station on the salt requirements of agricultural plants show large differences in the requirements and proportions of salts at different stages of growth.

Studies on the translocation of mineral matter of plants at the Kentucky station confirmed previous observations that when the jack bean is grown in distilled water about half the mineral content of the bean remains unused in the cotyledons.

Studies at the California station show that sap concentration decreases as growth becomes rapid and that growth and high concentration are opposed to each other.

Conditions adverse to the normal growth of the tree were found by the same station to be responsible for die-back or winterkilling of walnuts, such as early fall frosts, prolonged drought during the early winter, a high water table, especially with sudden fluctuations of the same, and highly alkaline soils.

The California station found that plants grow well with very weak nutrient solutions. If the amount of nutrients is sufficient, the concentration, if not too high, is not an important factor. Excess of nutrients can be taken up by a plant, above the amount needed for optimum growth, without effect on the yield, and with little or no change in the composition of the seed.

In a study of nitrogen fixation at the New York Cornell station certain green algæ were found to have the property of fixing nitrogen in large quantities.

Studies of enzym activity of plants at the Delaware station showed that this was increased by the anions of plant food elements much more than by the cations.

Investigations on the optimum conditions of light for plant response at the Massachusetts station showed that cutting down the light intensity stimulated leaf growth up to a certain point, but blooming

and fruiting were diminished. It was also noted that when the stomata are closed from diminished light stimulus injury from fumigation is much diminished.

The carbohydrate metabolism in sweet corn has been studied at the Maryland station. The changes in the starch progress much more rapidly in early than in late corn. Fiber, protein, and fat come to an equilibrium at an early stage, after which the change is mostly in sugar and starch.

BACTERIOLOGY.

At the Idaho station a study has been made of the influence of various woods and sawdust on the biological activity of soils, which will apply to considerable areas in the State. The decomposition of sawdust was found generally to be so slow that it did not have much effect on the bacterial flora. There was no retarding of ammonification on the addition of sawdust where the moisture requirements were sufficient, but the addition of over 1.5 per cent of white pine sawdust caused a marked decline in nitrification.

Investigations at the Delaware station on the bacterial changes brought about in soils by liming and other treatments showed that nearly all soils were improved from a bacteriological standpoint by meeting the lime requirement, the usual effect being to increase the azotofiers and nitrifiers, and in some cases the actinomyces. The addition of lime and manure to some of the soils increased their bacterial flora 400 per cent. Manure increased the ammonifiers, especially the subtilis group, and if added without lime tended to increase the number of molds and mematodes. Phosphorus compounds alone had no influence on the flora. Fungi have been supposed to be present especially in acid soils, but the New Jersey station found this not to be the case. Azotobacter was absent in unlimed but present in limed soils, the number of fungi also being larger in the latter.

At least one organism has been isolated from Kentucky soils capable of exerting a solvent action on soil silicates, but this action is not very marked on the liberation of potash. In a study of the longevity of *Bacillus radicicola* in the soil at the Missouri station it was found that drying in the sunlight or storing in the dry state for 6 to 12 months apparently had no seriously injurious effects on the inoculating power of the soil. Associative action of bacteria in soils has been under investigation at the Colorado station, but thus far, with over 500 combinations of 17 different organisms, the ammonia formation from peptone proceeded at practically the same rate with pure cultures alone as in mixtures. A study of bacterial forms found upon rock surfaces has brought out some that are possibly new species, which appear to have the power of atmospheric nitrogen fixation.

Investigation on the form of nitrogen in the nodules of legumes at the Tennessee station has been largely a study of the agencies active in breaking down the protein in the nodules, and a pure enzym has been isolated capable of doing this. Cultures of the nodule bacteria, grown in nitrogen-free culture solutions, never contained sufficient protein to give even a qualitative reaction, but a resinous substance free from nitrogen was produced which is believed to have some relation to the growth of the plant. No amino acids were produced in the cultures and the accumulation of nitrogen in them was not definitely demonstrated. Experiments carried on at the Wisconsin station indicate that soy bean nodule bacteria are capable of living under field conditions for at least 17 years, and that they will tolerate soils having a strong acid reaction.

Studies at the New York State station on the decomposition of manure indicate that spore-forming organisms do not play an important part in this process. The most active organisms of manure are also found in the soil.

The New Jersey station has found a number of organisms, including species of Fusarium and a number of bacteria, that will oxidize sulphur.

The South Carolina station is making a study of the bacterial content of milk from milking to cooling. Holsteins showed a uniformly lower count, but the percentage increase in bacterial content was the same for both Helsteins and Jerseys. Care of the utensils used was found the main factor in producing milk low in bacterial content and in holding it sweet for the longest period of time. A rapid method for the bacteriological examination of milk by direct microscopical examination has been devised by the New York State station, which is sufficiently accurate to grade commercial milk as good medium, or poor, and which has been adopted in many localities.

Media based on liver and spleen tissue were found, by the Colorado station to be far superior to any other for the cultivation of *Bacillus abortus*.

A study of the deterioration of cane sugar at the Louisiana station has shown that mold spores contain enzyms and have the power of inverting manufactured cane sugar. A decrease in concentration of the sugar solution in the films surrounding sugar crystals, as well as an increase in the number of mold spores present, is responsible for an increase in deterioration. The mold causing most of the deterioration was *Aspergillus sydowi*. The practical control of deterioration depends upon the proper drying of the sugar under sanitary conditions which prevent mold infection.

GENETICS.

Extensive studies carried on by the Alabama station on the inheritance of oil and protein in cotton seed and the correlation of these with other characters showed that there is a much more definite correlation of characters in the "lint index" or quantity of fiber in a unit weight of seed than in percentages. A high and a low lint index were found to be associated respectively with a small and a large amount of oil in 1,000 seed. In the relation of lint and protein also, a high lint index was associated with large amounts of protein in 1,000 seed. This was illustrated in two strains of the same variety, one with a low and one with a high lint index. The low index strain, with 6.10 per cent, required 170 bolls to give a pound of lint and 85,000 bolls to give 500 pounds of cotton. The seeds produced contained 184.5 pounds or 24.6 gallons of oil and 193 pounds of protein. With the high index strain, with 8.25 per cent, 128 bolls gave a pound of lint and 85,000 bolls gave 665 pounds of cotton. The seed contained 200 pounds or 26.7 gallons of oil and 210 pounds of protein. Thirty and five-tenths per cent more bolls must be produced by the low index cotton to equal the high index one.

Seventy-two distinct strains have been isolated from King cotton by the North Carolina station, of which 28 are still under observation in the study of plant characters. The range in these strains is considerable, the lowest averaging only 74.6 grams of seed cotton per plant, as against 183.6 grams for the highest yielding strain. In weight of bolls there was a range from 4.55 grams to 7.25 grams in length of lint from 21 to 28 millimeters and in per cent of lint from 35.3 to 42.1.

Inheritance in cereals, especially resistance to smut in wheat and oats, has been studied at the Washington station. In wheat this was found to be inheritable but complex in its segregation and not a unit character, involving at least three factors, which differ somewhat in different varieties, some of which will transmit it, others not. Crimean and Australian wheats resisted smut infection for two generations. Oats were found to act quite differently from wheat, the first generation from parents with 55 per cent of immunity showing complete immunity. Studies in the correlation of long-headed plants to yield in wheat at the South Dakota station showed some increase the first year which fell off rapidly in succeeding crops, indicating that if any benefit is to be expected from such selection it must be done yearly. From a series of studies on the correlation of characters in inheritance in oats at the Montana station correlation coefficients have been worked out for many characters that appear to be quite definite and of general application. Investigations on wheat at the North Dakota station indicate a definite segregation relative to inheritance of susceptibility to rust, but this is not conditioned by

simple ratios. Much sterility results from crossing different subspecies of wheat.

Studies in plant breeding at the Connecticut State station led to the conclusion that the physiological stimulation resulting from crossbreeding and the loss of this following inbreeding allow of a strictly Mendelian interpretation, and that good or bad results from inbreeding depend solely on the constitution of the organisms before inbreeding is commenced. As a means of analyzing and purifying a crossbred stock by the elimination of undesirable qualities, inbreeding is of the first importance in plant and animal improvement. In work with corn, vigor and productivity were reduced by inbreeding, but when lines were once established vigor was regained as a result of cross-fertilization. By following this method, high and low protein strains were developed with extremes of 17 and 6 per cent, respectively.

From crosses of a white sweet with a yellow dent corn at the Washington station a yellow sweet variety was obtained with a 5 per cent increase in sugar content. Extensive plant breeding experiments at the New York Cornell station have resulted in the development of several improved and desirable strains of field and cereal crops. Some success has been attained in combining resistance to more than one disease in the same strain, and a strain of field beans has been secured resistant to both rust and anthracnose.

A study of the inheritance of characters in tobacco at the California station showed that there may be obtained from hybrids derivatives that represent any combination of the characters of the original species and also derivatives that are not in evidence in either parent. After four or five generations of self-fertilization, the derivatives breed true, continuing so and behaving like pure lines thereafter.

At the Kansas station two, three, and four characters have been linked in orthoptera so that they will breed true, these linkages following Mendel's law perfectly.

In a study of the heritability of mutant characters in skunks at the Illinois station the method of transmission of a pure white fur was established. A study of syndactylism in swine showed that this and the normal hoof are an allelomorphic pair, as is also red and black coloration, but the two are independent of each other. A factor was found which dilutes red to a cream or white but has no effect on black.

The Delaware station has made extensive studies of inbreeding with cattle and pigs, from which the following conclusions are drawn: The dam's productive ability has little influence upon her daughters' ability to produce; a good sire is able to transmit either heavy milking ability or high butter fat test to his daughters; a small amount of inbreeding (under 10 per cent) appears to be associated with best production; an increased proportion of males seems to be associated

with inbreeding in cattle; in swine the certainty of pregnancy is reduced and smaller litters result from inbreeding; the mortality rate is higher in inbred pigs than in crossbred ones, and the rate of growth is greater in the latter; as in cattle, close breeding in pigs seems to increase the proportion of males and close inbreeding is followed by even more detrimental results than in cattle.

From data obtained by the Kansas station it is believed that it will be possible to establish a strain of Shorthorn cattle, of the broad, deep, thick-fleshed type, the cows of which will produce large quantities of milk. Five cows in this experiment are producing from 366 to 380 pounds of butter fat annually.

The records of a large number of twin births in cattle at the Maine station showed the sex ratio to be one of 2 bulls, two of 1 bull and 1 heifer, and one of 2 heifers. Twins were found to occur on an average once in 125 births.

SOILS.

Studies of the drift soils of the State by the Minnesota station show that while the fertility of both the younger and older drifts is naturally high, the limestone is practically gone from the older or red drift. This series is richer in phosphoric acid, organic and volatile matter, and nitrogen than the younger or gray drift.

The Ohio station finds the soils of that State generally deficient in phosphorus. The average increase in yield for 100 pounds of 14 per cent acid phosphate, used alone, was approximately 6 bushels of corn or $4\frac{1}{3}$ bushels of wheat, with sufficient increase in the hay crop following to pay for the fertilizer. When the phosphate was reinforced with nitrogen and potash the increase was much larger, although not always as profitable, at prevailing prices for the carriers of these elements. Investigations on the availability of phosphorus in the soils of the State indicate that it exists largely in an organic form, which is quite resistant to the agencies of decomposition promoted by cultivation, and that soil reaction has little or no influence on this resistance. Experiments on the effect of sulphofication and nitrification on the availability of rock phosphate showed that through the oxidation of sulphur the availability was increased to an appreciable extent in acid soils, but much less so in basic or neutral soils. Rock phosphate apparently does not support nitrification. The biological soil processes were found to increase slightly the water-soluble potash.

Mineralogical combined with chemical studies of the soils of the State by the North Carolina station have explained the fact, noted in many cases, that a soil evidently rich in plant food may not show a corresponding yield unless fertilized. With a few exceptions, phosphoric acid is low in the soils of the State.

Some interesting results have been obtained at the Tennessee station from cylinder experiments extending over a series of years with five types of soils. The cylinders were sunk in the ground, with rims 2 to 3 inches above the surface, and otherwise exposed to natural conditions. These became unproductive to the extent of complete crop failure in a few years except when limed, fertilizer and manure applications having little or no effect. The trouble is believed to lie in the increased moisture supply and excessive leachings, arising from the prevention of run-off by the raised rims, whereby the soil supply of calcium bicarbonate was reduced until it became the limiting factor. This has an important bearing on this method of soil investigation. Uncropped cylinders receiving lime as oxid, hydrate, and carbonate, mixed with the soil, showed a marked reduction in nitrogen content as compared with either untreated soils or those treated with ground limestone. The depth of cylinder has much to do with the amount of nitrogen recovered from sodium nitrate or other nitrogenous material, in the drainage water, as does the kind of soil, whether heavy or light.

Studies at the Minnesota station of the movement of moisture in soils showed that the difference in water capacity caused by manuring or cultural operations has little effect on productivity.

Soil moisture investigations at the Utah station indicated that the final equilibrum under irrigation requires a long period of time, involving a number of factors, and that capillarity is much more complex than is generally supposed. The optimum soil moisture for ammonification was found to be between 65 and 75 per cent of the water-holding capacity of the soil.

A study at the New Jersey station of the relation of the adsorbed material to nutrient soil solutions in sand, indicated that the adsorptive properties of unwashed sand are due to the finely divided colloidal or semicolloidal material, which is removed by washing. The reaction of the nutrient soil solution was not altered by contact with very fine unwashed sand. The adsorptive capacity of this material reduced the total osmotic salt concentration of the nutrient solution by 8.5 per cent, which, however, was eliminated by renewing the solution. The physiological balance of nutrient solutions in sand cultures was not altered by variations in the moisture content of the solid substrata. A good physiological salt balance and optimum total concentration of a nutrient solution is not sufficient to produce the best growth of which the solution is capable, when it is diffused as a film on the particles of the solid substratum, but an optimum degree of moisture is necessary to impart to the solution the maximum physiological value. A low degree of moisture results in low yields, low transpiration rates, and low water requirement ratios; a high degree of moisture results also in a low yield but in high

transpiration rates and water requirements; and medium degrees of moisture produce highest yields with high transpiration rates and medium water requirement.

At the Michigan station a study of the rate and extent of the solubility of soils showed that the concentration of the soil solution depends on the relative masses of the soil and water and is influenced by many factors. The amount of material that goes into solution increases as the ratio of soil to water is increased, up to about the the optimum water content, and then decreases. The concentration of the soil solution of the subsoil shows little variation.

It has been demonstrated at the New Mexico station that with suitable amounts of water alfalfa can be grown on the mesa lands of the State. Applications of 34 to 53 inches of water gave increasing yields of from 9,900 pounds to 1,360 pounds per acre. Cultivation of the soil after irrigation appeared to have no effect on the conservation of moisture on this type of soil.

A study of alkali in soils in its relation to crop production at the California station showed that applications of manure at the rate of 20 or more tons per acre prevented wholly or in part the injurious effect of alkali. Treatment with sulphuric acid is not considered practicable, for although it gives good results the first year it eventually leads to an accumulation of alkali. Nitrate of soda and other sodium salts were found to liberate calcium in a soluble form, available for plant growth and also subject to loss by leaching, heavy rains and irrigations tending to leach it below the root zone. In time the calcium is thus much reduced, with a concentration of sodium salts in the soil, which becomes greatly deflocculated; water penetrates with difficulty and aeration is retarded. Four years' results with soils cultivated but not cropped, compared with cropped soils, showed a falling off in total nitrogen at about the same rate in both cases, but the importance of a good summer fallow, properly cultivated to maintain a good surface mulch and prevent the growth of weeds, was demonstrated. It was found by the Utah station that water containing over 4,000 parts per million of alkali can not safely be used for irrigation. The small grains as a class were much more resistant to alkali than most other field crops, peas, beans, and blue grass being particularly sensitive. Nitrifying bacteria were found to be more sensitive to alkali action than ammonifiers. The compounds which are strongest in stimulating plants are also the most active in increasing the nitrogen content through bacterial action.

The Virginia station in studying the effects of green manure on the soil found that after turning under a crop a high degree of soil acidity was developed for about a month, but was not injurious where a good crop rotation was practised and lime was applied to the soil.

Leguminous cover crops turned under in a rotation gave striking increases in the yield of corn and wheat, but noticeably smaller increases where cut off for hay.

A series of experiments conducted at the South Dakota station to demonstrate the practicability of maintaining soil fertility by rotation, combined with applications of manure only, showed that this was not possible without the addition of some phosphorus for that section of the country. Where live-stock farming is not practiced the turning under of legumes can take the place of manure. Experiments on the depth of plowing showed that 6 or 7 inches was best for corn and 5 or 6 inches for wheat, the benefits derived from deep plowing not being sufficient to pay.

The Tennessee station found that applications of lime, either as oxid or hydrate, were identical in their effect. Moisture was found to be one of the major factors in the change of these compounds to the carbonate, which takes place usually in four or five days. The major portion of the carbon dioxid concerned in these changes was found to come from the atmosphere. Studies on the action of lime and magnesia salts on the soil potash indicate that these tend to depress the amount of potassium entering the free and film water of the soil, except with long-continued heavy treatments with calcium oxid, from which after two years there was some evidence of potash liberation. Magnesium compounds are even more pronounced than calcium in effecting the repressive action. Sulphates, formed by the oxidation of the sulphids in the soil, do not leach out when the lime is not carbonated.

The effect of lime in crop rotations at the Delaware station was marked, increasing the yield of hay nearly 40 per cent, but it appeared to be detrimental to soy beans. Crops fertilized with potash showed greater disease resistance. The use of different forms of lime gave but slight differences in crop production.

The Illinois station found dolomitic limestone to be as effective in correcting soil acidity as high calcium limestones, more lasting in effect, and not injuring crop yields. The total product from a one-fourth-inch screen was as effective as finer material. The average of the results of 10 fields, representative of southern Illinois, showed a threefold increase of wheat yield from the use of fertilizers applied in a profitable system of soil treatment.

Studies on soil acidity at the Rhode Island station indicate that this is to some extent dependent on the condition of the aluminum present, and that liming and phosphorus reduce acidity and give beneficial results, partly by rendering the aluminum unavailable. No harm resulted from the use of magnesium limestone for neutralizing acidity. An investigation at the Pennsylvania station of the residual effects of lime upon the soil showed more nitrogen and or-

ganic carbon in the soils treated with limestone than in those treated with burned lime. The relation of hydrogen-ion concentration to plant growth, studied at the West Virginia station, gave the maximum growth of the crops tried (which were wheat, corn, soy beans, and alfalfa, in cultural solutions) in slightly acid solutions. Reactions of P_H3 or lower were found decidedly toxic to all crops and a reaction of P_H7 was decidedly less favorable than P_H6. In all cultures the growth of the seedlings resulted in a slight change of reaction toward a neutral condition. Germinating seed was less sensitive to the reaction than the subsequent growth of the plant, there being little difference between P_H3 and P_H8. The effect of reaction on plant growth is largely the result of two factors—the effect on the plant and on the soil organisms—especially those responsible for the changes in soil nitrogen. No effect of the soil reaction was observed on the hydrogen-ion concentration of the cell sap of the plant. For red clover, the highest acidity permitting successful inoculation was found to be P_H5 and for alfalfa P_H6.

The Kentucky station studied the changes taking place in acid soils before and after adding various calcium salts, and found that two of the six soils tried did not respond to the treatment by increased yields. One year after treatment, during which the soils were exposed to the elements, no calcium was found where it had been added as carbonate or sulphate. There was a noticeable increase of compounds of calcium with humus, except in the two soils that did not respond. An examination of the soil solutions before and after treatment showed that nitrates had increased in those soils that responded; that in all the soils the addition of calcium sulphate caused large quantities of potash to become soluble; and that in some cases the solubility of the magnesium was increased. The calcium content remained nearly constant whatever the treatment; the soluble phosphorus diminished slightly under all treatments, and sulphofication occurred in the soils that responded.

Plants grown in flasks at the New York Cornell station showed nearly a complete consumption of the nitrates present in the first three weeks of plant growth, and in some instances the plants were able to mature without additional nitrogen. The evidence showed that organic matter plays an important part in the reduction of nitrates and that growing plants probably liberate organic materials that function extensively in this way. The most active reduction occurred when the plants were approaching maturity. Enzymotic action was found to be of comparatively little importance in the reduction process. With regard to the effect of cover crops on nitrate production, it was found that with plants that winter over there is a higher soil nitrate content than is the case where the plants are killed by freezing. Grass lands, however, run low in nitrates, probably

because of the greater reducing power, which may be an explanation of the injurious effect of grass sod on orchard trees.

Studies at the California station on nitrogen fixation showed in the soil under investigation a variation of 25 to 30 per cent in the carbon and nitrogen content within an area 100 feet in diameter, indicating that soil varies to such an extent that experimental treatments and checks must be repeated many times to allow for this, otherwise erroneous conclusions may be reached.

The Missouri station found that nitrate production in the soil is related to the growth of the crop. With corn, the nitrates increased to a considerable concentration until late June, when the crop made a vigorous growth and the nitrates were rapidly exhausted. Oats and wheat exhausted the nitrates most completely by June. With grass crops the nitrates increased in early spring, but were soon practically exhausted, and remained very low during the entire season. Plowing increased nitrate production, but cultivation of the surface soil reduced the nitrates in the upper layers, indicating that shallow cultivation is better than deep as far as the nitrogen feeding of the plant is concerned. The moisture and nitrate content of a soil were negatively correlated and significant reductions of nitrates followed continued rains on open soils. Nitrification and to a less extent nitrogen fixation are dependent somewhat on the moisture content, as reported by the Montana station.

The examination of a large number of soils at the Kansas station showed about 40 per cent to contain no azotobacter, with a correspondingly low nitrogen fixing power. In no case did soils with a high hydrogen-ion concentration contain these organisms, but after the addition of lime to such soils good growths of azotobacter were obtained by inoculation. The Iowa station found a wide variation in sensitiveness of soil molds to acidity and alkalinity, some growing in high acid concentrations while others showed opposite tendencies.

Observation that the addition of any considerable quantity of straw to a soil decreases the yield in the following crop led the Washington station to make a study of the effect of this material on the bacterial flora. The results indicated that with small amounts of straw, from 0.1 to 0.7 per cent, the formation of nitrates was stimulated, but when straw was added in increasing quantities above this amount there was a progressive loss in nitrate formation, although the total nitrogen remained the same. As the amount of straw increased there was an increase in the number of bacteria, which are believed to act on the nitrate nitrogen and transform it into protein nitrogen. Cellulose apparently had no inhibiting effect on the nitrifying bacteria. In pot experiments some inhibition of the growth of wheat showed with 3 per cent of straw.

An investigation of soil erosion at the Missouri station indicated that with light and well distributed rains there is always more erosion as well as greater run-off from unplowed lands, the loss increasing somewhat with the depth of plowing. Sod land was most efficient in preventing erosion and absorbed a greater percentage of the rainfall. About 60 per cent of the rainfall was absorbed on uncultivated soil, 74 per cent on plowed soil, and 87 per cent on sod land.

A study of soil toxins at the Alabama station showed that while these are widely distributed, practically all soils contain organisms that decompose them. In many cases the organism was isolated and identified. Moisture was found to be an important factor in this decomposition. Salicylic aldehyde is not readliy decomposed and is slightly toxic. The presence of manganese in a soluble form was found to be a good indication of an acid condition, but of itself is not likely to produce harmful effects unless present in very large amounts. On the addition of lime it goes largely into an insoluble form. The toxicity of certain soil extracts is apparently due more to the acidity of the solution or to the combined effect of the acid and aluminum than to manganese, if present.

FERTILIZERS.

A number of stations have been investigating the effect of composting ground rock phosphate with soil and various other materials to increase the availability of the phosphorus. At the Georgia station composts containing phosphate with cottonseed meal when first mixed rose in temperature to 136° F., with a loss of ammonia, sulphur compounds, and othe volatile constituents. By keeping the piles covered with wet bagging, the temperature was kept below 100°, with a decrease in the losses. At the Virginia station composts of rock phosphate, sulphur, soil, and manure after 24 months gave 17 per cent of the total phosphorus as water-soluble and 84 per cent citrate-soluble. Inoculation with a sulphofying organism reduced the time one-third. The best conditions for bringing about the changes were found to be initial inoculation, a high temperature, thorough aeration, and a fair moisture content. At the Texas station no increase in availability was reported, although field applications of the compost gave crop gains in some cases. The Iowa station, on the other hand, secured a rapid production of available phosphorus in the above mixtures.

Experiments at the Virginia station on the fixation of phosphoric acid in the soils, in which the water solutions of acid phosphate were treated with iron, aluminum, and calcium salts and then added to soils in which the phosphoric acid had been depleted by growing crops, showed that the phosphorus in the so-called fixed forms was available for plant growth, although the test with neutral ammonium citrate did not show in an available form. Field studies on this

subject showed that relatively the same amounts of phosphoric acid are taken up by the corn plant or fixed in the soil, whether the phosphoric acid is applied in the form of acid or rock phosphate or as basic slag. Acid phosphate showed its superiority over rock phosphate in experiments at the Pennsylvania station in all cases except in the growth of sweet clover, where the latter constantly gave greater yields.

The results of a number of years of experiments on the fertilization of citrus trees at the Florida station showed that phosphorus, applied in any form, increased growth. Eighty per cent of the phosphoric acid that has been applied has been fixed as tricalcic phosphate. Different sources of nitrogen were found to be equally satisfactory. It was found that while citrus trees can adjust themselves to adverse conditions produced by overfertilization, this has a more marked retarding effect than quantities below the optimum. Slag, unslaked lime, ground limestone, and hardwood ashes were all followed by frenching, the most injurious of these materials being ground limestone and slag, which resulted in partial defoliation. Some of the best trees were in the most acid soils.

The Florida station demonstrated also the need of available phosphoric acid and potash for the Irish potato, and that the plants show phosphorus starvation quicker than potash starvation. The results of fertilizer tests at the Louisiana station showed profitable returns in increased yields of potatoes from the application of phosphoric acid up to the rate of 72 pounds per acre.

Experiments at the Oregon station pertaining to the relation of sulphur fertilization to plant growth indicate that this element acts directly in promoting development and also stimulates the development and action of legume bacteria, thereby causing the assimilation of more nitrogen by clover. In some sections of the State it was found to be the limiting element in legume production.

The California station has investigated the nutrition of plants as affected by nitrogen and sulphur, indicating the important rôle played by the latter. Sulphate of ammonia gave a better growth of barley than nitrate of soda or dried blood, but when an equivalent amount of sulphur was applied with the latter an equally good growth was obtained. Sulphur applied without the nitrogen gave no results.

At the Washington station, where untreated alfalfa yielded $1\frac{1}{4}$ tons per acre, applications of gypsum increased this to $4\frac{3}{4}$ tons. Oats responded readily to gypsum, while wheat did not.

In a study at the Oregon station of efficiency in handling manure to prevent losses and reduce labor, the best results were obtained when the cattle were kept in covered sheds, with top coverings of straw over the ground renewed as often as necessary. This builds up about 30 inches in a year. The cows are kept clean, there are no

flies, no leaching, and no firefanging, and the manure is handled but once a year.

At the Nebraska station in none of a series of fertilizer tests with various crops did the returns pay for the cost. Fertilizing the peanut at the Florida station increased the crop only 4 bushels per acre, not enough to pay for the application.

FIELD CROPS.

Cereal breeding at the Minnesota station has resulted in several improved strains, both for disease resistance and for yield. Soil and climate were found to have more influence on the yield than size of seed. The Nebraska station has developed and distributed a strain of wheat yielding 4½ bushels per acre more than the original, and a strain of oats yielding 7 bushels more. Excellent success has attended breeding work at the Alaska station, especially with spring wheat, barley, and oats suited to the country, as well as with new varieties of hardy strawberries. A strain of Turkey Red wheat developed at the Illinois station has averaged for five years 6 bushels per acre more than the ordinary strains. The Iowa station has also been very successful in breeding and distributing improved varieties of grain, especially oats and wheat. The South Dakota station has obtained a cross between rye and wheat by pollinating the latter with the former, but not vice versa.

The Minnesota station finds that the only relation of lodging to structural characteristics of small grains is in the thickness of the sclerenchyma cell wall. Observations on the factors related to the lodging of grain at the Ohio station indicate a direct connection between fertilizer treatment, moisture content, and strength of straw.

Cropping experiments at the Idaho station show that a more profitable system than summer fallowing wheat lands can be practiced. Growing corn in the place of fallow gave an increased profit of $35 per acre over the fallow system; with potatoes there was an increase of $100, and with peas $150, for the whole three years' rotation. The Washington station found decided variations in soil moisture and nitrate content in the summer fallow plats as affected by time and method of tillage, the most favorable practice being early spring tillage followed by such subsequent working as is necessary to keep down the weeds.

At the Delaware station bearded varieties of wheat proved to be the most dependable as to yield and tillered more freely. Potash was a valuable factor in improving the quality of grain. The yields for 20 years on continuous plats of wheat at the North Dakota station averaged 17.49 bushels for the first 10 years and 13.59 bushels for the last 10. When systematic crop rotation was practiced 60 per cent more wheat per acre was produced than the average yield for the State.

Investigations on the relation of soil moisture to yield of wheat at the Colorado station show that if this crop fails to receive water in the 10 days previous to heading, the number and the filling of the heads are greatly reduced, the effects not being overcome if water is supplied later. With sufficient water at the critical stage, an excess has little effect on the yield and is largely wasted, which fact has an important application to irrigation practices.

Evidence obtained at the Washington station shows that nitrogen and not moisture is the limiting factor in wheat production, and nitrogen fertilizers used as a substitute for summer fallow gave an increased yield in all cases. The best results with spring wheat were obtained from fall applications of fertilizer, and with winter wheat from spring applications. Eleven pounds of nitrogen per acre gave an increased yield of 4.65 bushels, and 22 pounds gave 8.6 bushels. Where straw was plowed under in the spring just before seeding, it always resulted in a reduction of yield, but the detrimental effect was not so marked when it was disked in in the fall.

The Alabama station has developed several promising strains of Fulghum and Red Rust Proof oats which are being multiplied for distribution. Three superior pedigreed varieties of oats which it is anticipated will replace the many scrub varieties now planted, have been isolated at the Wisconsin station. The Texas station has developed for distribution an improved rust-proof oats, also a high-yielding feterita.

During 9 years of variety tests of cereals at the California station Mariout barley, an introduction from North Africa, has averaged 88 bushel per acre as compared with 80 bushels for the varieties commonly grown. It also shatters less, makes a lighter draft on soil moisture, and ripens earlier. A classification of American barleys at the New York Cornell station showed that of the 600 so-called varieties only about 60 should be considered as such, most of the others being synonyms.

The results of studies in breeding corn at the Nebraska station indicate that 1 year's inbreeding will reduce the yield nearly one-half, but that the original vigor returns after the first outside cross. Inbred strains that had gone down to 14 bushels per acre came back to 48 bushels in the first cross. Corn pollen was found to begin to deteriorate in 38 hours, giving very imperfect fertilization after 48 hours; and after 58 hours it had entirely lost its viability. The amount of inbreeding that takes place naturally in a cornfield was found to be very slight.

Two varieties of high-yielding corn that will germinate at a low temperature, suitable to northern conditions, have been originated at the Wisconsin station. The request for seed of these strains has been very large, including a number from foreign countries. Strains

of Rustlers White Dent corn which will mature in 100 days have been developed and distributed by the Idaho station. The Virginia station reports that when soil moisture is kept at between 60 and 80 per cent of saturation during the critical period, which with corn is in the early stage of growth, early maturing and high yields are favored. Corn breeding at the Illinois station has produced strains with an oil content five times greater in the high series than in the low, with the protein about doubled. The improved corn developed by the Virgin Islands station is now planted to the practical exclusion of all other sorts on the islands.

Surface irrigation water is found by the Texas station to be essential to the maximum development of the rice plant. Although the size of head and of the kernel is little influenced, surface irrigation increases tillering and thus produces more heads.

The introduction by the South Dakota station of proso as a food crop has been successful, 4,000 bushels having been grown in one county alone.

In breeding work with cotton at the Alabama station, only about 25 per cent of light seed was found to germinate, as compared with 100 per cent of heavy seed. A strain (No. 307–6) resistant to wilt has been developed, and sufficient seed has been distributed to plant 1,000 acres. This is to be improved in earliness and length of fiber. The results of cotton tests carried on for the past four years at the New Mexico station have aroused a great deal of interest and led to a considerable acreage being planted. The average yield of the plats at the station was 1¼ bales per acre. The Arkansas station reports that the dropping of cotton bolls may have other than bacterial causes and may occur in disease-free plants. Any mechanical injury kills the boll and causes it to drop.

Continued cropping with cotton at the Mississippi station did not show the decrease in yield that occurs with corn. Kainit used on cotton gave no increased yield, but apparently prevented or reduced attacks of rust.

A study of place variation in cotton has been carried on cooperatively by the North Carolina and Mississippi stations, from seed originating from one self-fertilized plant in North Carolina in 1914. Seed grown at the Mississippi station planted in North Carolina has consistently produced taller and earlier maturing plants, with slightly heavier bolls and a little longer staple than that locally grown. Practically all of the Sea Island cotton planted during the year in the Virgin Islands was from pedigreed seed produced at that station. This station has made good progress in cane, corn, and cotton breeding, and is testing legumes and other crops as to their adaptability to local conditions. One seedling cane, S–C 12–4, is arousing much interest among planters and is now widely grown.

The Porto Rico station has been successful in the introduction, breeding, and distribution of varieties of sugar cane immune to the so-called mottling disease that is threatening this industry on the island. Seedling cane L511 continues to give very promising results at the Louisiana station. Last season it produced 25 tons per acre, the juice containing 13.86 per cent of sucrose, or about 3 per cent more than the common varieties. At the Florida station it was found profitable to replant Japanese cane at least every five years, and preferably every three years. Both the Porto Rico station and the Virgin Islands station have introduced Napier grass, which is receiving much attention as a forage crop. This grass has also given good results in Florida, yields of over 39 tons per acre of green feed having been obtained. It must be fed when young and succulent.

Through the efforts of the Montana station sunflowers are being planted extensively in the State. They stand more frost than corn, and yield, without irrigation, 20 tons and with irrigation 30 tons of green feed per acre. The best variety is the Mammoth Russian, which should be planted as early as possible, in Montana by the first of June, in rows 36 inches apart and 4 inches apart in the rows.

As a result of experiments in growing flax for fiber at the Michigan station a considerable increase in acreage devoted to this crop is noted in the State. Similar work is being done with hemp. Largely through the efforts of the Wisconsin station that State now leads the United States in the production of hemp, much of the fiber being shipped to England. The average yield for the year was 1,100 pounds of fiber per acre, giving a return of about $100 at the prices prevailing. The problem of seed production for this crop is being worked out by the station with promise of success. The feasibility of growing fiber flax successfully, especially in the northern counties of Wisconsin, has been demonstrated.

At the Wisconsin station attention is being given to the sorghum industry, which has resulted in the development of two improved strains, improvement in the utilization of the plant by better juice extraction and ensiling the tops and leaves, and in standardizing the sirup.

At the Nebraska station experiments on the frequency of cutting alfalfa showed that both yield and vigor are reduced if it is cut before the proper stage of maturity, but if it is allowed to get too mature the yield of hay is less. The injury done by too early cutting is permanent. The highest yield at the Kansas station was obtained by cutting when the alfalfa was one-tenth to full bloom, and the lowest yields by cutting when it was either in the bud stage, which causes a rapid deterioration of the stand, or when the seed was formed.

Considerable progress has been made at the South Dakota station in improving alfalfa for hardiness and yield.

The advantage of scarifying legume seed was shown at the Wisconsin station by an increase in the germination of sweet clover seed of from 5 to 95 per cent as a result of scarifying. Crimson clover seed was improved 16 per cent, which, with seed worth 60 cents per pound, gives scarification a value of from $9 to $10 per hundredweight.

Imported French and Italian crimson clover seed was found by the Delaware station to be superior to the native-grown seed.

The annual sweet clover, introduced by the Iowa station, continues to give excellent results both in this and other countries, especially as a green-manure crop and for pasture improvement.

The acreage of soy beans seeded in Delaware has increased very rapidly during the past two years, largely as a result of the work of the station.

Selection of Japan clover for hay and for pasture purposes, which has been conducted at the Tennessee station for a number of years, has resulted in an excellent variety, yielding more than twice the quantity of dry hay produced by the next best strain and also a large quantity of seed. The pasture strains developed make an abundance of late pasturage and ripen enough seed to reseed the ground.

A study at the Tennessee station of cowpeas grown with wheat and with corn and wheat, either harvested or turned under, with and without lime, led to the conclusion that in that State at least this crop tends to loosen the soil too much and thus facilitates the loss of nitrogen. Removal of the crop resulted in a rapid decrease in soil nitrogen.

The Louisiana station is recommending corn and soy beans as the best silage combination for the State. With this mixture a silage can be made with about 4 per cent of protein.

Sheep tansy, a native wild drought-resistant plant of California, was found by that station to be an excellent pasture for sheep and also a good bee plant.

Satisfactory results have been obtained at the Utah station in commercial sugar-beet seed production, with excellent prospects of establishing a domestic beet-seed industry which will largely replace the former importation of seed from Europe. No decided advantage to sugar beets has been obtained at the New Mexico station from the use of fertilizers or manures or the use of shade. Early plantings gave a good tonnage, high in sugar and purity.

A study at the Wyoming station of the relation of number of stems to the hill to yield of potatoes indicated that three or four stems per hill were superior in total number and weight and in marketable tubers. The average weight per hill was found to increase directly as the distance apart of hills in the row increased, up to 36 inches,

but the total yield per acre and of marketable tubers was greatest with close planting, the percentage of marketable tubers, however, being lowest in those planted close together. In a comparison of large, medium, and small tubers for seed, the average weight per hill increased directly as the size of the seed piece increased, as did the total yield and yield of marketable tubers.

Experiments at the Montana station in thinning potatoes to one stem per hill showed a decrease in total yield but an improvement in the marketable yield. It is not recommended, however, except where there is a market for a fancy product. The South Carolina station has devoted considerable attention to factors influencing seed production in the potato. Much of the pollen was found to be impotent, and it is believed that this is the cause of the failure of many varieties to produce seed. Seed production of the Lookout Mountain potato depends largely on weather conditions at the time of planting, the spring-planted crop bearing little or no seed, but later plantings being usually comparatively prolific in this respect. In selecting potato seed stock at the Nebraska station, tubers from irrigated fields were found not to be as good as from nonirrigated fields.

A study at the Maryland station of the behavior of potato tubers in the ground after the vines die showed that after the tops freeze many small tubers are formed at the expense of the large ones, hence the crop should be harvested at once after a killing frost. Tubers that have been long in cold storage tend to produce "spindling sprout," which is also found to be related to the size of the seed piece. If the seed piece is less than 1½ ounces the vigor of the plant is reduced and typical spindling sprout results. Flat seed pieces gave a weaker growth than deeper sections. An accumulation of soluble carbohydrates was found in the small pieces that produced spindling sprout, indicating that such pieces had lost their synthetic power.

Potato culture experiments at the New Mexico station showed that this crop was not a dependable one at altitudes of less than 7,500 feet in the State.

Sweet-potato storage experiments at the Alabama station showed that properly cured and matured potatoes were much less injured by cold in any method of storing, while those dug after frost all rotted. If potatoes are planted, dug, and cured early they may be kept with little danger of loss.

A cross has been originated between Sumatra and Broad Leaf tobacco at the Connecticut State station that is of excellent quality, with good yields and apparently resistant to a form of root rot that has devastated fields of Havana tobacco. Investigations at the Virginia station have shown the close relation of seed bed and field diseases of tobacco, and emphasize the importance of seed-bed control.

The results secured at the Tennessee station, in keeping crops free from weeds by merely cutting them, without cultivating the soil, showed the great effect of weeds as crop reducers.

Studies on the water requirements of sweet clover at the South Dakota station showed a decrease in growth corresponding to a decrease in water content of the soil. It was noted that those plants in which water was most nearly a limiting factor suffered most from freezing. Similar studies on the corn plant at the Nebraska station showed that the amount of water used per pound of dry matter is about the same regardless of the source or kind of seed, there apparently being no greater efficiency with dry land or even special drough-resistant corn, the only difference being that the latter varieties are histologically smaller and thus have less dry matter. The rate of seeding has considerable influence on the water requirement, which is also reduced as the fertility increases, although the total amount of water required increases on account of the more vigorous plants. The main factors influencing the water requirement are climatic conditions and leaf area.

Investigations by the Idaho station on the duty of water showed that with wheat growing in pots, it required at Moscow, where the rainfall is about 20 inches with a high humidity, 252 pounds of water for each pound of dry matter, while at Idaho Falls, with a rainfal of 15 inches, about 550 pounds were required.

Studies at the Rhode Island station on the relative ability of different crops to satisfy their phosphorus requirements when that element was quite unavailable in the soil showed that while carrots secured their entire needs, turnips and cabbages were unable to grow without phosphatic applications. Beans, wheat, and oats ranked between these extremes. With limited available phosphorus, oats made a more nearly normal growth than wheat.

The Mississippi station found that the limit of the amount of green manure which will still produce an increase in the succeeding oat crop was somewhere between 40 and 60 tons of green weight, or far beyond the quantity that could be grown on the soil at any one time. Green manuring experiments extending over a period of 10 years raised the yield of corn from 35 to 75 bushels per acre by plowing under three crops of clover during this period. Kainit used on cotton gave no increased yield but apparently prevented or reduced attacks of rust.

Applications of limestone and acid phosphate in a rotation of corn, soy beans, wheat, and clover at the Kentucky station gave a net gain of $44.71 per acre for the rotation. Investigations on the occurrence and distribution of manganese in plants, at that station, in which crops of wheat, oats, barley, and rye were grown on manganese-free sand with and without the addition of manganese compounds,

showed that the growth of wheat, barley, and rye was greatly retarded by the absence of this element, but that oats was not materially affected.

HORTICULTURE.

Good progress has been made at the South Dakota station in securing hardy fruits for the Northwest, the work of the year being mainly in crossing native raspberries with species from Siberia and other northern countries. Similar work has been done with excellent results in crossing the Alaska wild strawberry on the best French varieties to improve the quality. Work in developing hardy fruits has also included apples, pears, plums, cherries, and grapes.

Hardiness is found by the Minnesota station to be a complex character, measured by the maximum injury to the tenderest tissue at any given temperature. This station also has crossed the native raspberry with strains from the far North with good results. Winterkilling investigations at the Nebraska station indicate that as a rule scion roots are much more resistant to cold than stock roots, suggesting the possibility of improving the hardiness of fruit trees by propagating in such a way that the major portion of the root system comes from the scion wood.

The Iowa station has devised a method of securing perfect rooting from the scion by girdling its union with the stock with copper wire. The stock roots begin growth and feed the scion until the wire begins to cut through the outer bark and into the cambium layer, when the accumulation of plant food above the girdle induces root production and the scion soon establishes itself on a root system of its own. Investigations at the Missouri station indicate that the condition of hardiness may be produced as effectively by withholding moisture or by decreasing the supply of available plant food as by exposure to low temperatures. Hardiness of the roots of apple seedlings is found by the Wisconsin station to be dependent to a considerable extent on moisture, those in a dry soil suffering most injury from freezing temperatures. The cambium layer is hardier than the surrounding tissues.

Extensive studies have been in progress at the Minnesota station on the fundamental reasons for the failure of the plum to fruit. Although many blossoms may be set, often all of them are lost. A large percentage of this loss was found to be due to winterkilling, especially from sudden changes in temperature which may reduce the fruiting area from a third to a half. A large percentage of the sterility is due to the abortion of the pistil from nutritional troubles, also from the breaking down of the embryo after fertilization. Nonfertilized flowers are generally lost in the "June drop." Any or all of these causes may result in a failure to set fruit. No single American plum will set fruit when it stands alone, and a mixed planting may

give either a fertile or a sterile combination. Complete ringing of mature apple trees resulted in fuller blooming and the setting of more fruit.

Good cultivation and the application of nitrate of soda gave about equally good results in the growth of young apple trees at the Virginia station. The best fruit was obtained with high cultivation. Potash and phosphoric acid used singly had little effect on weak trees, while vigorous trees responded to the treatment. At the Indiana station 11-year-old apple trees in their fifth fruiting season, growing under a system of clean cultivation with a cover crop, bore 164 pounds of fruit per tree, while trees of the same age growing in sod produced only 24 pounds. Trees growing under a system of soil management which creates a condition of subnormal nutrition and moisture supply showed a greater loss of water per unit area of leaf surface than trees well supplied. Rye has proved to be the best cover crop for orchards in the State.

Soil treatment studies in the peach orchard at the Illinois station showed a more vigorous growth of young trees under clean cultivation than with cultivation and leguminous cover crops, and both of these treatments gave better growth than cultivation, leguminous green manure, and a fall planted cover crop of rye. Excellent results have been obtained at the Oregon station from the use of sodium nitrate in the apple orchard, an application of from 3 to 7 pounds per tree according to size increasing the yield in many cases tenfold. It was found that the type of growth, whether vegetative or fruiting, was largely dependent on the relation of the carbohydrates to nitrates in the tree, the best yields being obtained where an even balance is maintained. An excess of carbohydrates results in a large number of blossoms but the setting of very little fruit. An excess of nitrates gives a large vegetative growth and also very little fruit.

Data secured at the Washington station on orchard cover crops indicate that a permament cover, such as alfalfa and clover, may be established without checking the growth and production of the trees, provided a sufficient water supply is available and fertilizers carrying a high nitrate content are added at the time of or prior to the date of seeding the cover crop. If the crop is allowed to grow to maturity, however, it depletes the soil. The addition of nitrogen to orchard soils where this was lacking at the Arkansas station increased the set of fruit in some cases over 500 per cent, but an excess of this element tended to decrease the set. A direct correlation is noted between the vigor of the tree and the setting of fruit.

Orchard management experiments at the Iowa station showed the best results from a loose clover sod. Ten years' work on this subject at the New Hampshire station resulted in no profitable

increase in yield to date from fertilization in the apple orchard, but the fertilized trees are more vigorous. Cover crops appear to have been of some benefit, and nitrification under these has doubled that under clean culture. The response to fertilizers and cover crops is becoming more evident, however, as time goes on.

The Florida station as a result of its experiments recommends clean cultivation in the citrus grove after the trees are 3 or 4 years old. The effect of limestone in producing frenching was overcome by the use of stable manure, the beneficial action depending apparently not so much on the fertilizing effect as on the introduction into the soil of the proper bacterial flora. Fruit grown with various potash rations showed no difference in chemical composition, and the general belief that this element tends to sweeten the fruit has not been borne out, moisture and temperature factors being the most important in this respect. Lack of color in citrus fruit was found to be due to climatic conditions rather than fertilization, and is also apparently closely related to the stock used, some stocks not allowing a sufficient amount of dormancy. Trifoliate stocks seem to give the greatest dormancy.

Studies in cost of production of the apple at the Minnesota station, gave the net average profit from well managed orchards at $75 per acre. In some instances the profit went as high as $200.

A large number of hybrid apples are coming into bearing at the Idaho station, giving an opportunity to study the prepotency of the parents in transmitting their characters. In a majority of the cases where Wagner was one of the parents the shape of the seedling was typically that of that variety. In the color of the fruit none of the parents seemed to show a dominant color character except the striping of the Ben Davis, which was, however, often modified. The size of the fruit varied greatly but the average was below the size of the parent varieties. The shape of the fruit nearly always suggested a combination of the parent shapes. In flavor no apparent relation could be traced. Several of the seedlings are young fruit of exceptional flavor, of good size and keeping quality, and give promise of affording a good winter sweet variety for the State.

Some varieties that were self-sterile in one locality were found by the Oregon station to be self-fertile in others, 10 or 12 miles sometimes making the difference. A change of nutrition conditions will often ameliorate this.

A study of the relation of pollination to "June drop" of apples, at the Washington station, showed that practically all fruit that dropped before attaining a diameter of three-fourths inch contained no normal seed, indicating that fertilization had not been effective. Pollination studies at the California station show that nearly all

commercial varieties are self-sterile, so that mixed plantings are essential for successful yields.

Frost studies in the apple orchard at the Utah station showed that injury does not begin until the temperature falls below 28° F., and at 22° F. all buds were killed.

The Porto Rico station has done much to encourage the growing of vanilla, which is proving profitable as an adjunct to coffee growing, the latter industry now languishing.

A survey by the California station of the irrigation waters used in citrus and walnut groves in that State showed that in many cases such water contained considerable alkali, which although it might be considered safe ordinarily, may be dangerous in an arid country owing to the gradual accumulation of alkali through evaporation with little or no leaching. Several orchards were thus severely injured.

A simple but effective apparatus for testing the mellowness of fruit has been devised by the Washington station. It measures the pressure necessary to overcome resistance to a rounded surface.

An analysis of rosetted apple twigs showed a higher ash and alkali content than the normal, but attempts to reproduce the condition by feeding potted trees on strong alkali solution have not been successful.

The Texas station has secured a raspberry-dewberry cross that is fertile, with fine large fruit and a long picking season, and promises to be a valuable addition to the fruit of the State.

A muscadine grape has been secured at the Georgia station capable of transmitting its good qualities to its offspring. This grape is being used in crossing, to develop desirable strains. Sterility in grapes is found at the Minnesota station to be due to a degeneration of the generative nucleus, while in the strawberry it is due mainly to a tendency to dicœciousness with a lopping off of the secondary flowers. In many types the pollen was found to be degenerated.

Some interesting results have been obtained at the North Carolina station on the transmission of characters in hybrids of rotundifolia grapes, especially in regard to inheritance of sex, productivity, size of fruit, and disease resistance. The extent to which rotundifolia will hybridize with other species of Vitis has been determined. With the advent of prohibition, the utilization of the wine grape was an important problem at the California station. Sun-drying was found to be practicable in the warmer districts, the yields averaging 625 pounds of raisins from 1 ton of fresh grapes. Where sun-drying is not practicable evaporation may be successfully practiced.

Work in rose breeding at the South Dakota station has resulted in a number of hardy varieties. In one case the number of petals has been increased from 25 to 49.

A comparison of summer and winter pruning of fruit trees has been continued for 10 years at the Idaho station. For the first seven years there was a slight increase in favor of summer pruning. The two following years, Jonathan and Wagner still showed greater yields from summer pruning, but with Grimes and Rome winter pruning showed an increase. Summer pruning should be done after the terminal buds are set, especially in the northern part of the State. Summer pruning is beneficial in developing color of the fruit. The principal growth of the tree was found to take place before the fruit begins to grow.

At the Virginia station June pruning gave the densest trees but also resulted in a reduction of size and vigor, from which it is concluded that the late fall and winter pruning is best for that State. At the New Jersey station summer pruning did not give favorable results on the apple. Trees that were lightly pruned came into bearing earlier and bore the most fruit. Similarly, in the peach, the fruit was found to be more uniform in size and quality from winter pruning.

Pruning investigations at the California station showed that growth is not regular, but occurs in cycles not related to the fruiting period or to irrigation applications, and that pruning should be done between these cycles. The light pruning of young deciduous fruit trees, especially light heading back, produces larger, healthier, and more stocky trees than heavy heading back. The lightly pruned trees attain bearing size and age more quickly and are not injured by producing more fruit. Light pruning also gave more favorable results on old deciduous trees. The practice among growers of heading back closely has tended to retard the development of the root system and gives a thickly shaded head. Late summer pruning of peaches, plums, cherries, and a number of other fruits resulted in a marked decrease in the size and vigor of the trees.

In pruning experiments at the New York Cornell station with young trees the reducing of the leaf surface reduced both the root and top growth to about the same extent; with older trees the top was not so much affected. The application of nitrogen to young peach trees increased the top growth much more than the root growth. At the West Virginia station, light, dormant pruning gave the best growth. Summer pruning appeared to have a devitalizing effect.

The California station has reduced the time required for pickling ripe olives from 15 to 3 or 4 days by the use of heated, aerated, and circulating liquids.

In fertilizer experiments with tomatoes at the Illinois station the yield was increased approximately 130 crates per acre by the use of

manure, as compared with no treatment. Supplementing the manure with phosphorus gave a further increase of 76 crates.

Hand pollination of greenhouse tomatoes was very successful at the Oregon station. Plants which were regularly pollinated produced 80 per cent of fruitful blossoms and a yield of 8 to 9 pounds of fruit per plant, while unpollinated plants were fruitful to the extent of only 30 per cent, were from 2 to 3 weeks later in maturing, and produced only 3 to 4.5 pounds per plant.

Selection work with tomatoes at the North Dakota station has developed strains of "Earliana" that will ripen as early as July 7, and also strains that will produce over 700 bushels per acre under field conditions. The set of fruit was found to be increased in the tomato both by pruning and by mulching at the Oklahoma station.

The Pennsylvania station has done much toward improving cabbage, tomatoes, and rhubarb in the State by the development and introduction of new strains.

Cabbages stored with the roots on gave the best results at the Montana station. Cold-storage investigations for fruit at the California station indicated that a temperature of 36° F. was better than 32°, some varieties developing internal browning at the latter temperature. A high temperature, 100° or over, delays ripening of the fruit. Fruit will keep firm if left on the trees in a dry, hot year. A study of preserving fresh vegetables at the Michigan station showed that lettuce, radish, spinach, carrots, and other vegetables, can be kept in excellent condition for some time in a "moist chamber" such as a pail with a fairly tight cover.

Vegetable gardening experiments with manure and fertilizers at the New Hampshire station gave results proportioned to the amount of manure used, even when fertilizers were supplied in addition. With no manure, even a complete fertilizer gave practically no increase over no fertilizer.

At the West Virginia station the growing of mushrooms in abandoned coal mines, if they are free from overhead drip and have good drainage, has proved practicable and has commercial possibilities.

DISEASES OF PLANTS.

Investigations at the Minnesota station disclose at least 15 forms of stem rust on grains, which act quite differently on different varieties, some grains being susceptible to one strain in one locality and not in another. The injury is caused by penetration into the stem, which prevents proper transpiration and other physiological processes, eventually weakening the stem and causing it to split. At the Indiana station leaf rust of wheat was found to occur on several common grasses. The fungus appears to have several biologic strains, and the varieties of wheat vary widely in susceptibility to its attack.

The North Dakota station has found a variety of spring wheat, introduced from Russia, which is very resistent to attacks of stem rust and promises to be valuable as a basis for breeding strains resistant to this disease. Observations at the Iowa station show that rust on grain does not appear until after the spores on the barberry have matured. Wild grassses were found to be the active agents in bridging the gap between the barberry and grain, especially squirreltail and quack grass.

Experiments at the Idaho station show an apparent close correlation between soil moisture and stinking smut infection of wheat. Smutty wheat planted in infected soil containing under 15 per cent of moisture gave almost no smut in the resulting crop; but with over 15 per cent moisture there was a progressively larger amount of smut, up to 38 per cent moisture, which approaches saturation, when the crop was 100 per cent smutted. It is recommended that the seed be disinfected and either early or late planting practiced, eliminating summer fallow. Investigation by the Oregon station of reports that the treatment of seed wheat with formaldehyde for smut control injured germination, showed that when the solution was used in the usual strength of 1 pint to 40 gallons of water there was only slight or no injury to the germination in laboratory tests, but when planted in the soil there was at times a loss of 50 per cent. This indicates that the blotter test may be an unsafe guide. Stronger solutions than the above injured the germination considerably. Wheat smut studies at the Washington station showed that shallow planting gives less smut than deep planting, trenching less than level planting, and wide less than narrow spacing.

The Minnesota station has studied the effects of the same fungi on different crop plants. It was found that rot of tomatoes will cause a blight of wheat, and that wheat scab will cause a rot of potatoes. Rhizoctonia is sometimes parasitic on cereals.

In studies of gummosis of citrus trees at the Florida station no individual fungus has been isolated nor have inoculation experiments been successful, and it is believed that the trouble may be due to malnutrition. It may be controlled to some extent by cutting out the affected areas and painting with an antiseptic. The Alabama station finds that different species and varieties of the citrus family and its relatives differ considerably in susceptibility to citrus canker. The citrange-quot is practically immune. The character of the spot produced is found to be distinct for each species. The optimum temperature for growth was found to be from 15° to 20° and the limits from 5° to 38°. Between 15 and 30 per cent of humidity it showed a less active growth than just above or below these points, and was slow above 50 per cent.

Much attention is being given by the Florida station to a serious disease of the avocado which has made its appearance in the State. Spraying or other methods for its control have not proved very effective as yet. A new species of Botrytis was found on the castor bean, which ruined the whole crop in the State. Studies on the pineapple wilt showed that the probable means of entrance of the causal organism was injuries caused by root knot and that methods of control should be directed to this trouble.

Identification and life history studies by the Arizona station of the fungi attacking date fruits showed these to be a combination of anthracnose and rot. A Penicilium, Aspergillus, and Alternaria have been isolated, and there may be others. The Alternaria apparently causes the skin to rupture and allows other parasites to enter. The loss of fruit from this cause is very heavy when conditions are favorable, as with high precipitation. Its control would seem to depend upon getting rid of the brown spots on the petioles, which represent the wintering over of the Alternaria.

A study of the bacterial blight of Irish potatoes at the Florida station showed that this disease could be controlled to a considerable extent by spraying with a 5 : 5 : 50 Bordeaux mixture, especially in the early stages of growth. The disease caused a loss of 50 per cent in the crop in some sections. At the Montana station a number of closely related fungi were found to be responsible for wilt and dry rotting of potatoes. Planting dry-rotted tubers does not transmit the diseases. The organism causing blackleg of the potato was found not to live over in the soil, and its control rests on the use of disease-free seed. In treating seed potatoes with corrosive sublimate solution for Rhizoctonia, the Idaho station found that the strength of the solution is weakened by repeated dippings, and that it should not be used more than four or five times to get the best results. With untreated seed 50 per cent of the crop was affected.

At the Oregon station it was found that Verticillium wilt of potatoes spreads, to a considerable extent, from plant to plant in the field during the growing season. Its transmission in seed potatoes and the fact that the organism lives over winter in the soil was demonstrated, also that infected soil from a previous crop will infect clean potatoes. A study of the organisms in seed potatoes showed that *Fusarium oxysporium* is not generally so transmitted, while *Verticillium alboatrum* is to a considerable extent. *F. radicicola* is frequently present in the tubers, as are a number of miscellaneous fungi that are not serious.

Rhizoctonia was found not to be a serious factor in causing scab at the Nebraska station. The Fusarium associated with stem-end rot was found to have quite different pathological effects from the wilt Fusarium, but the temperature relations of the two were quite

similar. The Michigan station has demonstrated that the time of treatment of seed potatoes for the control of scab can be greatly reduced from that ordinarily employed, 30 minutes immersion in solutions of formalin or corrosive sublimate being sufficient to give perfect control.

Potato mosaic studies at the Maine station indicate that the disease is transmitted only by diseased tubers and by plant lice, and does not appear to live over in the soil. The causal organism is ultramicroscopic and infectious, infected tubers transmitting it to their progeny. The incubation period was found to be from 16 to 35 days. There appears to be a marked tendency of the seed-end cuts to develop plants with greater percentages of mosaic than the plants from stem-end pieces. Control of plant lice by means of nicotine sulphate, accompanied by hill selection of healthy plants, gave control of the disease. There appears to be some relationship between this disease and leaf roll, spot necrosis, and streak. The only method of avoiding Verticillium wilt was by using seed from healthy plants.

Scab and black scurf of the potato were controlled at the Iowa station by treating the seed for 2½ minutes at 118–122° F. with a solution of formaldehyde, 2 pints of a 40 per cent solution in 30 gallons of water. The Wisconsin station has found that with a soil temperature of 30° there is practically no black scurf and that variations in soil temperature largely influence the amount of disease present.

In a study by the Delaware station, sweet potato pox, which in some fields caused a loss as high as 90 per cent, was found to be a typical soil disease. Heavy applications of manure, lime, phosphorus, and combinations of these had little if any beneficial effects. White potatoes planted on an infected soil were susceptible to it, and the same is probably true of beets.

The organism causing buckeye rot of tomatoes in Florida was found by the station to be a Phytophthora, identical or very similar to one causing a number of plant diseases in tropical and subtropical regions. It occurs on the castor bean in India; on palms in Jamaica; citrus in Argentina, Cuba, and California; tomatoes in Florida, Louisiana, Texas, Central America, and Porto Rico; and peppers and roselle in Cuba. Resistance of the tomato to Fusarium wilt was found at the Tennessee station to vary in different sections, even on the same selections, indicating the probability of a number of strains or biologic forms of the fungus which are not equally infective. Wilt resistant strains with good yields have been developed. Evidently there is more than one form of Fusarium disease in the State, and apparently some relation between the tomato wilt fungi and those causing similar diseases in some other crop plants.

Winter blight of tomatoes, under investigation at the Pennsylvania station, is found to be carried in the seed. The organism causing this trouble is widespread and does not confine its activities to the greenhouse but sometimes appears on field-grown tomatoes. There are some indications that it may attack the potato. Cultures obtained from tomato blight at the Washington station gave a Rhizoctonia instead of a Fusarium as was expected. The organism is apparently the same one that causes the Rhizoctonia disease of the potato, and tomato blight may be produced by inoculation with potato Rhizoctonia.

An investigation of the organism causing late blight of tomatoes, *Phytophthora infestans*, at the West Virginia station showed that there were two strains, one attacking the tomato and one the potato, the latter not causing serious injury to the tomato plant. Both field and greenhouse studies at the Georgia station indicate that pepper mosaic is not transmitted through the seed nor is it carried in the soil, as has been suspected. Cross inoculations of the mosaic of pokeweed to the pepper were not successful, indicating that the practice of destroying diseased pokeweed is of no value in control of the disease on peppers.

Temperature and moisture were found to be the controlling factors in Chili pepper blight at the New Mexico station. No infection appears to take place when the soil temperature is 15° C. or less, or when the soil moisture is less than 12 per cent. The organism causing the disease, a species of Fusarium, has been isolated.

A method has been worked out at the South Carolina station which gives promise of controlling angular leaf spot of cotton as well as anthracnose, and also appears to increase and hasten germination. This consists in air-drying the seed, reducing the moisture from 9 or 10 per cent to 2 or 3 per cent.

Fusarium wilt of tobacco was found by the Wisconsin station to be worse with high soil temperatures and in acid soils. The different strains of tobacco differ markedly in susceptibility to this disease. The so-called tobacco "must," a white mold occurring on fermenting tobacco, proved to be caused by a species of Oospora. Tobacco root rot was found to live over in the soil and to cause what is called "tobacco sick" soils. This has a bearing on the place of tobacco in rotations. It can safely be rotated with clover or alfalfa but should not follow cowpeas. If no host plant is present the amount of fungus in the soil gradually decreases. The Massachusetts station finds that tobacco root rot is less prevalent on acid soils, and therefore liming for this crop has an unfavorable influence. Deficiency in organic matter also tends to augment the trouble. Comparatively large applications of phosphoric acid seem to remedy the trouble.

Owing to the appearance of mosaic disease of sugar cane, which threatens to be serious, the Louisiana station is making a special study of the disease. L511 seems to be the most resistant variety grown. The station has been quite successful in developing strains of alfalfa resistant to brown rot.

A study of corn diseases at the Indiana station indicates an apparent relation between the presence of the fungus causing rot and the accumulation of certain bases, particularly iron. This accumulates in certain tissues in the nodes of the plant, accompanied by an increased peroxidase action in these tissues, causing premature death of the affected plants. Symptoms characteristic of root and stalk rotted plants are produced by injecting iron compounds into the corn plant. These symptoms resemble one another so closely and are so intimately related to the effects of drought, low fertility of soil, poor drainage, and insect and frost injuries, that their diagnosis is sometimes difficult. The greatest loss from these rots is caused by using infected seed. Corn that is planted on infected soil may become infected later in the season. The most successful control measure that has been developed is the selection of seed from healthy, vigorous plants that show no evidence of disease in germination. The black mold of ear corn is found by the Texas station to be caused by two species of Aspergillus which enter the ear in the milk stage through some insect injury, usually the corn-ear worm. It is not a storage disease and can not be transmitted to ripe corn.

The Virginia station reports that most of the marrow type and red beans are resistant to the bean rust, while most pea and white beans are susceptible, the black and brown varieties being about equally in this respect. The work on bean mosaic at the New York Cornell station has established the fact that the virus of this disease is carried through the seed. The control of bean wilt has been successfully worked out at the Oklahoma station, by keeping the seed beans for 2 or 3 years. The loss in germination is very slight up to this time, but beans should not be kept longer than 3 years.

Three species of Fusarium were found at the Texas station to cause wilt on the watermelon but not on other cucurbits or field crops. The species causing cotton wilt will produce a similar wilt in okra. The use of manure favors the introduction and spread of cucurbit wilts. Spraying does not control them very well and resistant varieties are being sought.

The fungus causing Texas root rot is found to be sterile and to be reproduced by mycelia. It has a number of hosts, including the apple, plum, pear, and grape, and carries over particularly well on the sweet potato, but has not been found on the peach or pecan or on the grains.

Spraying with Bordeaux mixture and dry dusting with Bordeaux have given excellent results in the control of celery blight at the New

York Cornell station. The Wisconsin station has been very successful in developing strains of cabbage resistant to the "yellows," and seed of these strains has been widely distributed.

The black rot of apples has been shown by studies at the Virginia station to be less prevalent on certain varieties, especially trees on Northern Spy roots, which may give a basis for its control. The Arkansas station is also studying this disease and finds it to be the same as frogeye on the leaves. Deadwood in the orchards is a source of infection and should be destroyed. Spraying helps somewhat. This disease has caused serious losses in these two States.

Spraying experiments for the control of apple blotch at the Illinois station showed that this should be done from the second to the seventh week after the petals fall and is not necessary earlier or later. The West Virginia station has shown that for the successful control of apple rust by the eradication of red cedars this must extend at least 2 miles from the orchard. Horticulturists in the State estimate that many thousands of dollars were saved in the eastern part of the State, where this recommendation was carried out. Observations indicate that infection must take place within three weeks after the leaf opens, as it becomes immune after that. Hardy trees attacked by blister canker can be saved by cutting out the infected portion and painting the wound with lead paint containing 1 ounce of bichlorid of mercury to 2 quarts of paint, as demonstrated by the Iowa station.

A series of comparative tests at the Indiana station of dusting versus spraying for the control of apple diseases showed that dusting with Bordeaux or other standard fungicides was less effective. The best results in orchard spraying at the Maine station were obtained with lime-sulphur 20 per cent stronger than normal, with an addition of 1 pound of dry arsenate of lead to each 50 gallons. This gave the highest percentage of perfect apples, controlled scab better, and caused less russetting than any other combination.

Cherry leaf spot, which was causing serious damage in the State, was effectually controlled by the Wisconsin station by early clean cultivation and spraying with Bordeaux or lime-sulphur with lead arsenate.

Raspberry anthracnose was held in check at the Montana station by four applications of lime-sulphur, applied before the buds open, when the young shoots are from 4 to 6 inches high, again when 8 to 10 inches high, and just before bloom.

Investigations of the brown bark spot disease of fruit trees at the Montana station have led to the belief that it is a nutritional trouble, apparently connected with a shortage of phosphorus and in some cases of nitrogen. While often proving fatal to trees under clean cultivation, it usually disappears with the use of cover crops and improved management.

Two hours' treatment with sulphur was found by the New Hampshire station to kill the spores of snapdragon rust.

Studies of the white pine blister rust at the Connecticut State station have demonstrated that infection takes place through the stomata of the leaves, occurring in late summer, producing minute yellow spots. In the second year the stem is invaded, causing slight swelling and discoloration, which is further increased with possible stunting of the leaves, in the third year. The fungus appears to winter over on the currant under certain conditions.

It was noted at the Vermont station that while Bordeaux had little effect in stimulating growth in the potato, it did control tip burn to a considerable extent. This trouble seems to be due to scorching and has been produced in the greenhouse by mirrors. It occurs when osmotic pressure is low in the leaves. The New Hampshire station is led by its experiments to doubt the direct stimulation of plants by Bordeaux mixture, and it is believed that the effects noted are the result of retarded transpiration due to the shading effect, thus enabling the plant to make a more economical use of a limited water supply. The same effects were produced on plants grown in 40 per cent of sunlight. The New Jersey station also reports no stimulating action of Bordeaux on potatoes, while there did seem to be some from lead salts as far as the tops were concerned.

Experiments on the sterilization of greenhouse soils by steam at the Pennsylvania station have proved the process very effective, 20 minutes giving as good results as 60, and controlling all soil diseases of lettuce. Formaldehyde solution used for this purpose proved to to be of little value.

ENTOMOLOGY AND ZOOLOGY.

Summer fallowing with frequent cultivation is recommended by the Florida station for the control of the root knot nematode. For seed beds applications of sodium cyanid and ammonium sulphate are suggested. Similar recommendations are made by the Alabama station for greenhouse and market garden practice if the value of the crop justifies the expense, which is about $70 per acre. Planting can be safely done about a week after the application of sodium cyanid. The possibility of obtaining fruits and vegetables resistant to root knot is indicated by the result of studies at the Georgia station.

Studies on the field cricket at the South Dakota station show that the females gather in localized areas, preferably where there is no vegetation, to lay their eggs, and an effective means of control is stirring the soil in these areas to bring the eggs to the surface, where they shrivel up in the wind and sun. Other control measures found to be of value are placing hay or straw in the field in which the

crickets gather, and then burning; also poisoned bait, using meat scraps with Paris green or crude white arsenic. The annual loss by injury to binder twine by this insect is very large.

The Oregon station finds that tree crickets may transmit diseases, especially those affecting the bark.

Parasites were found by the Montana station to aid in reducing outbreaks of grasshoppers in many instances. In tests of poisoned bait for this insect at the Indiana station it was found that hardwood sawdust could be substituted in part for bran with a saving of expense. At the Utah station 80 per cent of grasshoppers were killed with a single application of poisoned-bran mash. Unrefined beet molasses was found to be as effective as citrus fruit in the mixture and much cheaper.

Successful control of the sawfly of the plum was accomplished at the South Dakota station by spraying with lead arsenate, 1 pound of the arsenate to 50 gallons of water.

The New Jersey station reports that sodium cyanid is highly effective in controlling the peach-tree borer, when placed around the base of the tree and covered with earth. At the Tennessee station the time of emergence of the adult of this insect was found to vary as much in orchards in the same locality as in widely separated sections, showing that any system of control must be continuous. The use of nicotine sulphate and other insecticides gave largely negative results in experiments at the Maryland station on the control of the oriental peach moth. The applications should be made at least once a month to have much effect. A number of parasites were found that are a material help in its control.

Methods for the control of the rice or corn weevil, worked out at the Alabama station, have been put into practical application through the extension service. The two most important factors in the control of this insect are the selection of a weevil-resistant type of seed corn and the utilization of the trap-plat method of concentrating the first generation in the field where they may be destroyed economically. While diversified farming is being much stimulated in the State by boll-weevil conditions, the injury to corn by this insect is proving a drawback to diversification. A minute parasite of the eggs of the European corn borer has been found by the New York Cornell station, which suggests a practical method of control. A native corn borer, closely related to the European species, was found by the Iowa station to be prevalent in that State, but was not abundant enough to do much damage. It attacks mainly smartweed and wild lettuce, but may be readily transferred to corn. The Kansas station reports that corn plantings in the latter part of April or first of May showed the least corn ear worm infestation.

The best means of control of the wheat stem maggot was found by the South Dakota station to be a poison bait consisting of $\frac{1}{16}$ ounce sodium arsenate, 1 fluid ounce of blackstrap molasses, and 1 quart of water. From studies of the Hessian fly at the Kansas station it was found that it may remain in the straw in the flaxseed stage for four years, if climatic conditions are not favorable for emergence. There may be from one to five broods a year.

An extensive study of leafhoppers by the North Carolina station indicated that they destroy much more pasturage and green forage than is eaten by stock. A species usually feeding on weeds was found to be attacking alfalfa fields. Studies were conducted by the California station on the beet leafhopper (*Eutettix tenella*), in connection with curly top of the sugar beet. Five broods were reared, the first generation completing its life history on the plains and foothills, and four broods on sugar beets and about 35 species of weeds growing in cultivated areas. Swarms of these insects were found to enter the beet fields in the San Joaquin Valley in April, the return flight to the foothills occurring in October and November; hence the beets should be planted in December or January so that the foliage covers the rows before the hoppers come into the field.

At the Kansas station evidence was obtained that the buffalo leafhopper carried raspberry cane blight to young apple trees. The potato leafhopper was found by the Iowa station to winter over in the adult stage. There are two generations a year, one occurring on the early, the second on the late crop. This indicates that it may be possible to control this insect with only one or two sprays. Its connection with "tip burn" was clearly established.

The control of the tobacco flea-beetle, as worked out at the North Carolina station, is based on the destruction of suckers in the fall to prevent overwintering, treatment of the seed with arsenate of lead and lime, and dipping the plants in solutions of this mixture when transplanting. Dusting with arsenate of lead and soda effectively controlled the horse-radish flea-beetle at the New Jersey station.

A study by the Montana station of the influence of the sugar beet louse on the sugar content of the beet showed a difference of 1.1 per cent between infested and noninfested beets, which in a crop of 15 tons to the acre would make a difference of 330 pounds of sugar. The louse can be controlled to a large extent by proper irrigation. Three broods of the sugar-beet webworm were found by the Utah station to be produced during the season, each brood being successively more heavily parasitized, to the extent of 33 per cent in the last, which aids materially in its control.

The Montana station studied cutworms, which did much damage to wheat during the year and found that as a control measure poi-

soned bran mash, dried and run into the ground with a seed drill at right angles to the grain rows, gave good results, catching about 75 per cent of the worms. About 20 species of cutworms were found by the Nebraska station to be injurious to corn, although as a rule only one species predominates in a field. All but two of the species are surface feeders, and a poison bait consisting of 25 pounds of bran, 1 pound of Paris green, ½ gallon of molasses, 3 gallons of water, and 6 lemons was used with success on alfalfa fields, the above amount being sufficient for 5 acres. A parasitic fly was found that destroys the variegated cutworm, sometimes entirely controlling it.

Wireworms and false wireworms, which have been very destructive to wheat in the drier sections, have been studied at the Washington station, where poisoned baits of sodium cyanid in rice balls or Irish potato have been very successful in their control. Summer fallow does not eliminate them because the larval stage is three years.

A cryptothrips has been found to be quite injurious to camphor trees, by the Florida station. It was controlled by spraying with tobacco and lime sulphur. The velvet bean caterpillar was found to attack the Florida velvet bean by preference, so that this may be used as a trap crop if planted with other varieties.

The importation of parasites from Cuba by the Louisiana station has given encouraging results in checking cane insects.

The clover aphis, which seriously threatened the crop in Idaho, was found by the station to be controlled by grazing with sheep and spraying. The control of the vegetable aphids was shown by the New Jersey station to be possible by the use of nicotine, soap, and water sprayed on the plants at high pressure as soon as the insects appear. The California station has successfully controlled the walnut aphis by the use of a dusting mixture composed of clay, hydrated lime, and 40 per cent nicotine sulphate, dried and pulverized. The Oregon station finds that the number of progeny of apple aphids varies directly with the rapidity of atmospheric evaporation, which also affects the period of development and the seasonal migration. *A. sorbi* was found to winter on the plaintain but may spend the whole summer on the apple.

The green aphis, which causes serious dwarfing of young apples and also causes fruit buds to change to leaf buds, was controlled at the New York State station by delayed dormant spraying with lime-sulphur. The Colorado station finds that the dogwood is apparently the only winter host of the aphis attacking the sunflower, which latter is now being extensively planted for silage. As this is proving to be a rather serious pest, its control may require the eradication of the dogwood. Nicotine sulphate, 40 per cent, and kerosene emulsion were successfully used by the Arkansas station to control both the cabbage worm and aphis. The apple woolly

aphis was found to have new generations about every 10 days through the summer. One of the pink and green aphids of the rose was found by the Maine station to cause wilt on the potato.

The Indiana station finds that in that State there are no well defined broods of the codling moth but rather a continuous succession from spring to fall, necessitating spraying every 10 days or 2 weeks throughout the season. At the New Mexico station it has been shown that while there is considerable overlapping of the broods in the summer most of the eggs are laid during July and August, the spring brood being comparatively small.

The egg-laying period of the pear psylla is not completed before blooming, according to observations by the New Jersey station. Consequently, spraying before this time is not entirely successful. Scraping during the dormant period has little effect, but winter treatment with a soluble oil is important. The late brood of Psylla can be checked with self-boiled lime sulphur, without danger of burning. A species of golden rod, *Solidago altissima*, is found by the Kentucky station to be a host of the locust borer, and locust trees are most attacked in localities where this species grows, little trouble being encountered where it does not occur.

Life-history studies of the clover leaf-beetle at the New York Cornell station shows that in favorable years there are two broods. Late in the season many of the beetles were found to be parasitized. The control of the meadow plant bug, feeding especially upon timothy, is believed by the Maine station to be mainly by rotations, with some advantage in burning, early cutting, and pasturing heavily in the fall.

Tobacco dust heaped about the plants gave effective control of the cabbage maggot at the New Hampshire station. By the use of a bait consisting of 2 quarts of molasses, 1 gallon water and 1 ounce of sodium arsenate, put in small containers 50 feet apart, losses from the onion magggot were cut down from 50 per cent to less than 5 per cent at the New Jersey station. The New York Cornell station controlled apple and cherry maggots by the use of poisoned baits.

The metabolism of the bean weevil was found by the New York Cornell station to be greatly affected by variations in atmospheric moisture, and it is believed that the utilization of a low humidity in storage may provide a satisfactory method of control.

Spraying with nicotine solution has proved satisfactory for the control of the chrysanthemum midge at the Connecticut State station.

The important discovery was made by the Pennsylvania station in connection with an outbreak of red spider that the insect concerned was an imported form, *Paratetranchyus pilosus*, not before

reported as occurring in the United States. It is suspected that this may be the insect causing serious damage to the apple, prune, and cherry in the State.

The Oklahoma station finds that two years are required for the development of the fish moth and that two broods a year are produced.

Soluble oil sprays are recommended by the Arkansas station for the San Jose scale, but dry lime-sulphur is also found to be very effective.

Sweet-potato weevil studies at the Texas station showed that the total period of the adult life may be over eight months, with an oviposition period of seven months.

Bee studies at the Iowa station showed that field bees average 82 milligrams in weight and can carry from one-half to three-fourths of their weight in nectar, requiring about an hour for the round trip in gathering honey. At the Indiana station the placing of hives of bees under screens with sprayed trees resulted in the death of many of the bees.

Mosquito control studies at the New Jersey station have given a marked degree of protection.

Life histories of the biting flies of cattle, especially the tabanids, have been worked out at the Nevada station. A study of the most serious of these, *T. phænops*, shows that on account of the moisture requirements of the larvæ, drainage of lowlands in which they breed offers a practical means of control. While the larvæ may live when the soil becomes dry, they do not range through the soil for food, and so they die of starvation, and the mature females do not lay eggs under these conditions.

Cereal insects in storage were controlled at the Ohio station by maintaining a temperature of 130° to 140° F. for 4 days.

The Maryland station found creosote emulsions, sprayed on the ground as repellents for ants to be somewhat injurious to germination under excessive moisture conditions if used stronger than a 0.5 to 1 per cent emulsion. Strengths above this were also injurious to plants when used as a spray. The South Carolina station found that cover crops of rye and oats drive off the ants attendant upon the activities of the cotton root-louse.

From data based upon 10 years of study of the relation of temperature and moisture to insect activities at the South Carolina station it is now possible to predict the prevalence of certain insects with considerable certainty. Thus, it is found that the minimum winter temperature has a determining influence on the red spider and its natural enemies; that cold, humid winters are favorable for aphid development, and that 12 per cent of soil moisture causes wireworms to disappear.

Studies at the Minnesota station on the toxicity of chemicals to insects show that in contact insecticides this rests largely on the power of vapors to penetrate the chitinous coat of the insects. The control of truck-crop insects with arsenical sprays was found to rest largely on the mechanics of application. Similar investigations at the Oregon station showed that the paste forms of lead arsenates are inferior to the powdered forms in toxic effect. The commercial powders vary greatly in their physical character. Those brands that are uniformly finely divided stay in suspension longer and show a higher degree of control effects. The physical properties of the spray solution may be materially improved by the use of organic spreaders, such as calcium caseinate, saponin, gelatin, or glue. The better brands of calcium arsenates were slightly superior, pound for pound, to the average lead arsenates as a poison for codling-moth larvæ.

A study of the insecticidal properties of pyrethrum powder for plant lice at the New Hampshire station showed the pure powder to have 100 per cent efficiency, but when the powder was mixed with flour the efficiency was diminished in proportion to the dilution.

Investigations on crawfish at the Mississippi station have resulted in finding at least two new species. The prairie-land crawfish burrows down to water, sometimes to a depth of 18 feet, coming to the surface at night, doing considerable damage to corn and cotton. The species inhabiting the dikes and levees rarely burrows over $5\frac{1}{2}$ feet.

A determination of the destructiveness of ground squirrels to wheat at the Washington station indicated that each squirrel costs the farmer from 35 to 50 pounds in reduced yields. The Arizona station has undertaken an investigation in rodent control in connection with range injury. The kangaroo rat, while living mostly on air-dry food, will eat green food material. The breeding season is irregularly distributed, but apparently occurs only once a year, the females producing only one or two young under desert conditions.

FOODS AND NUTRITION.

Several stations, notably Connecticut State, Minnesota, and Wisconsin, have devoted much attention to studies of the vitamines, their relation to nutrition and to deficiency diseases. The vitamine content of milk was found by the Minnesota station to be dependent on the diet of the cow. Raw lean beef contains no antiscorbutic principle, but rhubarb and tomato juice were found to be as efficient as orange juice in this respect.

The studies carried on by the Connecticut State station continue to yield valuable contributions in this important field, especially as regards the sources and occurrence of the vitamines and their influence on growth. Water-soluble vitamines have been isolated and

purified in sufficient amounts for experimental study, and their importance as an essential food constituent for the maintenance of the healthy condition of animals has been demonstrated. Clover, spinach, cabbage, and some other green vegetables were found to be important sources of these materials, and studies are being made of their occurrence in seeds, tubers, etc.

At the Oregon station it was demonstrated that skim milk contains sufficient fat-soluble A vitamine to produce satisfactory growth in dairy calves.

Among the vegetable proteins studied at the Connecticut State station zein from corn proved to be the least efficient for promoting growth. The best growth was obtained when a mixture of vegetable and animal proteins was fed. When a considerable portion of the endosperm of the wheat grain was removed there was found to be a reduction in the food value of the flour.

A study by the Wisconsin station of the proteins of the home-grown feeds ordinarily used on the dairy farm for milk production showed that it was not possible to furnish dairy cows of high milk-producing capacity with a protein content of sufficient amount or quality to maintain maximum production from a clover hay, corn silage, and cereal-grain mixture. This should be supplemented with any of the plant protein concentrates, such as the oil meals.

The importance of more careful attention to the mineral constituents in animal nutrition is well brought out by investigations at the Wisconsin station on the part played by calcium in reproduction. Animals fed a ration deficient in calcium, for example, as whole oats and oat straw, produced dead offspring, while the addition of 2 pounds of calcium acetate to each 100 pounds of grain entirely corrected the trouble. The need for calcium is paramount even as to maintenance of bodily weight and vigor, and is apparently independent of the demand for it as a base to neutralize acids in the body. When grains made up the sole diet, fortified only with salt and a naturally hard water, mature sows could be maintained in fairly good condition for a few months, but eventually went to pieces. No one grain was distinctly inferior to others in this respect, although earlier ill effects were noted when barley was used alone than with corn or oats. It is now being recognized that roughages are important carriers of mineral materials as well as the growth-stimulating vitamines.

The work on the mineral metabolism of animals at the Ohio station shows that a liberal milk production involves a certain degree of impoverishment of the skeleton in mineral substances; that rations containing no legume roughage are apt to be definitely lacking in mineral nutrients, especially calcium; that the response of heavily producing cows to a liberal intake of mineral nutrient is remarkable for its inefficiency, at least during the early part of the period of lac-

tation; and that the mineral constituents of the skeleton appear to be more readily available for use in milk secretion than are nutrients directly absorbed through the ration.

Investigations on the nutrition of calves at the Indiana station have resulted in a formula for a successful milk substitute composed of 12 parts of dried blood, 8 parts of corn meal, and 1 part of oil meal, the experiments showing that the gain in weight per gram of nitrogen consumed with this substance is approximately the same as the gain per gram of nitrogen when on a milk diet, and the mixture is readily digested and assimilated.

A series of cooperative experiments have been carried on by a number of stations on the maintenance, growth, and milk production requirements of cows. The Virginia station found that the feeding of a high protein ration to calves was as economical and more efficient than a low one. Those receiving a low protein ration were less efficient in digesting this food element than those receiving a high protein ration. In an experiment by the same station on the requirements for milk production, one animal was fed a bare maintenance protein with a high energy ration, another receiving a high protein with a relatively low energy ration. The digestibility was much affected by these combinations, the coefficient of digestibility of all the nutrients being very much reduced in the low protein and high energy animal, resulting in a protein starvation and consequent rapid loss of flesh when milk was being produced, although under normal conditions the protein should have been sufficient. The animal receiving the high protein and low energy ration digested a large amount of protein in excess of the requirements for maintenance and milk production, and the coefficient of digestibility of the nitrogen-free extract was slightly above the average.

A study of the effect of grain rations on the growth of chicks at the Kentucky station showed that the proteins of rice, oats, barley, hominy and gluten flour were inefficient in producing normal growth in the White Leghorn chick.

ANIMAL INDUSTRY.

Experiments at the Montana station in winter feeding the breeding herd showed that if the cows are strong and fat in the fall they may be wintered on straw alone, with no bad effect on the calves the following summer, if the cows have plenty of good water and salt. Supplementing the straw with a little cottonseed meal was of considerable benefit. At the North Dakota station cattle were wintered on barley and bran, with no corn, and finished exceptionally well. One hundred and seven pounds of barley was equivalent to 100 pounds of corn.

Experiments at the New Mexico station on the value of soapweed (*Yucca elata*) for the maintenance of range breeding cows showed

that 28 to 30 pounds of this material with 1 pound of cottonseed meal per 1,000 pounds of live weight was sufficient to maintain the cows unless they were suckling calves. After the animals had been accustomed to the feed they could be maintained on slightly less than at first. Those receiving the cottonseed meal supplement came through in excellent physical condition, while one lot fed Yucca alone showed signs of malnutrition. These results are confirmed by similar experiments at the Texas station.

The advantage of supplementing range feed was demonstrated at the New Mexico station with two lots of cows, one kept on the open range without other feed, the other receiving a light allowance of cowpea hay and kafir silage. The calves of the latter lot averaged 11 pounds more per head than those of the first lot.

White sage, which is considered an ideal winter range plant, has been eradicated in many sections by overgrazing. Valuable information in regard to seed germination, means of dissemination, and the proper depth of seeding have been worked out by the Nevada station.

In a comparison at the Colorado station of ground barley and oats with corn, supplemented in each case with cottonseed meal, for fattening steers, the lot that were fed barley and oats made as good gains as the corn-fed lot and at less cost, but did not show quite as much finish at the close of the test. The best results in feeding sugar-beet tops to fattening steers at this station were obtained by pasturing in the field.

In three years' cattle feeding experiments at the Oregon station steers fed for 80 days on a ration of 13 pounds of mixed grain, 13 pounds of silage, and 13 pounds of hay gained on an average 2.91 pounds daily. Feeding experiments at the Nebraska station showed no profit from the introduction of oil meal in the ration, but hominy feed was fed at a profit and the steers were better finished. At the Pennsylvania station, feeding tests indicated that at the present price of feeds it was more economical to use protein concentrates, as linseed or cottonseed meal, during the latter part of the finishing period, than to finish with corn.

At the Florida station a comparison was made of velvet-bean meal and peanut meal, both fed with corn, for fattening steers. Both lots made practically the same gains, but the peanut-meal lot cost a little more. When marketed the steers were classed as the best ever received at the Jacksonville market. No softening of the fat of the peanut-fed lot was noticed. In experiments at the Alabama station to determine how many pounds of velvet beans in the pod will produce 1 pound of beef, six yearling steers, with an initial weight of 900 pounds, on a 2-acre plat carrying about 614 pounds of beans to the acre, and with a supplementary forage of cornstalks, required from 4 to 6 pounds of beans to produce a pound of gain.

The Illinois station has demonstrated the feasibility of making a good silage from shock corn stover, producing an economic roughage for the maintenance of cattle. The stover should be cut and put in the silo with an equal amount of water. The product is somewhat less acid than that made from green corn. By supplementing this with 1 pound of linseed or cottonseed meal per day per 100 pounds live weight, the body weight was maintained at a cost of 7 cents per day.

The results at the Montana station of wintering sheep on sunflower silage, supplemented with a little cottonseed cake, have been very favorable, 2½ pounds of the silage being equivalent to 1 pound of hay. The introduction of oil meal in the ration for fattening lambs at the Nebraska station showed no profit, but hominy feed both increased the rate of gain and decreased the cost per 100 pounds. At the Washington station a comparison of pea straw and alfalfa hay as a winter roughage for lambs and pregnant ewes resulted slightly in favor of the pea straw as to cost. Although the lot receiving this required a little more grain the difference was not great. The most profitable ration for feeding lambs at the Iowa station, comparing a large variety of feeds, was shelled corn full-fed daily, with 15 pounds of linseed meal, daily per lamb, fed on corn silage full-fed twice daily, plus clover hay full-fed overnight, with salt at will. The lambs returned a margin of $3.32 over feed cost per head.

At the Wyoming station, in a comparison of native hay and silage with alfalfa for breeding ewes, the ewes on alfalfa did better and made more rapid gains but at greater cost. Strong young ewes did very well on native hay. A study of the cost of producing spring lambs at the Oregon station showed that native pastures will average 800 to 900 sheep days per acre, while cultivated crops will give from 1,000 to 1,200 sheep days. Of the latter, rape, vetch and oats, or rape and clover are available. The cost on native grasses was 5 to 6 mills per sheep per day. Sheep without shelter gave better results than those in confinement, a shed closed on two sides to protect from wind and rain being sufficient. It required on an average 1.06 acres of pasture to sustain one sheep for a year.

The Nevada station has found that losses on the range in the lambing season are largely a question of feed, and that alfalfa or meadow and swale hay must be supplemented to keep up a sufficient milk flow to prevent the losses. Sheep grazing upon feterita at the Texas station were found to be susceptible to the prussic acid in this crop, as are cattle.

In attempts to establish a breed of sheep for winter lambing, the Oklahoma station finds that early breeding is a dominant character of the Dorsets, which can be established by selecting those individuals that are born in the fall and have proved themselves to be early

breeders. The character can also be fixed in the higher crosses. Considerable progress has been made at the South Dakota station in breeding a tailless strain of sheep, with good vigor and quality of fleece, by crossing native varieties with tailless sheep imported from Siberia.

Investigations at the Montana station on factors affecting the character of wool showed that range sheep give a much weaker fiber and much more variation than barn-sheltered sheep. The factors that affect the strength also affect the diameter and there appears to be a correlation between these. The fiber is also affected by the feed. When well-fed and well-managed sheep are changed to a poor feed, a decided change is shown in the wool at that time. Humidity exerts more influence on the properties of wool than temperature, within certain limits.

Similar studies at the Wyoming station indicate that when the relative humidity increases from 40 to 80 per cent there is a decrease in breaking strength but an increase in elasticity. Above 80 per cent the elasticity begins to decrease and the breaking strength to increase slightly. The tensile strength decreases as the size of the fiber increases. The breaking strength is a better measure for comparison between the different grades than the tensile strength, especially with the finer wools. With the coarser fibers the tensile strength seems to be correlated to the diameter, with a figure lying somewhere between the first and second power, but in the finer fibers it is in closer correlation to the first power of the diameter than to the second power. Negative results were obtained so far as the effects of alkali and weather on the wool of live sheep were concerned, but in small flocks exposed to the weather the wool decreased 30 per cent in strength in one month and at the end of three months the fibers were destroyed. Feeding inorganic sulphur had no effect on the wool.

A number of the southern stations have investigated the relation of peanut feed to softness and other changes in pork. A series of feeding experiments were carried out at the Alabama station with lots receiving increasing percentages of peanuts with corn, compared with a check lot receiving corn and tankage only. All of the lots finished well, but the check lot was the best. No bad effect on the fat was noted when the peanut meal was fed in amounts sufficient to give a balanced ration. Most of the lots were classed as firm, although those receiving the largest percentage of peanut meal were classed by some of the judges as medium firm. Other experiments were conducted to determine the effect of dry lot feeding on the quality of the pork, and if it was profitable to finish off soft hogs in this way. Two lots that had been on peanut pasture for eight weeks were fed in the dry lot, one receiving corn and tankage, the other, peanuts only. The corn-and-tankage lot brought half a cent a

pound more than the other, and the dry lot finishing and hardening was conducted at a profit. Two lots of hogs were pastured on peanuts for 30 to 40 days, at the Oklahoma station, one lot finished on cottonseed meal, kafir, and alfalfa, the other on tankage, barley, and alfalfa; both gave pork that was classed by packers as soft, although there was a rise in the melting point of the fat of the tankage lot of $1\frac{1}{2}$° C.

Investigations at the Texas station indicate that exposure as well as feed, may produce a soft pork and that other factors such as breed, management, degree of finish, and health also have an influence. The best results with peanuts were obtained where these did not constitute more than a third of the ration. Two parts of corn with one part of peanut meal gave a hard pork. The best results were obtained by providing shelter with a lot to run in.

Experiments at the Montana station on the proper amount of grain for hogs in connection with forage crops indicate that a light grain ration is most economical. When a full grain ration was fed hogs could be finished in 20 to 30 days, but a lighter ration fed during the finishing period, from 1 to 2 pounds per 100 pounds of live weight, made the cheapest pig. The advantage of supplementing pasture and forage with some grain was brought out by experiments at the Virginia station, in which pigs receiving the largest grain allowance gave the best returns. Peas proved to be a very satisfactory pasture crop for hogs at the Washington station. The addition of a 2 per cent grain ration did not prove profitable. Pigs pastured on alfalfa with no supplementary feed did not make satisfactory gains.

A comparison of fish meal as a substitute for tankage in a corn ration at the Missouri station demonstrated the value of this comparatively new material. In all cases the hogs receiving it made a more rapid gain and required less feed to produce a given amount of gain. The Alabama station also reports satisfactory results with fish meal. That station also finds that no bad results followed the feeding of velvet beans to pregnant sows. The value of soy-bean forage in pork production was demonstrated at the Delaware station, where 1 acre of the beans supplemented with $89.97 worth of grain, produced 1,127.5 pounds of pork.

In a study of economical rations for pork production at the Nebraska station tankage was found to be preferable to shorts when fed in a self-feeder to supplement corn and alfalfa, increasing the net profit per pig. Hominy feed made a satisfactory substitute for corn at the Missouri station, although hogs getting this gained a little less rapidly and required slightly more feed to produce a given amount of gain than corn-fed hogs. Practically the same conclusions were reached in using barley as a substitute for corn. A com-

parison of barley and corn at the Iowa station showed the former to be excellent for brood sows, but not quite equal to the latter for fattening hogs. One hundred pounds of corn was equal to about 124 pounds of barley for this purpose, but the barley made an excellent quality of pork.

Pigs fed by the New Jersey station on garbage with 1 per cent shelled corn made satisfactory gains. Raw garbage alone produced more pork in a given time than cooked garbage alone, although neither gave as good gains as garbage finished with grain for the last 35 days of feeding. At the Oregon station 125 hogs were fed for two months on garbage, each one consuming on an average the garbage from 16 men, with a supplement of 2.38 pounds of barley, and gained 1.57 pounds daily. Making allowance for the barley consumed, the garbage from 1 man for 1 day produced 0.965 pounds of pork worth, at 18 cents a pound, 17 cents. The feeding value of garbage from a training camp was found by the Mississippi station to be $1.16 per 100 pounds. At the Michigan station 1 ton of garbage produced approximately 100 pounds of pork, and about 500 pounds of garbage was equivalent to 100 pounds of grain. The material, which was gathered daily from students' boarding clubs, gave better results when cooked. In garbage feeding experiments at the Oklahoma station 100 pounds of pork was produced from 1,177 pounds.

Adding molasses to grain feed at the Oregon station resulted in more feed being consumed and better gains obtained. Oats did not prove to be a profitable feed for hogs at the Oklahoma station. The use of self-feeders for fattening hogs at the Arkansas station reduced the labor about 50 per cent. Runts separated from more vigorous and larger pigs, and fed carefully with nutritious feeds, made rapid and economical gains at the Oregon station. Studies on the effect of acid in the feed of swine at the Iowa station demonstrated that mineral acids, even in large doses, failed to cause a significant loss of calcium or to interfere with the storage of protein.

An investigation on the effect of age of pigs on the rate and economy of gains at the Ohio station confirmed the general experience that the feed requirement per unit of gain increases with increase in weight, and that the dressing percentage of full-fed pigs also increases with weight.

At the Michigan station it was found that mature horses can be carried over the winter on silage and straw, providing the silage is of good quality, but young horses are not properly nourished by such a ration.

The Kentucky station reports that in its horse-breeding experiments approximately one-half of the mares bred proved to be sterile. This was found to be due to methods of breeding, to mares with

diseased organs, or to stallions partially or wholly impotent. In the latter case changes in exercise and diet, aided by tonics, helped in many cases.

In poultry feeding experiments at the North Carolina station, hens fed in the dry lot produced an average of 35.7 eggs per year as compared with 76.4 eggs per hen for range feeding. Experiments at the Missouri station showed that the efficiency of a ration for egg production is greatly increased by including a protein supplement from animal sources. Where no animal food was used it required from 12.3 to 14.25 pounds of grain to produce a dozen eggs, while with animal food this was reduced to 8.25 to 9.05 pounds. Cotton-seed meal did not materially increase the efficiency of the ration, but sour milk proved to be about equal to meat scraps. Similar results were obtained at the Iowa station, where it was shown that a large percentage of animal food is needed for winter egg production, the mash containing the largest amount of protein giving the largest number of eggs at least cost. At the Indiana station soy-bean meal, especially when supplemented with a suitable mineral mixture, proved to be a good feed for supplying protein to young chicks.

Pullets allowed free range at the Connecticut Storrs station showed 70 per cent hatchability of their eggs as compared with 44 per cent with no range. Those on range laid 740 more eggs in two years than the confined lot.

Studies on the relation of plant carotinoids to poultry production at the Missouri station led to the conclusion that the natural yellow pigment of fowls, which is derived from the xanthophyl of the food, bears no important relation to fecundity and reproduction, at least for one generation. When rations devoid of xanthophyl were fed to cockerels, the yellow pigmentation in the skin, beak, shanks, ear lobes, etc., gradually disappeared. The shanks of laying birds fade when egg-laying begins, and if this is continuous the shanks of even the yellow-skinned varieties will in time be entirely free from pigment. The explanation of this is that egg-laying deflects the normal path of excretion of xanthophyl from the skin to the egg yolk. At the Michigan station the egg yolk color was found to be intensified by feeding lobster shells.

Broodiness in poultry has been under investigation at the Massachusetts station. Nonbroodiness appears to be a recessive factor and is much more difficult to establish than broodiness. When a bird becomes broody, its temperature declines about one degree.

The Rhode Island station finds that high-producing ability is better shown by the weight of eggs than by the count.

Incubation studies at the New Jersey station indicate that the vital times for turning eggs are during the first week and just before

hatching, turning between these periods being unnecessary. Cooling retards the development of the embryo and is not necessary if the incubator is well ventilated.

At the California station artificial lighting of the henhouse increased the egg production in winter up to 60 per cent, the effect being to change the laying season, giving more eggs in winter but no more for the entire year. The effects were more marked with pullets than with hens. At the New Jersey station this practice increased production 100 per cent from November to February, and the net returns from feed cost over 400 per cent. At the Utah station also profitable increase in egg production was secured from lighting during the winter, but with only slight increase in the yearly production. The eggs from the lighted houses showed as high a percentage of fertility as those from unlighted houses.

DAIRY HUSBANDRY.

The effect of peanut meal fed to dairy cows on the quality of the butter fat was found by the Georgia station to be no greater than that exerted by the roughage in the ration.

A comparison at the South Dakota station of gluten feed with oil meals for the protein supply in the dairy ration, showed that only about half as much protein in the former is required to reach the nitrogen balance as in the latter. The adaptability of individual animals to the various proteins is a disturbing factor in getting reliable data on such problems.

From studies at the California station on the effect of barley on the milk secretion of cows, this grain was found to be excellent for dairy cows and no deleterious effect was noted on the milk when the ration fed contained sufficient nutriment. The use of barley, both for dairy and for stock feeding, is recommended when its market value makes it economical in comparison with other concentrates.

The Ohio station, comparing clover and alfalfa hay, found that while a preference was manifested for the alfalfa, and more of it was consumed, the production of milk per unit of protein consumed was greatest with clover. In experiments on methods of feeding velvet beans at the Alabama station bean and pod meal was the most satisfactory and palatable, and the soaked beans were better than those fed whole and dry. It is not advisable, however, to make the entire ration of velvet beans.

Feeding experiments with sunflowers, both green and as silage, for dairy cattle gave excellent results at the Montana station. The green sunflowers were found to be equal to green clover pound for pound. One pound of alfalfa hay was equivalent to 2.83 pounds of sunflower silage, the latter being considerably cheaper. At the

New Mexico station, sunflower silage gave as good results as cane silage for milk production, and velvet-bean meal was found to compare favorably with wheat bran.

Experiments at the Oregon station showed that young dairy cattle can be wintered satisfactorily on straw, molasses, and a small amount of grain, at a cost of from 30 to 40 per cent less than with clover hay. Barley compared well with bean and shorts for maintenance but did not fatten the cows. It was found that coconut meal could replace cottonseed meal in part for milk production without loss. Cottonseed hulls and corncob meal were found to have about the same value in feeding trials at the Mississippi station. A comparison of the effect on production of early and late fall calving at that station showed the advantage of the latter. Late fall calving cows milked 44 weeks compared with 48 weeks for the early calving cows, but gave 716 pounds more milk and 30.3 pounds more butter fat. The Iowa station also found that the time of freshening has a considerable influence on production, fall freshening giving about 10 per cent more than spring or summer.

From three years' trials of milking machines at the California station it is concluded that the modern machine is a practical and safe labor-saving device, giving as good results as regards the production of milk and butter fat during the lactation period as does hand milking if equal care is used.

A study of the hydrogen-ion concentration in milk as influenced by various factors at the New York State station indicate that this can be used for the rapid detection of abnormal milk. Under normal conditions 6.5 represents the highest acidity of normal milk. At the Michigan station a method has been devised for determining the keeping quality of milk by a colorimetric hydrogen-ion determination, whereby it is possible to predict the length of time required for a sample of milk to curdle. This method gives a very effective means of checking up market milk supplies, both more accurate and less complicated than the bacterial count method. The Wisconsin station has devised a very simple and rapid method of testing milk from a hygienic standpoint which consists in adding a minute quantity of methylene blue. The rapidity with which the color disappears is directly related to the bacterial content of the milk.

Studies on the keeping quality of butter at the Minnesota station show that heating the cream to a point high enough to destroy many or all of the enzyms present as well as the bacteria, which can be done at 175° F., will produce a butter with materially better keeping qualities than if the cream is heated to the usual temperature of 145°. Results of trials of the neutralization of the acidity of cream for butter making at the Oregon station showed without exception that butter made from such cream had better keeping qualities than that from

untreated cream. Studies at the Indiana station indicate that, in general, less change takes place in butter made from sweet than in that made from sour cream.

The Vermont station has successfully stored cottage cheese for four or five months, the product then scoring high with experts. Cheese from pasteurized milk kept a little better. Attempts at the South Dakota station to make a skim milk cheese that would keep showed this to be possible, but the results were not entirely satisfactory as the cheese tended to become hard from lack of moisture and the flavor deteriorated. Similar results were obtained at the Idaho station, when the flavor deteriorated rapidly at 50°, more as a result of acids formed by bacteria than of molds and yeast. After about 15 days the cheese was no longer marketable. Salting and washing reduced the bacterial count to some extent. A test of whey separators at the North Carolina station showed that 2½ pounds of fat may be recovered from 1,000 pounds of whey.

VETERINARY MEDICINE.

Contagious abortion has been investigated at a number of the stations. The Minnesota station believes the blood test to be of little value. Vaccine has been used with some success. A study at the Wyoming station showed that 50 per cent of cows that aborted became sterile from closure of the mouth of the uterus. Some success followed the use of spring wire pessaries to prevent this. Studies of the immunization of horses and cattle against abortion at the Kentucky station indicate that bacterin vaccination constitutes a reliable means of preventing the disease in mares. The treatment should be given before they are infected, three inoculations 7 to 8 days apart being recommended. The results with cattle have not been so encouraging.

From a large number of tests the Connecticut Storrs station finds that calves without exception give the same agglutination reaction as their mothers, and that after the sixth month all calves are nonreactors. The greatest danger from infection exists at the time of sexual maturity and for several months following, and if heifers are safeguarded against infection from without they remain uninfected indefinitely. Whether they were reactors or not at their birth has no bearing on the readiness with which they become infected at or after maturity nor upon their breeding record. Repeated efforts to infect calves, heifers, and cows by feeding *Bacillus abortus* in capsules and milk proved complete failures. The results of five years' study very strongly indicate that the male is the most important factor in the transmission of the disease, and disinfection of the sheath of the male is therefore an important means of prevention.

The Oregon station finds that one of the common sources of infection is pen exposure of pregnant animals. From studies on the effect of food on abortion at the Maryland station it is believed that in general the substitution of corn for wheat products has reduced this trouble in the herd.

Positive results have been obtained at the Alabama station in the transmission of hog cholera by lice, both by injecting with extracts of the insect and by transferring from infected hogs. At the Indiana station sterile earth saturated with blood of an infected hog fed to a healthy animal produced symptoms up to five days, similar tests with urine and feces not being so positive. Attempts to transmit the disease by house and stable flies gave negative results. Experiments have been made at the North Dakota station to attenuate hog-cholera virus through other nonsusceptible species, as goats and rabbits, and the evidence indicates that a 10 days' sojourn of the virus in the rabbit robs it of its disease-producing property, but susceptible pigs died of cholera following injections with the blood of rabbits which had been inoculated 5 to 7 days previously. In both peccaries and goats infectiousness was carried through four generations. Dilution experiments showed that 1/400 cubic centimeter of the virus was sufficient to produce the disease.

The California station finds that in making the tuberculin test on cattle there is a small but constant percentage of reactors that do not show local reaction until later, and that early observations can not be depended on. Two observations are recommended, one at 48 to 60 hours after injection and one at 96 to 120 hours.

A study of the extent to which infected environment may be responsible for the spread of the disease showed that tuberculous material placed in 1½ inch thickness of manure in a small pen in which cattle were exposed to the dust lost its infectiousness after 17 days if no rains intervened. In water holes, on the other hand, or if the material was kept moist, it was infectious to guinea pigs for 687 days. Two out of three cattle became tuberculous when forced to drink water taken from water holes 149 days after such holes were infected.

This leads to the conclusion that environment contaminated with tuberculous discharges from cattle loses its infectiousness rapidly after the media lose their sensible moisture, but that the tubercle bacilli retain their virulence for long periods in such places as water holes, mud holes, and watering troughs.

This station has also investigated a disease known as lymphangitis in cattle, the casual organism of which closely resembles the tubercle bacillus, and a large percentage of the cases gave positive reactions with the intradermal tuberculin test, although tuberculosis could not be found on autopsy.

That swamp fever of horses can be transmitted by certain flies has been confirmed by the Wyoming station. Mild cases showing no symptoms often serve as carriers, and it will be necessary to find some diagnostic test to recognize these. Besides its transmission by insects, especially those with habits of interrupted feeding, the disease may be transmitted by introducing the nasal discharge from a sick horse into the nasal cavity of a healthy one, and in some cases may be transmitted by food contaminated with urine. Mosquitoes, especially from their manner of feeding and the structure of their mouth parts, do not appear to carry it. The blood of an infected horse is only virulent at certain times. The mortality of acute cases is very high. The North Dakota station has also investigated this disease and finds that if the blood of an infected horse is heated to 60° C. it loses its virulence. The infection may be carried by the urine as well as the blood and is also transmitted in the milk to the young, as nursing colts receiving no other food become infected.

The Wyoming station has also studied and isolated the organism of necrobacillosis. This organism does not invade the blood stream but remains near the point of infection, the lesion produced being wholly local, consisting of necrosis but with no pus formation. The same organism, apparently, according to the place of infection, may produce calf diphtheria, stomatitis in calves and pigs, pneumonia in calves, lambs, and pigs, necrotic enteris, necrotic dermatitis, and lip and leg ulceration in sheep. The organism grows only in an atmosphere of nitrogen and no good medium has been found for it, but it may be kept by inoculating rabbits.

Studies on the cause of "trembles" in farm animals, by the North Carolina station, which have definitely shown it to be caused by rich weed (*Eupatorium ageratoides*) also show that another common species of this genus, *E. incarnatum*, apparently does not cause the disease.

Results of experiments with nonbiting flies, particularly the house and maggot flies, at the Louisiana station show that these insects can carry anthrax infection to wounds on otherwise healthy animals after feeding upon anthrax-infected flesh or upon the discharges from carbuncular swellings on animals sick with anthrax, indicating the necessity for prompt and complete destruction of all anthrax carcasses and also of giving animals greater protection against the ravages of all insects during outbreaks of the disease.

From studies at the Kentucky station it is believed that clover bloat in cattle does not ordinarily take place unless there is some indigestion. Its artificial production by feeding clover blossoms even with glucose and yeast, was not always successful.

At the West Virginia station it is found that newly hatched lungworms of calves will live for long periods at a temperature of 32° F.,

and that eggs will hatch after being exposed to extreme cold for 35 days.

Studies on an unidentified hemorrhagic disease in cattle at the Nevada station resulted in a serum that has been quite successful in its control. The specific organism has not been found.

Investigation by the Wyoming station on the sarcocystic parasites of sheep indicate that infection is seasonal, occurring during summer and early fall, and that it is usually from grass contaminated with droppings. Progress has been made at the Texas station in producing a serum for treatment of swell head of sheep and goats. Goiter and hairlessness in Angora goats was effectually controlled at the Washington station by pouring 1 cubic centimeter of tincture of iodin on the skin once every two weeks throughout pregnancy.

The Nebraska station finds that rabbits, poultry, and guinea pigs are susceptible to hemorrhagic septicemia, but has not been successful in inoculating it into cattle or horses. It may be successfully inoculated into hogs when they are recovering from cholera. Blood from an inoculated horse seems to have some immunizing qualities on rabbits. The causal organism has been found in cattle and swine.

At the Minnesota station experimental infections of the preventricular and gizzard worms of fowls were unsuccessful. The bacillus of bacillary white diarrhea of poultry was isolated by that station. The New Jersey station has been very successful in the preparation of autogenous vaccines for chicken pox, roup, and canker. Tobacco dust as a vermifuge for the control of intestinal roundworms in poultry has given excellent results at the California station. Studies on the tapeworm of poultry, *Hymenolepis caroica*, by the Oklahoma station show that the intermediate stage is passed in the stable fly, and the parasite has been transmitted by feeding these flies to chickens. Life-history studies of the chicken tapeworm, *Choanotænia infundibuliformis*, at the Kansas station show that this is transmitted by the common house fly as an intermediate host.

A number of stations have been engaged in investigations on poisonous plants. It was found at the Montana station that an average acre of loco weed can be grubbed out by one man in about seven hours. All of the so-called loco weeds are not harmful. Studies at the Oregon station show that plants not usually regarded as dangerous may cause trouble under certain conditions. Thus, a cress (*Radicula* sp.) is suspected of being the chief cause of a serious outbreak of cattle poisoning although this plant has not hitherto been reported as poisonous.

Increasing losses on the Nevada ranges have led to an extensive study of this subject by the station, and a number of plants formerly thought to be suitable for pasture are found to be poisonous at certain

stages, including three species of Solidago and several milkweeds. The succulent green tips of the rabbit brush cause heavy losses, and goose grass, not formerly suspected, is found to be very toxic to sheep but not to cattle. The cause of the increasing losses seems to lie in the progressive destruction of palatable forage, forcing the animals to eat plants which a few years ago would seldom if ever have been touched. The station is working out the poisonous doses, habits of the plants, and methods of control. Swell head of sheep appears to be connected with these troubles, and has caused heavy losses at times in certain areas and is apparently due to some plant irritant.

Poisonous-plant studies at the Colorado station have been mainly on the whorled milkweed, from which the toxic principle has been isolated. Spraying with salt solution is an effective means of killing it out.

Reference is made to other investigations along this line under the head of agricultural chemistry.

AGRICULTURAL ENGINEERING AND RURAL ECONOMICS.

The Oregon station has perfected a cheap and practicable method of land clearing, by means of a small oven and pipe, which will consume a large stump, with the roots, in about four days and leave no hole in the ground, at a cost of about $1.20 per stump.

At the Wisconsin station T. N. T. was found to be excellent for clearing land, as it is not affected by moisture up to 5 per cent or by dry cold.

Two forms of silo giving the best results at the Iowa station, which are also not expensive, are the concrete block and concrete stave silo.

Tractors were found by this station to be satisfactory to 90 per cent of those using them, the principal cause of failure being lack of experience. Kerosene was the most generally used fuel, and two and three plow outfits were found best adapted to field work.

A study of methods of storing ice on the farm at the South Dakota station gave a recovery of 47 per cent under the best conditions.

A study of the cost of producing farm products at the Nebraska Station showed that this has risen in about the same proportion as that of manufactured articles. Wages paid farm labor have more than doubled in the last five years. Nearly all farmers receive less per hour for their labor than skilled city laborers.

INSULAR STATIONS.

The Office of Experiment Stations continued to exercise general supervision over the stations in the insular possessions which derive their support from direct Federal appropriation to the Department

of Agriculture. These stations are located in Alaska, Hawaii, Porto Rico, Guam, and the Virgin Islands. The relations of the office with them are in immediate charge of W. H. Evans. Separate reports are made upon their operations.

VISITATION OF THE STATIONS.

The examination of the work and expenditures of the stations was carried on as in the past, each continental station receiving Federal funds being visited by a representative of the office during the year. This examination was participated in by five members of the office force—the Chief (E. W. Allen), W. H. Evans, W. H. Beal, E. R. Flint, and J. I. Schulte.

In addition to this personal examination on the ground, the office maintains close relations with the stations through correspondence, passes upon and approves the projects conducted under the Adams fund, and at the close of the year examines the financial reports of the stations before they are formally approved.

STATISTICS.

General statistics, 1919.

Station.	Location.	Director.	Date of original organization.	Date of organization under Hatch Act.	Number on staff.	Number of teachers on staff.	Number of persons on staff who assist in extension work.	Publications during fiscal year 1918–19.		Number of names on mailing list.
								Number.	Pages.	
Alabama (College)	Auburn	J. F. Duggar	Feb. —, 1883	Feb. 24, 1888	26	11	20	11	224	26,000
Alabama (Canebrake)	Uniontown	J. M. Burgess	Jan. 1, 1886							
Alabama	Tuskegee Institute	G. W. Carver	Feb. 15, 1897		10	9				
Alaska	Sitka	C. C. Georgeson	1898		6			1	96	4,232
Arizona	Tucson	D. W. Working		1889	18	9		8	281	20,000
Arkansas	Fayetteville	Martin Nelson		1887	18	18		52	403	6,359
California	Berkeley	T. F. Hunt	1875	Mar. —, 1888	124	95	71	50	1,411	36,753
Colorado	Fort Collins	C. P. Gillette		Feb. 29, 1888	33	18	6	7	478	9,000
Connecticut (State)	New Haven	E. H. Jenkins	Oct. 1, 1875	May 18, 1887	21	1	6	9	498	9,300
Connecticut (Storrs)	Storrs	do		May 18, 1887	10	5	5	4	171	7,018
Delaware	Newark	Harry Hayward		Feb. 21, 1888	11	6	4	4	114	8,000
Florida	Gainesville	P. H. Rolfs		1888	10	2	1	27	402	17,000
Georgia	Experiment	H. P. Stuckey	Feb. 18, 1888	July 1, 1889	7			29	146	11,000
Guam	Guam	C. W. Edwards	1909		4					2,983
Hawaii	Honolulu	J. M. Westgate	1901		9		8	1	55	5,906
Idaho	Moscow	E. J. Iddings		Feb. 26, 1892	29	17	7	11	260	12,475
Illinois	Urbana	Eugene Davenport		Mar. 21, 1888	83	67	35	38	912	42,000
Indiana	Lafayette	C. G. Woodbury	1885	Jan. —, 1888	56	16		31	1,304	26,000
Iowa	Ames	C. F. Curtiss		Feb. 17, 1888	74	22		21	998	29,000
Kansas	Manhattan	F. D. Farrell		Feb. 8, 1888	74	40		12	514	10,000
Kentucky	Lexington	T. P. Cooper	Sept.—, 1885	Apr. —, 1888	49	20	7	8	294	20,000
Louisiana (Sugar)	New Orleans		Sept.—, 1885							
Louisiana (State)	Baton Rouge	W. R. Dodson	Apr. —, 1886		21	1	2	2	48	8,330
Louisiana (North)	Calhoun		May —, 1887							
Maine	Orono	C. D. Woods	Mar. —, 1885	Oct. 1, 1887	19			65	374	15,000
Maryland	College Park	H. J. Patterson	1888	Apr. —, 1888	24	12		10	212	16,000
Massachusetts	Amherst	F. W. Morse [1]	1882 [2]	Mar. 2, 1888	42	17		21	497	26,266
Michigan	East Lansing	R. S. Shaw		Feb. 26, 1888	60	21		20	1,341	45,000
Minnesota	University Farm, St. Paul.	R. W. Thatcher	Mar. 7, 1885	1888	83	61	3	11	551	9,800
Mississippi	Agricultural College	J. R. Ricks		Jan. 27, 1888	19	7	1	8	240	20,000
Missouri (College)	Columbia	F. B. Mumford		Jan. —, 1888	51	43		147	776	14,613
Missouri (Fruit)	Mountain Grove	F. W. Faurot	Feb. 1, 1900		5					
Montana	Bozeman	F. B. Linfield		July 1, 1893	26	13		16	270	12,500
Nebraska	Lincoln	E. A. Burnett	Dec. 16, 1884	June 13, 1887	34	15	2	10	256	18,304

Nevada	Reno	S. B. Doten		Dec. —, 1887	16	4	1	4	164	4,500
New Hampshire	Durham	J. C. Kendall	1886	Aug. 4, 1887	18	14	16	22	125	22,000
New Jersey (State)	New Brunswick	J. G. Lipman	Mar. 10, 1880		30	18	13	121	1,515	9,000
New Jersey (College)	do	do		Apr. 26, 1888	17					
New Mexico	Agricultural College	Fabian Garcia		Dec. 14, 1889	21	16	2	88	291	9,500
New York (State)	Geneva	W. H. Jordan	Mar. —, 1882		38			31	2,159	50,000
New York (Cornell)	Ithaca	A. R. Mann	1879	Apr. —, 1888	45	61	18	18	1,169	2,450
North Carolina	West Raleigh	B. W. Kilgore	Mar. 12, 1877	Mar. 7, 1887	51	6		5	281	51,000
North Dakota	Agricultural College	P. F. Trowbridge		Mar. —, 1890	26	6	11	7	268	5,500
Ohio	Wooster	C. E. Thorne	Apr. 25, 1882	Apr. 2, 1888	64			77	1,650	65,000
Oklahoma	Stillwater	H. G. Knight		Dec. 25, 1890	24	16		8	230	15,241
Oregon	Corvallis	A. B. Cordley		July —, 1888	37	38	14	164	382	2,000
Pennsylvania	State College	R. L. Watts		June 30, 1887	65	52	65	5	110	36,000
Pennsylvania (Nutrition)	do	H. P. Armsby	1907		7					500
Porto Rico	Mayaguez	D. W. May			9		2	3	135	4,160
Rhode Island	Kingston	B. L. Hartwell		July 30, 1888	8	2		7	403	2,000
South Carolina	Clemson College	H. W. Barre		Jan. —, 1888	19	11	12	4	268	4,300
South Dakota	Brookings	J. W. Wilson		Mar. 13, 1887	18	14		5	148	24,000
Tennessee	Knoxville	H. A. Morgan	June 8, 1882	Aug. 4, 1887	24	6		5	54	11,183
Texas	College Station	B. Youngblood		Apr. 3, 1889	51	3		20	916	38,425
Utah	Logan	F. S. Harris		1890	30	20	7	12	386	8,300
Vermont	Burlington	J. L. Hills	Nov. 24, 1886	Feb. 28, 1888	14	7	3	4	136	14,000
Virginia	Blacksburg	A. W. Drinkard, jr	1888	1891	26	9		4	182	10,000
Virginia (Truck)	Norfolk	T. C. Johnson			7			4	94	6,500
Virgin Islands	St. Croix	L. Smith			1					
Washington	Pullman	E. C. Johnson		1891	30	11		4	107	8,500
West Virginia	Morgantown	J. L. Coulter		June 11, 1888	28	17	18	9	198	16,000
Wisconsin	Madison	H. L. Russell	1883	1887	84	56	49	14	341	44,200
Wyoming	Laramie	A. D. Faville		Mar. 1, 1891	17	11	1	6	208	5,500
Total					1,881	944	410	1,285	25,046	958,598

[1] Acting director.
[2] In 1882 the State organized a station here and maintained it until June 18, 1895, when it was combined with the Hatch station at the same place.

Revenue and additions

	Station.	Federal.		State.	Balances from previous year.[1]	Fees.	Sales.	Miscellaneous.
		Hatch fund.	Adams fund.					
1	Alabama	$15,000.00	$15,000.00	$27,000.00	$4,715.69	.....	$705.13	$5,294.93
2	Alaska	.....	.....	.....	.....	.....	.....	[2]65,000.00
3	Arizona	15,000.00	15,000.00	34,395.55	2,351.89	.....	25,173.56	.....
4	Arkansas	15,000.00	15,000.00	40,047.35	3,090.89	$785.30	19,497.03	.....
5	California[3]	15,000.00	15,000.00	106,803.44	.....	6,097.00	59,851.11	7,786.11
6	Colorado	15,000.00	15,000.00	93,125.40	20,955.47	.....	1,952.49	.....
7	Connecticut (State).	7,500.00	7,500.00	27,250.00	1,496.50	7,700.00	.....	14,407.39
8	Connecticut (Storrs).	7,500.00	7,500.00	7,500.00	3,267.69	.....	.....	11,990.45
9	Delaware	15,000.00	15,000.00	10,000.00	.....	.....	32,776.45	.....
10	Florida	15,000.00	15,000.00	9,250.89	4,427.87	.....	5,737.92	.....
11	Georgia[4]	15,000.00	15,000.00	639.57	3,983.68	18.25	5,046.97	.....
12	Guam	.....	.....	[5] 3,600.00	.....	.....	.....	[2]20,000.00
13	Hawaii	.....	.....	.....	.....	.....	.....	[2]46,284.91
14	Idaho	15,000.00	15,000.00	.....	993.96	.....	2,287.25	.....
15	Illinois	15,000.00	15,000.00	195,500.00	68,448.23	.....	93,543.56	.....
16	Indiana	15,000.00	15,000.00	81,000.00	139,211.38	149,710.85	185,713.01	.....
17	Iowa	15,000.00	15,000.00	142,193.37	19,715.64	.....	53,947.88	.....
18	Kansas	15,000.00	15,000.00	59,500.00	21,606.18	.....	54,436.08	.....
19	Kentucky	15,000.00	15,000.00	50,000.00	47,884.57	120,953.35	74,884.36	1,000.00
20	Louisiana	15,000.00	15,000.00	24,500.00	.....	.....	8,992.94	7,349.04
21	Maine	15,000.00	15,000.00	16,252.85	.....	11,839.25	14,645.28	.....
22	Maryland	15,000.00	15,000.00	28,118.76	5,856.89	.....	38,562.68	.....
23	Massachusetts	15,000.00	15,000.00	37,789.82	20,829.91	120.00	16,010.04	6,745.81
24	Michigan	15,000.00	15,000.00	52,350.64	.....	22,145.00	8,183.85	8,328.10
25	Minnesota	15,000.00	15,000.00	205,113.45	.....	.....	100,662.49	517.61
26	Mississippi	15,000.00	15,000.00	34,250.00	6,041.27	90.00	24,148.70	2,329.96
27	Missouri	15,000.00	15,000.00	8,283.89	34,627.32	37,442.06	34,203.39	.....
28	Montana	15,000.00	15,000.00	99,394.15	.....	.....	13,479.80	.....
29	Nebraska	15,000.00	15,000.00	60,600.29	89,138.26	.....	81,470.11	.....
30	Nevada	15,000.00	15,000.00	2,923.47	2,181.43	.....	3,788.93	.....
31	New Hampshire	15,000.00	15,000.00	.....	.....	.....	1,695.63	11,360.74
32	New Jersey(State)	.....	.....	65,782.86	.....	41,893.95	35,282.70	38.75
33	New Jersey (College).	15,000.00	15,000.00	.....	.....	.....	.....	.....
34	New Mexico	15,000.00	15,000.00	7,500.00	14,688.91	.....	6,872.83	.....
35	New York (State)[4 5].	1,500.00	1,500.00	148,160.71	5,137.96	.....	.....	.....
36	New York (Cornell)[3].	13,500.00	13,500.00	.....	.....	.....	.....	175,000.00
37	North Carolina	15,000.00	15,000.00	109,318.00	1,616.70	.....	7,370.83	.....
38	North Dakota[4]	15,000.00	15,000.00	66,500.00	17,780.43	.....	48,768.79	6,000.00
39	Ohio	15,000.00	15,000.00	265,530.00	80,521.67	.....	50,140.16	.....
40	Oklahoma	15,000.00	15,000.00	4,502.31	5,270.57	.....	11,519.94	.....
41	Oregon	15,000.00	15,000.00	44,933.34	25,225.78	.....	14,570.79	2,000.00
42	Pennsylvania	15,000.00	15,000.00	.....	3,449 13	.....	102,145.21	2,637.30
43	Porto Rico	.....	.....	.....	.....	.....	.....	[2]45,000.00
44	Rhode Island	15,000.00	15,000.00	.....	2,344.43	.....	.....	4,602.47
45	South Carolina	15,000.00	15,000.00	.....	1,009.41	.....	3,926.61	20,629.06
46	South Dakota	15,000.00	15,000.00	15,546.92	8,941.25	.....	3,679.59	11,543.22
47	Tennessee	15,000.00	15,000.00	33,162.55	.....	.....	22,169.23	.....
48	Texas	15,000.00	15,000.00	195,270.40	3,297.29	.....	61,995.54	.....
49	Utah	15,000.00	15,000.00	28,485.46	599.66	.....	10,351.20	.....
50	Vermont	15,000.00	15,000.00	4,150.00	.....	.....	.....	.....
51	Virgin Islands	.....	.....	.....	.....	.....	.....	[2]15,000.00
52	Virginia	15,000.00	15,000.00	38,250.00	11,944.40	.....	9,148.20	705.38
53	Washington	15,000.00	15,000.00	47,253.65	5,402.46	.....	23,841.90	.....
54	West Virginia	15,000.00	15,000.00	45,148.00	.....	.....	17,270.25	.....
55	Wisconsin	15,000.00	15,000.00	157,212.11	.....	.....	47,513.01	.....
56	Wyoming	15,000.00	15,000.00	.....	603.76	.....	1,854.50	.....
	Total	720,000.00	720,000.00	2,734,089.20	688,658.53	398,795.01	1,439,817.92	491,551.75

[1] Not including balances from Federal funds.
[2] Including Federal appropriations: Alaska $65,000; Guam $20,000; Hawaii $45,000; Porto Rico $45,000; Virgin Islands $15,000.
[3] The resources from other than the Federal funds are estimated.

to equipment, 1918–19.

Total.	Additions to equipment.							
	Buildings.	Library.	Apparatus.	Farm implements.	Live stock.	Miscellaneous.	Total.	
$67,715.75	$634.35	$417.91	$616.67	$468.45	.....	.....	$2,137.38	1
65,000.00	4,908.21	.....	18.28	1,327.93	$427.50	$160.00	6,841.92	2
91,921.00	10.50	12.21	496.25	1,550.00	600.00	1,000.00	3,668.96	3
93,420.57	300.00	250.00	350.00	375.00	1,200.00	200.00	2,675.00	4
210,538.18	8,012.27	868.94	1,013.58	2,951.90	7,922.44	1,191.14	21,960.27	5
146,033.36	12,996.93	185.77	1,799.09	3,900.37	411.75	1,273.38	20,567.29	6
65,853.89	9.48	598.10	111.20	734.65	.....	335.12	1,788.55	7
37,758.14	521.55	14.50	46.25	304.99	281.00	897.80	2,066.09	8
72,776.45	.....	175.00	770.03	1,238.18	2,000.00	.....	4,183.21	9
49,416.68	.....	375.44	526.74	731.66	.....	247.43	1,881.27	10
39,688.47	.....	47.24	1,209.37	1,340.96	1,500.00	.....	4,097.57	11
20,000.00	.....	.....	.....	.....	.....	.....	.....	12
49,884.91	.....	.....	.....	.....	.....	.....	.....	13
33,281.21	8,000.00	100.00	1,000.00	3,000.00	4,000.00	3,500.00	19,600.00	14
387,491.79	2,890.74	.....	4,997.01	.....	17,671.63	.....	25,559.38	15
585,635.24	109,700.00	1,400.00	4,200.00	10,000.00	8,000.00	3,500.00	136,800.00	16
245,856.89	.....	.....	2,980.35	1,447.21	2,103.00	.....	6,530.56	17
165,542.26	2,000.00	100.00	1,500.00	4,000.00	9,009.50	.....	16,609.50	18
324,722.28	5,751.24	344.10	2,312.64	598.94	7,159.70	14,885.79	31,052.41	19
70,841.98	1,482.32	425.78	220.28	371.61	1,599.30	260.35	4,359.64	20
72,737.38	.....	400.00	200.00	800.00	1,150.00	.....	2,550.00	21
102,538.33	.....	277.11	1,684.06	4,196.63	67.00	1,242.12	7,466.92	22
111,495.58	1,502.91	426.47	829.32	390.68	132.00	.....	3,281.38	23
121,007.59	12,260.00	640.00	1,273.00	2,555.00	826.00	692.00	18,247.00	24
336,293.55	16,630.00	1,328.00	1,288.00	3,265.00	14,750.60	3,778.00	41,039.00	25
96,859.93	3,266.56	41.25	.....	1,792.17	6,247.28	1,770.58	13,117.84	26
144,556.66	2,953.36	37.96	2,032.17	5,484.13	11,927.41	1,069.85	23,504.88	27
142,873.95	10,235.00	581.00	1,854.00	2,332.00	2,132.00	2,696.00	19,830.00	28
261,208.66	105,000.00	1,050.00	564.30	2,527.81	27,067.87	100,000.00	236,209.98	29
38,893.83	3,000.00	60.00	379.64	75.00	.....	.....	3,514.64	30
43,056.37	.....	116.00	649.19	475.85	22.50	.....	1,263.54	31
142,998.26	.....	.....	.....	.....	.....	.....	.....	32
30,000.00	2,000.00	260.00	2,500.00	2,300.00	40.00	1,400.00	8,500.00	33
59,061.74	1,041.43	18.30	470.20	887.19	3,535.00	162.90	6,115.02	34
156,298.67	.....	.....	.....	.....	.....	.....	.....	35
202,000.00	5,200.00	983.47	2,198.85	168.95	646.12	1,000.00	10,197.39	36
148,305.53	2,500.00	500.00	200.00	400.00	375.00	.....	3,975.00	37
169,049.22	.....	30.00	912.00	175.00	2,260.00	350.00	3,727.00	38
426,191.83	14,007.69	1,063.28	3,244.20	1,593.46	1,772.17	4,692.52	26,373.32	39
51,292.82	685.33	478.04	200.55	1,146.99	782.28	395.60	3,688.79	40
116,729.91	664.35	37.55	485.29	.....	3,186.42	1,324.52	5,698.13	41
138,231.64	.....	922.80	300.00	388.45	18,401.35	.....	20,012.60	42
45,000.00	4,552.91	84.70	227.75	806.11	674.60	786.20	7,132.27	43
36,946.90	675.00	180.00	80.00	155.00	130.00	130.00	1,350.00	44
55,565.08	800.00	300.00	900.00	200.00	600.00	.....	2,800.00	45
69,710.98	.....	27.27	278.69	341.23	200.00	198.97	1,046.16	46
85,331.78	47,394.37	279.33	639.13	8,261.67	6,500.00	641.89	63,716.39	47
290,563.23	14,009.18	1,750.00	3,774.51	6,915.11	2,069.10	2,571.52	31,089.42	48
69,436.32	926.59	404.92	1,297.50	4,502.35	128.97	1,260.87	8,521.20	49
34,150.00	1,147.04	19.98	382.38	37.77	350.30	.....	1,937.47	50
15,000.00	1,497.13	.....	1,110.87	2,702.91	28.00	613.67	5,952.58	51
90,047.98	1,512.99	189.53	110.52	1,249.77	5,452.65	.....	8,515.46	52
106,498.01	3,690.99	179.18	2,403.73	2,003.24	184.00	.....	8,461.14	53
92,418.25	10,000.00	700.00	3,000.00	2,400.00	2,700.00	400.00	19,200.00	54
234,725.12	5,095.16	794.46	3,285.36	6,473.72	4,661.30	2,168.32	22,478.32	55
32,458.26	4,228.68	250.00	624.31	821.26	1,761.67	250.00	7,935.92	56
7,192,912,41	433,694.26	19,726.59	63,547.26	102,166.30	184,646.81	157,046.54	960,827.76	

[4] Including balances from previous year: Georgia $4,388.12 Hatch, $9,267.80 Adams; New York (State) $47.81 Hatch, $245.12 Adams; North Dakota $276.08 Hatch, $361.15 Adams.

[5] Territorial.

[6] For unexpended balances in 1918–19 see tables immediately following.

Expenditures from United States appropriation received under the

Station.	Amount of appropriation.	Classified expenditures.						
		Salaries.	Labor.	Publications.	Postage and stationery.	Freight and express.	Heat, light, and water.	Chemical supplies.
Alabama	$15,000.00	$7,740.19	$3,085.72	$899.72	$202.33	$218.08	$313.82	$79.84
Arizona	15,000.00	11,758.62	.....	75.40	458.92	71.52	725.91	213.73
Arkansas	15,000.00	7,835.92	1,600.39	2,474.72	483.49	240.77	128.00	222.79
California	15,000.00	12,952.12	840.00	1,187.88	.....	.....	.....	.....
Colorado	15,000.00	9,402.98	1,466.40	1,792.49	57.19	60.04	.....	69.77
Connecticut:								
State	7,500.00	7,086.80	413.20	.....	.....	.....	.....	.....
Storrs	7,500.00	6,107.02	1,057.44	.....	20.80	12.97	.50	.....
Delaware	15,000.00	9,551.94	1,274.61	898.30	497.57	130.95	.....	550.14
Florida	15,000.00	6,201.65	3,409.22	2,250.39	554.59	93.35	211.68	3.75
Georgia	[1] 15,000.00	6,608.03	2,405.80	1,651.15	470.76	241.19	352.62	.....
Idaho	15,000.00	9,217.11	2,145.16	309.00	227.32	52.77	52.40	201.80
Illinois	15,000.00	13,764.92	185.85	914.70	60.05	.....	.....	12.50
Indiana	15,000.00	10,962.08	1,414.30	7.00	44.70	.....	.....	79.10
Iowa	15,000.00	7,564.05	1,158.49	1,416.84	323.95	187.96	236.34	32.54
Kansas	15,000.00	9,191.67	4,504.58	.....	186.83	13.66	.....	249.53
Kentucky	15,000.00	13,975.02	121.14	26.95	18.25	.....	781.85	.....
Louisiana	15,000.00	7,664.62	3,825.73	268.38	155.95	108.06	2.40	.75
Maine	15,000.00	6,851.45	2,168.67	125.38	683.31	149.22	566.83	.....
Maryland	15,000.00	11,173.32	2,653.30	418.69	21.67	.....	.....	44.74
Massachusetts	15,000.00	13,631.68	915.26	80 50	.....	.....	.....	20.59
Michigan	15,000.00	11,473.65	1,216.07	119.81	145.09	5.00	147.15	202.16
Minnesota	15,000.00	15,000.00	.....	.....	.....	.....	.....	.....
Mississippi	15,000.00	8,175.81	2,081.22	.....	101.61	99.88	93.57	.....
Missouri	15,000.00	10,019.20	1,905.33	.....	208.93	331.94	42.85	117.84
Montana	15,000.00	10,572.19	1,956.77	339.20	503.35	95.36	29.21	34.12
Nebraska	15,000.00	6,453.33	4,034.01	1,395.84	.....	.....	.....	323.32
Nevada	15,000.00	9,839.80	1,969.07	690.71	151.58	22.07	162.52	93.05
New Hampshire	15,000.00	8,532.35	898.95	2,071.71	901.82	350.78	600.00	22.71
New Jersey	15,000.00	8,852.78	750.51	937.06	480.86	34.94	.....	461.31
New Mexico	15,000.00	4,519.92	3,548.40	1,121.79	87.02	80.97	69.73	124.96
New York:								
State	[1] 1,500.00	466.58	660.32	.....	62.90	78.44	.....	.....
Cornell	13,500.00	6,481.66	2,834.98	.....	119.67	76.46	.....	912.19
North Carolina	15,000.00	6,735.56	2,888.79	895.97	136.91	48.99	168.45	54.77
North Dakota	[1] 15,000.00	11,814.65	2,022.79	16.05	1.31	.....	.....	33.00
Ohio	15,000.00	5,902.80	53.60	1,032.38	289.69	681.25	180.62	359.92
Oklahoma	15,000.00	8,911.83	1,854.54	758.00	104.34	11.41	163.40	107.99
Oregon	15,000.00	9,843.26	1,772.37	1,305.76	139.62	108.26	21.00	78.33
Pennsylvania	15,000.00	9,400.00	2,316.44	1,875.65	6.18	153.09	.....	.....
Rhode Island	15,000.00	6,070.00	3,414.66	1,966.45	181.25	151.87	490.57	.....
South Carolina	15,000.00	6,400.35	3,416.72	622.21	587.12	145.31	86.07	.....
South Dakota	15,000.00	8,511.64	1,699.29	2,411.59	596.49	39.31	.....	113.01
Tennessee	15,000.00	11,195.00	1,316.31	233.54	328.16	38.90	421.76	16.25
Texas	15,000.00	8,623.41	1,706.20	377.34	557.80	247.42	178.60	343.87
Utah	15,000.00	7,564.00	2,712.24	20.19	566.46	82.40	42.56	33.22
Vermont	15,000.00	7,603.61	1,590.33	773.27	343.87	201.84	1,379.49	235.82
Virginia	15,000.00	9,273.15	2,820.35	383.08	345.61	127.84	85.82	72.95
Washington	15,000.00	8,482.46	3,478.94	698.80	247.41	.....	7.25	179.25
West Virginia	15,000.00	10,210.67	2,252.74	1,045.10	19.22	.....	.....	5.71
Wisconsin	15,000.00	10,717.50	628.00	150.15	84.71	5.40	26.66	826.67
Wyoming	15,000.00	7,759.17	2,509.38	1,062.47	36.84	52.66	279.18	195.01
Total	720,000.00	444,647.52	94,923.58	37,101.61	11,821.50	4,852.33	8,048.81	6,729.00

[1] Including balances as follows: Georgia, $4,388.12; New York (State), $47.81; North Dakota, $276.08.

act of Mar. 2, 1887 (Hatch Act), for the year ended June 30, 1919.

Classified expenditures—Continued.											
Seeds, plants, and sundry supplies.	Fertilizers.	Feeding stuffs.	Library.	Tools, implements, and machinery.	Furniture and fixtures.	Scientific apparatus.	Live stock.	Traveling expenses.	Contingent expenses.	Buildings and repairs.	Balances.
$281.33	$274.55	$678.59	$408.20	$247.92	$60.00	$114.29	.....	$137.26	$20.00	$238.16	.....
110.24	38.28	.....	12.21	112.56	188.21	207.25	.....	1,027.15	.....	.....	.....
397.80	106.54	127.97	.....	610.78	241.03	57.34	.....	341.84	20.00	110.62	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	20.00	.....	.....
205.23	.57	34.86	98.76	.....	209.73	485.07	$186.00	910.91	20.00	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
155.83	.....	22.50	.....	55.80	4.50	.....	.....	42.64	20.00	.....	.....
435.58	360.38	39.40	142.69	374.64	263.60	183.50	.....	268.90	27.80	.....	.....
183.34	44.64	1,265.97	316.20	279.33	5.89	4.03	.....	118.97	20.00	37.00	.....
409.37	570.52	256.40	5.25	569.19	269.73	15.78	356.00	232.72	108.93	476.56	.....
313.47	15.00	1,481.60	.....	148.90	14.60	109.93	.....	475.94	20.00	215.00	.....
.....	.....	.....	.....	.50	.....	.....	.....	41.48	20.00	.....	.....
178.63	20.00	1,655.95	3.98	81.39	.....	62.70	.....	488.77	.....	1.40	.....
980.46	62.90	2,249.74	.....	126.02	8.15	.....	335.00	235.46	.....	82.10	.....
261.50	.....	119.15	3.25	134.00	51.60	117.00	.....	164.43	.....	2.80	.....
6.04	.....	.....	50.75	.....	.....	.....	.....	.....	20.00	.....	.....
42.50	291.75	1,155.00	314.75	12.70	3.00	166.70	589.40	132.72	.....	265.59	.....
475.52	924.20	1,155.01	249.53	384.56	45.28	.....	235.00	409.50	20.00	556.54	.....
110.87	.....	.....	27.11	9.72	320.70	215.08	.....	.....	4.80	.....	.....
.....	203.65	6.30	.....	.....	1.20	120.82	.....	.....	20.00	.....	.....
262.12	45.60	.....	537.80	181.62	.90	11.29	.....	632.34	20.00	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
38.00	.....	2,616.37	.....	35.53	106.65	.....	1,651.36	.....	.....	.....	.....
239.22	8.50	1,838.90	.....	62.29	53.29	5.26	69.20	27.64	.....	69.61	.....
504.43	.....	348.23	64.81	24.20	43.75	276.60	50.00	188.78	.....	.....	.....
72.23	.....	1,887.63	8.45	554.18	156.85	114.16	.....	.....	.....	.....	.....
155.63	.....	796.00	40.45	76.09	162.05	.....	280.00	395.18	.....	165 80	.....
459.89	150.19	86.17	116.80	214.65	17.40	19.70	7.50	508.86	20.00	20.52	.....
348.72	51.70	.....	19.56	9.94	417.71	28.80	.....	2,102.82	7.90	495.39	.....
346.05	59.17	2,191.50	18.30	357.52	102.27	65.16	1,770.00	278.55	21.95	236.74	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
68.93	.....	.....	.....	53.03	.....	2.74	.....	9.22	.....	85.03	$11.81
489.06	232.30	.....	16.57	727.57	353.65	351.40	.....	231.62	.....	672.87	.....
689.01	731.70	1,097.36	.....	371.75	.....	115.00	129.00	166.74	20.00	750.00	.....
501.98	71.17	.....	.....	183.73	194.85	72.00	.....	48.80	22.67	.....	.....
1,167.63	470.70	1,943.96	.....	2,206.10	6.50	175.91	.....	40.23	20.00	468.71	.....
591.38	.....	1,407.27	69.39	174.78	325.00	44.89	12.50	210.45	20.00	232.83	.....
618.03	29.47	418.07	.....	36.40	33.00	.....	.....	576.38	20.00	.....	.....
270.40	320.35	99.90	213.14	83.50	.....	.....	.....	254.78	.....	6.57	.....
356.58	1,455.79	270.19	197.29	149.92	5.25	6.35	44.00	7.10	20.00	212.73	.....
410.77	886.84	1,190.75	100.97	268.80	389.13	142.13	.....	251.85	20.00	80.98	.....
262.19	.....	643.37	9.00	290.45	109.50	151.72	.....	51.96	53.20	57.28	.....
460.06	.....	513.13	95.02	243.80	45.96	.....	.....	71.01	20.00	1.10	.....
275.10	302.85	19.00	42.79	725.54	753.38	85.67	.....	179.18	20.00	561.85	.....
947.17	70.00	971.34	279.50	443.59	145.91	39.44	41.47	913.54	20.00	106.97	.....
1,092.22	6.63	607.94	17.00	42.80	73.15	68.46	43.30	292.31	20.00	607.96	.....
516.04	306.13	74.00	176.98	340.52	126.00	.....	3.00	231.46	40.00	77.07	.....
527.61	21.00	67.85	15.00	267.39	85.94	636.96	.....	252.14	20.00	12.00	.....
324.00	269.79	49.00	.....	15.89	2.00	.....	.....	805.88	.....	.....	.....
552.86	233.89	59.90	.....	121.13	.....	880.70	12.00	700.43	.....	.....	.....
341.54	.....	1,685.79	129.00	73.76	.....	263.45	.....	19.15	.....	592.60	.....
17,436.61	8,636.15	31,132.06	3,800.50	11,484.48	5,397.31	5,417.28	5,814.73	14,477.09	767.25	7,500.38	11.81

Expenditures from United States appropriation received under the

Station.	Amount of appropriation.	Classified expenditures.						
		Salaries.	Labor.	Postage and stationery.	Freight and express.	Heat, light, and water.	Chemical supplies.	Seeds, plants, and sundry supplies.
Alabama	$15,000.00	$10,457.60	$1,193.01	$89.45	$317.70	$233.07	$447.95	$205.49
Arizona	15,000.00	11,737.76	1,104.81	102.85	53.22	13.75	127.91	281.20
Arkansas	15,000.00	10,632.58	1,368.79	121.85	173.49	249.72	348.12	528.28
California	15,000.00	8,754.04	1,270.05	24.83	.10	10.78	1,576.85	407.62
Colorado	15,000.00	13,133.55	522.68	13.21	29.09	3.00	322.06	110.57
Connecticut:								
State	7,500.00	5,730.37	110.43	50.00	85.09	497.32	305.72	198.42
Storrs	7,500.00	5,655.95	1,046.88	24.86	.86	.....	112.52	63.89
Delaware	15,000.00	11,395.50	1,176.30	25.16	23.34	.....	1,290.57	215.13
Florida	15,000.00	10,012.31	1,115.28	108.53	241.31	67.57	779.18	367.75
Georgia	[1] 15,000.00	6,916.63	816.77	73.10	266.63	339.43	794.74	708.99
Idaho	15,000.00	9,594.27	2,137.59	32.23	168.07	68.90	583.43	354.11
Illinois	15,000.00	12,820.02	1,153.38	32.60	9.53	.....	263.31	.....
Indiana	15,000.00	9,993.35	394.02	63.57	1.33	.....	553.09	282.92
Iowa	15,000.00	7,152.40	2,752.33	313.04	81.83	136.02	763.17	1,063.41
Kansas	15,000.00	7,916.42	3,400.77	33.59	89.92	27.67	512.47	423.28
Kentucky	15,000.00	12,183.42	417.70	33.00	45.04	135.61	187.18	148.03
Louisiana	15,000.00	11,208.58	509.00	100.81	61.68	644.89	1,022.66	258.51
Maine	15,000.00	9,726.27	1,973.28	126.52	82.31	299.35	10.50	287.06
Maryland	15,000.00	10,948.31	230.83	21.70	.....	.....	942.77	162.46
Massachusetts	15,000.00	13,088.31	687.01	.....	.....	.....	225.38	129.55
Michigan	15,000.00	12,037.75	1,553.12	2.80	37.88	.....	35.49	39.89
Minnesota	15,000.00	15,000.00	.....	.....	.....	.....	.....	.....
Mississippi	15,000.00	7,470.69	6,147.03	56.01	40.01	231.39	.....	210.31
Missouri	15,000.00	7,302.29	2,247.79	7.04	383.41	38.22	730.14	398.61
Montana	15,000.00	11,891.50	1,016.97	45.98	48.87	29.09	429.15	260.05
Nebraska	15,000.00	9,328.21	2,119.57	40.94	205.24	.....	202.48	534.72
Nevada	15,000.00	9,483.33	2,485.42	71.37	120.09	15.05	151.41	189.27
New Hampshire	15,000.00	9,635.02	1,981.94	26.58	6.13	.....	154.69	442.65
New Jersey	15,000.00	12,482.56	773.44	36.16	2.00	596.08	318.17	143.48
Mew Mexico	15,000.00	8,350.78	2,661.94	48.68	35.60	278.34	654.02	273.94
New York:								
State	[1] 1,500.00	1,459.50	.....	.....	.....	.....	38.00	.....
Cornell	13,500.00	12,004.85	913.17	25.53	.....	.....	272.61	129.81
North Carolina	15,000.00	12,659.07	896.15	93.85	7.13	84.25	127.87	204.22
North Dakota	[1] 15,000.00	9,695.04	772.46	42.44	.....	.....	628.06	204.89
Ohio	15,000.00	7,724.83	.....	.....	.....	.....	1,486.80	.....
Oklahoma	15,000.00	10,429.46	1,889.92	9.17	1.28	13.45	151.03	210.40
Oregon	15,000.00	13,559.41	219.92	.....	48.46	.....	552.01	105.52
Pennsylvania	15,000.00	11,870.35	26.53	8.78	76.94	23.55	733.42	43.84
Rhode Island	15,000.00	8,368.24	3,300.05	122.43	30.59	333.64	167.86	101.75
South Carolina	15,000.00	10,292.88	1,909.46	40.31	31.20	261.82	596.96	283.72
South Dakota	15,000.00	9,396.61	2,732.85	24.47	180.50	.....	229.99	357.71
Tennessee	15,000.00	11,597.66	872.05	57.64	28.29	250.09	707.52	64.10
Texas	15,000.00	10,560.08	1,445.90	101.19	236.08	234.79	758.33	182.31
Utah	15,000.00	7,255.71	4,335.31	16.38	169.88	115.98	1,037.01	308.35
Vermont	15,000.00	8,000.11	2,795.66	29.95	74.90	27.37	264.87	248.18
Virginia	15,000.00	9,980.00	2,809.64	2.23	26.04	9.90	238.30	255.20
Washington	15,000.00	11,433.04	2,134.88	63.37	10.34	.....	309.96	272.78
West Virginia	15,000.00	9,954.55	1,030.44	.....	3.19	.....	472.69	685.37
Wisconsin	15,000.00	9,013.00	3,039.76	22.26	5.52	38.95	327.02	335.31
Wyoming	15,000.00	9,177.93	1,632.58	12.27	42.60	118.80	651.49	129.26
Total	720,000.00	496,472.09	77,124.86	2,399.73	3,582.71	5,427.84	23,596.93	12,812.31

[1] Including balances as follows: Georgia, $9,267.80; New York (State), $245.12; North Dakota, $361.15.

act of Mar. 16, 1906 (Adams Act), for the year ended June 30, 1919.

Classified expenditures—Continued.										
Fertilizers.	Feeding stuffs.	Library.	Tools, implements, and machinery.	Furniture and fixtures.	Scientific apparatus.	Live stock.	Traveling expenses.	Contingent expenses.	Buildings and repairs.	Balances.
$158.98	$740.02	$9.31	$187.26	$15.75	$422.58	.....	$466.43	.....	$55.40	.....
.....	.....	.....	108.41	.75	161.85	.....	1,112.20	.....	195.29	.....
98.10	386.00	.....	207.23	11.90	300.50	$20.50	549.44	.....	3.50	.....
.....	85.55	12.50	47.05	39.47	593.34	950.70	1,055.69	.....	171.43	.....
2.96	4.38	4.50	100.85	2.45	258.58	23.50	468.62	.....	.....	.....
78.43	346.07	.....	.....	5.40	.....	.....	92.75	.....	.....	.....
3.50	241.25	.....	.90	.....	.....	138.67	210.72	.....	.....	.....
.....	.....	19.34	.....	.....	586.53	.....	145.40	.....	122.73	.....
109.99	.....	53.74	285.94	196.54	287.06	.....	1,309.94	.....	64.86	.....
741.09	504.95	41.97	671.77	124.63	1,193.59	1,569.75	11.30	.....	224.66	.....
.....	121.40	13.00	278.09	148.95	728.80	.....	531.00	.....	240.16	.....
.....	494.63	.....	91.23	26.46	.....	15.00	93.84	.....	.....	.....
.....	25.99	52.30	479.79	258.15	1,234.29	1,286.73	239.13	.....	135.34	.....
27.61	1,609.41	.....	163.40	170.18	355.17	.....	92.38	.....	319.65	.....
.....	1,126.63	.....	135.63	53.81	336.15	622.88	142.17	.....	178.61	.....
.....	766.62	15.61	266.43	.....	113.72	684.50	3.14	.....	.....	.....
.....	239.15	99.00	.....	223.25	53.58	.....	578.89	.....	.....	.....
.....	1,810.54	110.30	107.74	.....	10.03	.....	352.13	$60.00	43.97	.....
.....	.....	.....	584.97	570.20	1,376.38	.....	91.22	6.60	64.56	.....
115.20	201.25	.....	.....	.....	553.30	.....	.....	.....	.....	.....
3.00	682.19	.....	19.52	1.90	36.10	56.50	6.65	.....	487.21	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	459.75	10.75	201.68	.....	.....	.....	172.38	.....	.....	.....
.....	1,418.56	.....	275.33	868.25	532.55	352.50	15.72	.....	429.59	.....
.....	.....	36.33	122.14	125.50	624.31	.....	370.11	.....	.....	.....
.....	1,191.04	.....	317.30	20.64	215.28	611.47	186.73	.....	26.38	.....
.....	1,072.41	2.50	33.73	3.00	44.67	678.00	635.20	.....	14.55	.....
267.50	965.64	.....	261.20	18.48	629.49	15.00	174.54	.....	421.14	.....
3.13	360.00	.....	62.72	21.85	131.49	.....	24.70	.....	44.22	.....
27.60	335.24	.....	492.07	57.63	269.97	800.00	.....	.....	714.19	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	$2.50
6.10	.....	.....	69.16	4.00	74.77	.....	.....	.....	.....	.....
279.25	9.00	.....	115.50	.....	107.04	250.00	166.67	.....	.....	.....
.....	1,339.86	5.10	554.29	69.00	440.46	995.36	80.45	.....	172.59	.....
.....	1,507.40	.....	685.87	300.00	3,000.34	.....	.....	.....	294.76	.....
.....	424.10	44.68	297.21	9.07	152.56	769.78	188.39	.....	409.50	.....
.....	.....	.....	19.95	14.50	477.73	.....	2.50	.....	.....	.....
.....	358.00	10.00	46.06	31.16	1,537.48	.....	233.89	.....	.....	.....
44.00	1,703.10	6.80	298.67	134.37	40.30	133.84	.....	8.11	206.25	.....
252.89	.....	39.20	33.74	152.72	968.77	.....	62.12	.....	74.21	.....
68.80	294.69	29.34	99.93	258.80	176.57	430.00	667.64	.....	52.10	.....
18.00	.....	75.53	284.64	154.90	354.70	.....	205.13	.....	329.75	.....
.....	119.95	10.00	312.16	286.40	438.38	80.00	78.63	.....	155.80	.....
.....	200.20	.....	176.80	214.14	784.20	.....	322.36	.....	63.68	.....
18.00	1,838.05	2.98	20.27	.....	557.74	307.00	199.94	.....	614.98	.....
456.06	726.75	.....	27.64	9.10	84.15	.....	220.09	.....	153.90	.....
8.23	6.50	.....	109.62	.....	329.33	9.00	312.95	.....	.....	.....
396.84	184.10	.....	316.04	813.90	682.79	.....	460.09	.....	.....	.....
.....	1,709.44	.....	64.94	.....	407.95	.....	35.85	.....	.....	.....
.....	1,685.20	22.15	223.24	8.35	343.74	632.50	92.69	.....	227.20	.....
3,185.26	27,295.01	726.93	9,258.11	5,425.55	22,008.31	11,433.18	12,461.81	74.71	6,712.16	2.50

Disbursements from the United States Treasury to the States and Territories for agricultural experiment stations under the acts of Congress approved Mar. 2, 1887, and Mar. 16, 1906.

State or Territory.	Hatch Act.		Adams Act.	
	1888–1918	1919	1906–1918	1919
Alabama	$463,956.42	$15,000.00	$161,619.89	$15,000.00
Arizona	429,803.10	15,000.00	164,955.61	15,000.00
Arkansas	463,139.12	15,000.00	164,900.00	15,000.00
California	465,000.00	15,000.00	164,926.84	15,000.00
Colorado	464,718.82	15,000.00	163,638.93	15,000.00
Connecticut	465,000.00	15,000.00	165,000.00	15,000.00
Dakota Territory	56,250.00			
Delaware	463,382.87	15,000.00	160,475.12	15,000.00
Florida	464,966.06	15,000.00	164,996.06	15,000.00
Georgia	464,981.55	10,611.88	161,360.67	5,732.20
Idaho	389,824.13	15,000.00	160,842.22	15,000.00
Illinois	464,564.95	15,000.00	164,851.62	15,000.00
Indiana	464,901.19	15,000.00	165,000.00	15,000.00
Iowa	465,000.00	15,000.00	165,000.00	15,000.00
Kansas	464,995.00	15,000.00	165,000.00	15,000.00
Kentucky	464,996.57	15,000.00	165,000.00	15,000.00
Louisiana	465,000.00	15,000.00	165,000.00	15,000.00
Maine	464,999.62	15,000.00	165,000.00	15,000.00
Maryland	464,967.40	15,000.00	164,236.48	15,000.00
Massachusetts	464,617.70	15,000.00	165,000.00	15,000.00
Michigan	464,676.10	15,000.00	161,341.20	15,000.00
Minnesota	464,917.78	15,000.00	164,345.00	15,000.00
Mississippi	465,000.00	15,000.00	165,000.00	15,000.00
Missouri	460,097.24	15,000.00	164,999.90	15,000.00
Montana	375,000.00	15,000.00	162,417.04	15,000.00
Nebraska	464,932.16	15,000.00	165,000.00	15,000.00
Nevada	464,214.32	15,000.00	163,180.28	15,000.00
New Hampshire	465,000.00	15,000.00	165,000.00	15,000.00
New Jersey	464,949.97	15,000.00	164,558.78	15,000.00
New Mexico	429,509.05	15,000.00	165,000.00	15,000.00
New York	464,825.56	14,952.19	164,745.65	14,754.88
North Carolina	465,000.00	15,000.00	165,000.00	15,000.00
North Dakota	406,778.34	14,723.92	165,000.00	14,638.85
Ohio	465,000.00	15,000.00	163,514.02	15,000.00
Oklahoma	389,568.96	15,000.00	146,360.56	15,000.00
Oregon	450,156.64	15,000.00	160,000.00	15,000.00
Pennsylvania	464,967.43	15,000.00	164,995.41	15,000.00
Rhode Island	465,000.00	15,000.00	162,464.20	15,000.00
South Carolina	464,542.15	15,000.00	163,460.12	15,000.00
South Dakota	408,250.00	15,000.00	160,000.00	15,000.00
Tennessee	465,000.00	15,000.00	165,000.00	15,000.00
Texas	465,000.00	15,000.00	162,592.26	15,000.00
Utah	330,000.00	15,000.00	164,821.94	15,000.00
Vermont	465,000.00	15,000.00	165,000.00	15,000.00
Virginia	462,824.12	15,000.00	164,949.01	15,000.00
Washington	402,102.65	15,000.00	161,080.11	15,000.00
West Virginia	464,968.71	15,000.00	162,859.12	15,000.00
Wisconsin	465,000.00	15,000.00	165,000.00	15,000.00
Wyoming	450,000.00	15,000.00	165,000.00	15,000.00
Total	21,707,345.68	715,287.99	7,849,488.04	710,125.93