SECOND

ANNUAL REPORT

OF THE

KENTUCKY

Agricultural Experiment Station

OF THE

STATE COLLEGE OF KENTUCKY.

1889.

FRANKFORT, KY.:
PRINTED BY THE CAPITAL PRINTING COMPANY.
1892.

LETTER OF TRANSMITTAL.

To His Excellency, GEN. S. B. BUCKNER, *Governor of Kentucky:*

DEAR SIR: Under the authority of the Board of Control, and in accordance with an act of Congress, approved March 2, 1887, and entitled "An act to establish Agricultural Experiment Stations in connection with the Agricultural Colleges established in the several States, under the provisions of an act, approved July 2, 1862, and of the acts supplementary thereto," and of an act of the Legislature of the State of Kentucky, approved February 20, 1888, and entitled "An act to accept the provisions of an act passed by the Congress of the United States, approved March 2, 1887, for the establishment and maintenance of Agricultural Experiment Stations in connection with the Agricultural Colleges established by the several States and Territories under the act of Congress, approved July 2, 1862," I hereby submit the Second Annual Report of the Kentucky Agricultural Experiment Station.

Very respectfully,

M. A. SCOVELL, *Director*.

FEBRUARY, 1, 1890.

ERRATA.

Page 19, last line, for *attennæ* read *antennæ*.

Page 20, first line, for *antennæ* read *antenna*.

Page 21, near top, for *Oestridæ* read *Œstridæ*.

Page 23, near middle, for *Chrysemclidæ* read *Chrysomclidæ*.

Page 24, near top, for *Hatica memorum* read *Haltica nemorum*.

Page 27, near top, for *Disonyca* read *Disonycha*.

Page 42, fourth and fifteenth lines from top, for *curculis* read *curculio*.

Page 96, fourth line from bottom, for *ferterlizer* read *fertilizer*.

LIST OF OFFICERS.

BOARD OF CONTROL.

DR. R. J. SPURR, Chairman.
JUDGE W. B. KINKEAD, Chairman of Executive Committee.
W. D. NICHOLAS, Treasurer.
JUDGE P. P. JOHNSTON.
PHIL. BIRD.
R. A. SPURR.
DR. J. D. CLARDY.
J. K. PATTERSON, President of the College.
M. A. SCOVELL, Director, Secretary.

STATION OFFICERS.

M. A. SCOVELL, Director.
A. M. PETER, Assistant Chemist.
H. E. CURTIS, Second Assistant Chemist.
H. GARMAN, Entomologist and Botanist,
A. T. PARKER, Microscopist.
JAMES MURRAY, Practical Horticulture.
C. L. CURTIS, Assistant Agriculturist
SAM. E. BLACK, Secretary and Stenographer.

Address of the Station, LEXINGTON, KY.

THE AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE UNITED STATES APPROPRIATION.

1889.		
To receipts from the Treasurer of the United States, as per appropriation for fiscal year ending June 30th, 1889, under act of Congress, approved March 2d, 1887		$14,996 57
Balance in hands of Treasurer from 1888		3 43
		$15,000 00
By salaries	$6,064 65	
By labor	2,461 95	
By supplies	1,506 01	
By freight and express	269 95	
By postage and stationery	154 19	
By printing	877 60	
By library	282 64	
By tools, implements and machinery	308 25	
By chemical apparatus and supplies	1,127 10	
By scientific apparatus	92 23	
By furniture	652 22	
By live stock	68 29	
By traveling expenses	77 85	
By incidentals	72 25	
By building	750 00	
By seeds, fencing and cistern	234 82	
		$15,000 00

We, the undersigned, duly appointed auditors for the Institution, hereby certify that we have examined the books and the accounts of the Experiment Station of the Agricultural and Mechanical College of Kentucky, for the fiscal year ending June 30th, 1889; that we have found the same well kept and correctly classified, as above, and that the receipts for the time named are shown to have been $15,000.00, and the corresponding disbursements $15,000.00, for all of which proper vouchers are on file, and have been, by us, examined and found correct.

[Signed]

PHILEMON BIRD,
JAS. K. PATTERSON,
Auditing Committee Board of Trustees.

I hereby certify that the foregoing statement of account to which this is attached is a true copy from the books of account of the Institution named.

[Signed]

W. D. NICHOLAS, *Treasurer.*

SECOND ANNUAL REPORT OF THE KENTUCKY AGRICULTURAL EXPERIMENT STATION FOR 1889.

REPORT OF THE DIRECTOR.

ORGANIZATION.

The Station is governed by a Board of Control, consisting of the Executive Committee of the Board of Trustees, the President of the College, and the Director of the Station. The actions of this Board are subject to the Board of Trustees of the College.

EQUIPMENT.

The station building is now completed, and work is being carried on in it. The library is becoming quite complete in reference books, especially in chemistry, entomology and botany.

The farm has been especially fitted for field and feeding experiments; 200 1-10 acre plats have been carefully surveyed for the field experiments.

LINES OF WORK.

Of the lines of experiment work in which the Experiment Station has been engaged during the year, most have been reported in the Bulletins. Part of these investigations have been a continuation of those previously begun, while some new work has been undertaken. The work may be summarized as follows:

I. Pig-feeding experiments undertaken by Prof. J. H. Connell. The object was first to test the relative value of our most common hog feeds, namely, shelled corn and corn-meal, in the cost of pork per pound; second, to test the relative value of corn-cob meal as compared with corn and corn-meal. Third, to find the length of time that these feeds would produce pork at a paying figure ; fourth, to test the feeding of highly nitrogenous food versus non-nitrogenous food. The results in detail are given in Bulletin No. 19, printed in this report on page ——. Professor Connell reached the following conclusions from the experiments :

First, shelled corn produces fat more rapidly than other feeds tested ; second, corn produces fat at a cheaper rate than other feeds stated ; thrid, nitrogenous foods produced so little gain in live weight that it may be attributed to growth and not fattening. A mixture of cotton-seed meal with other foods was fed unprofitably.

II. *Fertilizer Control Work.*—A large part of the time of the Chemist has been occupied in analyzing commercial fertilizers, both officially and for farmers. The analyses of samples sent in by manufacturers, in compliance with the State law, are given in Bulletin No. 20, to which have been added a few analyses made since the publication of the Bulletin.

The analyses made for farmers are reported to the parties concerned, and have not been published. In most instances they show a reasonably close agreement with the manufacturers' samples.

III. *Field Experiments.*—The field experiments under headway are: First, tests of varieties, including wheat, oats, potatoes, sorghum, strawberries and other small fruits ; second, field tests of fertilizers on wheat, corn, potatoes, hemp, tobacco, oats, pasture and meadow ; third, tests of different grasses ; fourth, the effect of different ways of planting and cultivating of wheat, oats and corn. These results are not concluded.

The results of this year's trial on wheat and potatoes may be found in bulletins number twenty-one and twenty-two.

In connection with the field experiments, analyses of products have been made to study the effect of different fertilizers on corn and grass.

CHEMICAL WORK.

As already stated, the chemical work has been mainly analysis of fertilizers and of products from the field experiments. However, considerable time has been spent in studying methods of analysis, especially in connection with the Association of Official Agricultural Chemists, for the purpose of comparison. A great number of analyses have been made in the study of the Kjeldahl method for nitrogen and nitrates.

DEPARTMENT OF ENTOMOLOGY AND BOTANY.

Prof. H. Garman, formerly of the University of Illinois, has been secured as Entomologist and Botanist of the Station, and has entered upon his work. His work is given in detail under the Department of Entomology and Botany.

PUBLICATIONS.

Six Bulletins have been published this year, and are incorporated in this report. About ten thousand copies of each of these Bulletins have been distributed in the State.

[Signed] M. A. SCOVELL, *Director*.

DEPARTMENT OF ENTOMOLOGY AND BOTANY.

Observations on Injurious Insects and Fungi.

BY H. GARMAN, ENTOMOLOGIST AND BOTANIST.

NOTES OF THE SEASON.

The most notable insect outbreak of the season was that of the grain louse (*Siphonophora avenæ*), which did a great deal of injury to wheat and oats in the spring. When these grains were cut the insect was lost sight of by farmers, and nothing was heard of it until late in the fall, when it appeared again on winter wheat in such numbers as to attract attention. The mild winter kept the wheat growing until March, in the early part of which month sudden frosts killed it to the ground in many places and put a stop to the work of the lice. Up to this time, the plant lice had been active and injurious, being especially destructive in the counties in the south-western part of the State. The injury would doubtless have been more severe if it had not been for the prevailing dampness in the fields, due to frequent rains. This condition of weather induced an epidemic disease among the lice, which destroyed them in great numbers, and it is altogether probable that the three species of parasitic fungi noticed as engaged in the work would have reduced the numbers of the lice to such an extent that little injury would have been done the succeeding spring. The cold weather of March seemed, however, to finish the good work, numbers of the exposed lice being destroyed on the blades; and no complaints have reached us since of the presence of lice in fields. Since last summer, grain lice taken from corn have been kept confined in growing wheat and blue-grass at the Station, and during the whole of this time have reproduced viviparously. Those observed out of doors during the winter were also viviparous.

Another insect, which claimed attention from its abundance and injuries, is the corn root-worm. This insect has now been followed at the Station through the whole winter, and found to hibernate as an adult beetle. Its abundance, together with its wide distribution in the United States, are calculated to make it a very troublesome pest, if, as seems probable, it is just acquiring the corn-infesting habit.

The cabbage worms, of which there are two species (*Pieris rapæ* and *Pieris protodice*) in Kentucky, did a good deal of injury to late cabbage. In the early part of summer the imported cabbage worm was very scarce, evidently because of the prevalence of an epidemic disease (believed to be due to bacteria), which left the blackened and putrid bodies clinging to the leaves. Both cabbage-worms were destroyed in numbers later in the season by a small four-winged fly (*Apanteles congregatus*), which, in the grub state, lives in the bodies of the worms, and completes their destruction when it emerges through the skin.

The corn-worm (*Heliothis armigera*) was common in the ends of corn ears in the latter part of summer, and from what I learn by inquiry is one of the annoying and injurious pests throughout the State. I have no observations to add to those recorded in an excellent illustrated account of the insect which will be found in the fourth report of the United States Entomological Commission (pp. 355–384). The conclusion of the authors as to remedies is to the effect that the best means of lessening injuries to corn are fall plowing, so as to expose the pupæ to frosts, and the use of traps consisting of sweets, such as molasses and vinegar in plates, scattered about the fields so as to attract and entrap the moths.

The ox warble appears to be exceedingly injurious to cattle in the State, not more than two per cent. of the hides received by dealers during February being free from the holes made by grubs. Not less than $50,000 worth of hides is handled in a year in the city of Lexington. These would be worth about one-fourth more if they were all free from injury by this insect. The butchers sell most of the hides to dealers, and hence the loss comes directly home to them ; but it is certain that it falls ultimately upon the farming class, and that the diminished value of the hides is only a part of what is lost, since the inevitable reduction in the weight of infested stock will occasion a loss to farmers of at least twice as much more.

Of such insects as the chinch-bug, hessian-fly and army-worm, but little was seen, and no reports reached me of severe injury from them.

In general, the season was characterized by a scarcity of insects, a fact which bore a direct relation to an unusual abundance of parasitic fungi, and an indirect one to the frequent rains of the fore part of the season. Most of the insects which were given any thing approaching close attention were found to be infested with one or more of these parasitic plants. The grain louse was attacked by three distinct species of Empusa. A new corn insect, mentioned below, was very frequently found clinging to the blades, dead from the attacks of *Empusa grylli*. The blackened bodies of the common road grasshopper (*Dissoteira carolina*) were everywhere found bearing the spores of the same fungus. The tarnished plant bug, several small leaf-hoppers, caterpillars, known as woolly bears, a species of Aphodius, the corn root-worm and other insects noted, were affected by epidemic diseases due to these fungi. The general scarcity of the codling-moth, though not absolutely traced to this cause, was very probably, I believe, occasioned by vegetable parasites of this kind.

With the general scarcity of insect pests was a corresponding abundance of the fungus pests of the farm. Apples were found to be infested with three species of parasitic fungi, and many bushels were lost from their destructive work.

Potatoes suffered from a peculiar blight, closely resembling in its final effects the well-known potato murrain.

A very singular and destructive disease appeared in the latter part of summer on tobacco grown on the College grounds. The early symptoms of its presence were a yellow mottling, followed by a crumpling of the leaves ; and ending in their becoming brown and brittle. No recognizable fungus accompanied the disease, and we are still in the dark respecting its exact nature, though I believe it is caused by fungi.

One of the most notable and unusual injuries of the season was that suffered by growing hemp and tobacco from broom-rape, an injury unlike any known to me which has been reported from this country. The parasite in this case is one of the flowering plants which is dependent on other flowering plants for sustenance, and by robbing them of this prevents their complete and perfect development. Its injuries are confined at present to the hemp-growing counties of Eastern Kentucky. Its distribution is, however, probably more extended in the United States than is generally supposed. Under date of April 4th, 1890, Dr. E. R. Boardman, of Stark county, Illinois, wrote me: "Some years ago a lady brought me a plant which she said she found growing among some hemp that had sprung up where she had thrown the refuse from her bird cage, and which I called *Phelipæa ludoviciana*. I afterwards visited the place and found it growing from the hemp roots. Since reading your description (in Bulletin 24 of the Station) and comparing it with my own made at the time, I am inclined to think that my plant was *P. ramosa*. I have never been able to find any more specimens of it in this vicinity."

It is probable from this observation that the parasite occurs in small numbers on tobacco and hemp elsewhere in the country, and in view of its powers of injury under circumstances favorable to it, it is important that every one concerned in growing crops liable to be attacked, should inform himself as to the appearance and nature of the pest, with a view to preventing its further spread.

A NEW CORN INSECT.

(*Tettigonia mollipes*, Say.)

Order Hemiptera; family Jassidæ.

This is a green leaf-hopper which is very common everywhere on grasses, and may be taken with an insect net during the greater part of summer in meadows. It is very quick in its movements, running with a sidling motion when approached with the hand, and, when pressed, taking wing for a short flight. Its injury consists in puncturing the blades of corn, and sucking the sap.

Last July it was abundant in several stages of growth on corn on low ground, generally concealed in the hollow formed by the partly unfolded blades. Recently matured females predominated. About half as many adult males occurred, and about the same number of young. When the corn was about two feet in height, as many as twenty leaf-hoppers occurred on a single plant, in some fields. The area infested was not large, and the insects were not often observed on corn grown on high land. This corn-infesting habit is probably not usual to this species, since it seeems not to have been observed elsewhere, although the species is common in probably most of the corn-growing States. If its injury should increase in the future, it may be abated, in all probability, by the use of pyrethrum (the Persian insect powder of drug stores).

DESCRIPTION.

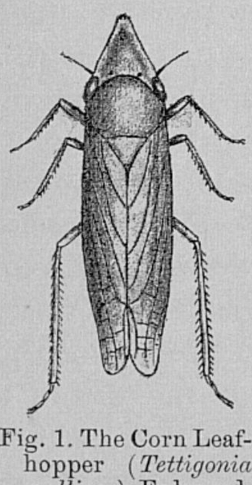


Fig. 1. The Corn Leaf-hopper (*Tettigonia mollipes*). Enlarged. H. Garman, Del.

Body, as is usual in the family Jassidæ, boat-shaped; head produced, and bluntly pointed; abdomen tapering, pointed behind in the female; wings extending a little beyond the tip of the abdomen. Antennæ very small; first two segments short and stout, next three smaller, each with a lateral spine; remainder indistinct, tapering in the form of a bristle. Color above nearly uniform pale green. The head, anterior part of the prothorax and scutellum, yellowish. Eyes green. Head above, with a few indistinct, very narrow, dusky lines, one of which is median and longitudinal. Body green beneath, more or less suffused with deep brown, this color prevailing, in some examples, on the under side of the head, and in some males on the middle of the abdomen. A series of narrow curved lines on each side of the head, and a band at each side of the thorax, brown. Inner side of tegmina, the wings and the dorsum of the abdomen, dark brown. Legs pale green, or, with some brownish in dark individuals. Young examples uniform pale green. Males .26 inch long; females .31 inch long.

AN EPIDEMIC DISEASE.

In the latter part of July and in early August the adult insects were found to be affected with a disease which destroyed a great many of them. The affected examples were generally found dead attached to the upper blades of corn by the inserted beak, and with the wings partly expanded. With the microscope, the bodies of such examples were found to be occupied by the growing parts of a parasitic fungus belonging to the genus Empusa, while the surface of the body, and to some extent the surface of the blade of corn in neighborhood of the dead insect, was dusted with the spores of the fungus. The species of Empusa was in this case *E. grylli*, best known from its destruction of grasshoppers, and one which had not hitherto been found on insects of the order Hemiptera.

THE WHEAT THRIPS, HARVEST FLY.

(*Limothrips cerealium*, Haliday.)

Order Thysanoptera; family Stenopteridæ.

In the early part of July last season a small slender black insect, about .05 inch long, was very common in the air, and was the occasion of some discomfort from coming indoors on warm days and alighting upon one's person These insects, I am informed, appear in the air and invade houses at about the same time each year, during and for a short time after the harvesting of wheat and oats. Last season they were present during the first two weeks in July, disappearing by the 16th of the month. At this date an examination of a field of oats showed the insect to be rather common on plants which were still green. It is unquestionably a grain insect of some importance in this region, and doubtless is the occasion of some loss each year from its injury to small grains. The annual flights are probably occasioned by the ripening of the grain and the operations of the harvesters, the females leaving the grain at this time and scattering in search of fresh plants.

We have in this country several species of the order Thysanoptera, which are known to injure wheat at the north. Two species were described by Dr. Asa Fitch in 1856. The wheat thrips of this locality is different from these, nor is it the same as Prof. Comstock's *Limothrips poaphagus*, a species which is sometimes injurious to grasses. It agrees in most respects with the *L. cerealium* as described by Curtis, and if not the same, is certainly very closely allied to this insect. In England this thrips is said to fix itself at the bases of the grains of wheat, and to puncture and withdraw their juices so that they shrink, become wrinkled, and fail to attain the usual size and weight. It is said also to injure the plants to some extent. Kirby, as quoted by Curtis, says he has seen heads of wheat in which a fourth of the grains were thus rendered worthless.

DESCRIPTION.

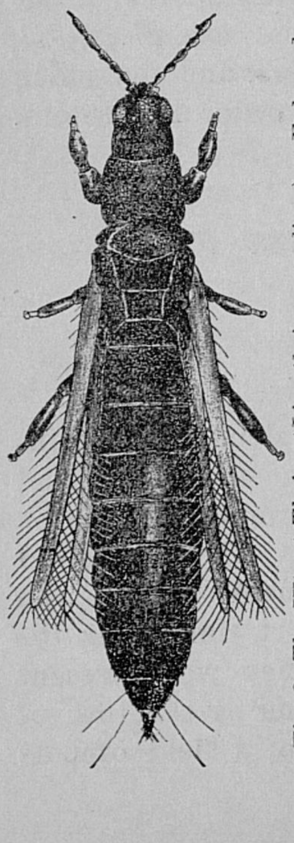


Fig. 2. The Wheat Thrips (*Limothrips cerealium*). Enlarged. H. Garman, Del.

Specimens of the insect taken at Lexington last July and preserved in alcohol are about .05 inch in length, and are thus a trifle shorter than three-fourths of a line, the length given by Curtis for the species. The wings also are shorter than the body, and the antennæ consist of eight, not nine segments. Otherwise than as concerns these points, Curtis' description fits the Kentucky specimens of the winged females perfectly. The length of the wings may be supposed to vary, since the two figures given by Curtis are not alike in this respect.

The body of the winged female is depressed, elongated, and fusiform, as seen from above. The head is a trifle longer than wide, is placed horizontally, with the mouth opening in a conical prominence, which projects backward to the middle of the bases of the first pair of legs. A frontal groove produces a slight notch between the antennæ. The antennæ are placed close together on the vertex, and consist each of eight articles—the first two are thick and short, the next three are obovate and about equal in length; the fifth is fusiform and longest; the remaining two are small and slender, the seventh the thicker, the eighth a trifle longer and pointed. A ring of setæ towards the distal extremity of these articles gives an appearance of joints where none are present. The compound eyes, borne well towards the front of the head, are large and coarsely facetted. Between them are three rather large simple eyes. The first segment of the thorax is a trifle wider than the head, and is quadrangular in shape. A pair of small pits occur in each side above. The second division is the widest, and is decidedly rounded at the sides. The third division is nearly as wide as the second, but its lateral margins are less rounded. The legs are, as is usual in the group, short and stout. The femora of the anterior legs are here especially strong. The feet terminate in the usual pads. The wings are very slender, the anterior pair a trifle the longer, and each bears a loose fringe of long, slender hairs on each edge. The front wings are provided with three longitudinal veins; the hind wings are veinless. When folded, they reach beyond the seventh segment of the abdomen, in some examples to the middle of the eighth. The abdomen consists of ten segments, of which the first is small, and those following increase in diameter to the sixth, from which they rapidly diminish towards the extremity, the last one forming a narrow conical terminal prominence. The segment, the third from the last, bears at each side three strong curved ambulatory bristles; the segment next to the last bears two long bristles at each side; the conical terminal division is armed with two short, nearly straight spines, and bears also a pair of slender hairs about half the length of those on the preceding segment.

The color of the whole body is a uniform blackish brown. The antennæ and legs are a trifle paler distally. The anterior wings are faintly brownish; the posterior wings are white. I have not seen the wingless male nor the young. The young of

L. cerealium have been described as "deep yellow, with the greater part of the head and two spots on the prothorax dusky."

LIFE HISTORY AND HABITS.

Insects of this group live upon plants in all their stages of growth, and are, at all times, after they leave the eggs, active and injurious. Their small size enables them to work their way in between the ensheathing parts of the blades of grains and grasses, where they puncture the plant and take up the sap. The damage which they do is, consequently, similar to that of the grain louse, but unlike the punctures of the latter, those of the Thripidæ are often followed by a deadening of the tissues of the plant at the place attacked. By injuries of this sort certain species lessen the yield of fruit by attacking the blossoms of fruit trees. Others, according to Prof. C. V. Riley, are carnivorous, and do us good service in destroying the eggs of the plum curculio, and the young of the grape Phylloxera.

They are themselves devoured by other insects to some extent. The injuries of the grain-infesting species (*L. cerealium*) it is claimed may be avoided by early planting.

THE AMERICAN MEROMYZA, *WHEAT-BULB WORM.*

(*Meromyza americana*, Fitch.)

Order Diptera; family Oscinidæ.

Although I have not observed, in this State, any severe injury to wheat caused by this insect, its general presence in grain fields and pastures, together with its known capability for occasional destructive outbreak, lead me to call attention to it here.

The fall brood of the pest works, in the grub or maggot state, on young wheat, which it injures by burrowing in the bases of the plants, mining and eating out the central part. At this season its work is very similar to that of the Oscinis, to which I have called attention in a Station Bulletin, and the grub which does the mischief is much like the larva of that insect. The nature of the injury done by the fall brood led Prof. S. A. Forbes to assign to the species the common name "Wheat-bulb worm."

Another brood, which attacks wheat in spring, mines the stems, into which the grubs, as soon as hatched, gnaw their way above the upper joints, complete their growth, and change to pupæ in the interior. The first evidence of the presence of this brood among wheat is seen in a premature change in the color of the ears from green to yellowish-brown shortly before the ripening of the grains. The character of the injury at this season of the year led Prof. J. A. Lintner to apply the name "Wheat stem maggot" to the pest. Dr. Fitch, the describer of the species, applied the common name "American Meromyza," a rendering into English of the technical name.

DESCRIPTION AND LIFE HISTORY.

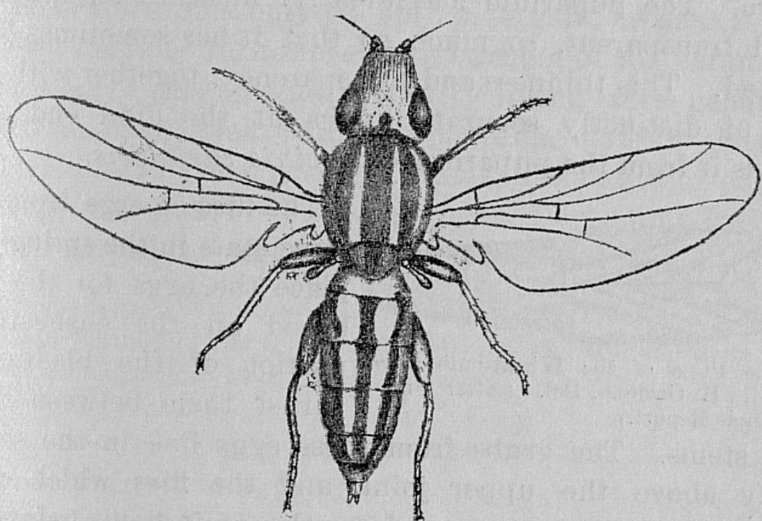


Fig. 3. The Imago of the Wheat-bulb worm. Enlarged. H. Garman, Del. After Fig. 1, Pl. I., 13th Illinois Report.

The adult fly is about .17 inch long, is pale green in color, marked with three wide longitudinal blackish bands on the thorax, and three others on the abdomen, the latter converging and uniting near the hind end of the body.

It is larger than the Oscinis mentioned in Bulletin 30, and its head is more produced before the eyes. Otherwise it is not very different. Excepting its inferior size and its color, it is a good deal like the common house fly.

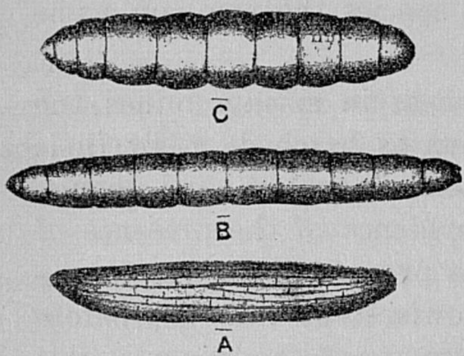


Fig. 4. A, the egg; B, the larva; C, the puparium of the Wheat-bulb worm. Enlarged. H. Garman, Del. (After figures 5, 3 and 6, 13th Illinois Report.)

In September its eggs, which are long, white and with ribbed surface, are placed against the blades of young wheat, where they adhere. The grubs which come from them exist in the plants all winter, commonly feeding upon the tissues. They are, when grown, about .25 inch long, cylindrical, without legs or definite head, are faintly green in color, and are provided with a pair of strong black jaws. The grubs become pupæ within wheat in the spring. In this state they are enclosed in the larval skin, which forms a protective envelope, the puparium. The puparium measures .17 inch in length, and is thin and transparent, so much so that it has sometimes been overlooked. This thinness and transparency, together with the absence of distinctly separate knobs at the hind end, distinguishes it from the puparium of *Oscinis variabilis*.

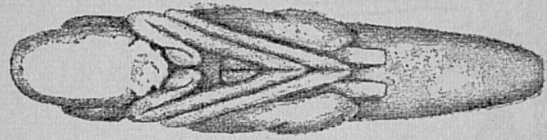


Fig. 5. The Pupa of the Wheat-bulb worm. Enlarged. H. Garman, Del. (After Fig. 8, 13th Illinois Report.)

The flies emerge from the pupa state in the spring and place the eggs for the first brood on the ensheathing portion of the blades, or thrust them between these and the stems. The grubs from these eggs live in the stems, generally above the upper joint, and the flies which come from them emerge and scatter from the grain fields before the wheat is cut.

Prof S. A. Forbes has given us our most complete account of this insect, but appears to have lost track of the flies soon after they deserted the ripening wheat. He suggests as an explanation of this apparent disappearance that the flies may deposit their eggs on some plant other than wheat, and another brood develop on this in August and September. From the rapidity with which the insect passes through its different stages under favorable circumstances this seems very probable, and especially so since the fly is a native insect, and must have subsisted on some native plant before wheat was grown in America. Yet the failure to find the adults was in this case probably only accidental, since they occurred at all times last season (1889) during July, August and September, up to the time when wheat came up. They were especially common in blue-grass pastures,* even when they were closely grazed.

The females deposit their eggs promptly when wheat comes up in the fall, and some flies mature from these before winter. Others remain in the wheat in the grub state until spring.

REMEDIAL TREATMENT.

Late planting may be expected to serve as a means of avoiding injury from fall broods, but volunteer wheat is so abundant that the flies have enough food in the autumn without attacking the sown wheat. Late planting can therefore be expected to defer the attack only till spring—a gain, because it allows the wheat a start. If, however, the burning of all volunteer wheat in the early part of winter or early spring were generally practiced in connection with late planting, several wheat insects, which, like this one, pass the winter in the grub or pupa state in the plants, would be greatly reduced in numbers, and their power for injury proportionally diminished.

*Since the above was written I have learned that Mr. James Fletcher, Entomologist and Botanist of the Government Experiment Farm at Ottawa, Canada, has found the midsummer brood in several grasses.

THE CLOVER BARK-LOUSE.

Coccus trifolii. Forbes.

Order, Hemiptera; family, Coccidæ.

In the fourteenth report of the Illinois State Entomologist are descriptions of two species of Coccidæ, one from sorghum, the other from white clover, which appear to differ chiefly in the character of the attennæ.

The antennæ of the clover-infesting species is described as "obscurely seven-jointed, the first joint as wide as long; the second a little shorter and much narrower than the first; the third and fourth a little smaller than the second, and not distinctly divided; the fifth and sixth distinct, equal in length and about equal to the first; the seventh long, cylindrical, equal to the two preceding, obtusely pointed at tip."

An opportunity to add something to a knowledge of these singular insects is afforded me by the occurrence of the clover species in this locality. The antennæ, in specimens taken from the knotted roots of white clover last July, vary in the number of segments, some having eight of these, and thus agreeing with the sorghum species, others conforming with the original description of *C. trifolii.* The differences have probably to do with age or sex, and since the two species are so closely alike, a form of *C. sorghiellus*, with antennæ of seven segments, is to be looked for.

Large specimens taken July 30th are .06 inch long, oval, depressed, segmented, and covered with a coating of white wax, which, at the posterior end, covers also certain long hairs. When the antennæ are long, the segments composing them are as follows: The first, stout and short; the second, more slender, but equal to the first in length; the third, still more slender, but of the same length as the second; the fourth, about half as long as the third, and not distinctly separate from it; the fifth and sixth equal to the third; seventh, a little longer than the sixth; eighth, long, oval, about equal in length to the preceding three together.

Each tarsal claw is provided with four capitate hairs (digitules). The mouth parts used in puncturing consist of two long chitinous filaments, which can be withdrawn, and then form a long loop, which nearly reaches the bases of the posterior pair of legs.

Only the wingless forms were collected.

THE BOT OR WARBLE FLY OF CATTLE.

(*Hypoderma bovis.* De Geer.)

Order, Diptera; family, Oestridæ.

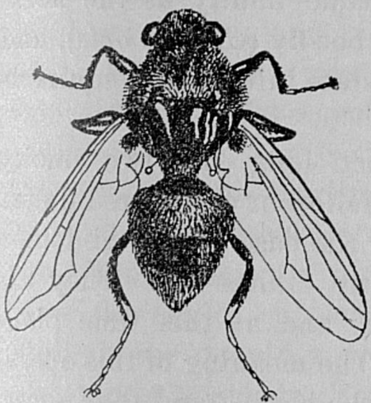


Fig. 6. The Ox Warble Fly. Enlarged. H. Garman, Del. (After a figure published by Packard.)

My attention was recently called to a young Jersey cow, which was suffering from numerous rounded, boil-like swellings along each side of the back, between the shoulders and thighs. An examination showed these to be due to the presence of the grubs of this fly beneath the skin. At this time, February 27, ninety of these swellings, each with a round hole at its apex, were visible. Another older cow on the same farm was also infested, though not so badly. I am unable to say how abundant and injurious this pest is in the State, as this is the first case reported to me. However this may be, the importance of the stock interests of Kentucky renders desirable some notice of a pest which is capable of doing great injury both to the beasts and to the hides which are used for leather.

In England the damage which the grubs do to the hides, by cutting holes in the most valuable part, has been estimated as amounting to thousands of pounds sterling for single dealers. One Manchester firm has recently reported to Miss Eleanor Ormerod, the English Entomologist, a loss of £16,716 on the skins handled by them from January to December, 1888. Out of 250,740 hides which passed through their hands, 83,580 were damaged by the bot fly grubs.

The injury to the affected cattle themselves is probably not less than that to leather made from their hides. Where not very common, cattle do not seem greatly worried by their presence. But any one who will take the trouble to examine the sores which they produce, or to examine the inside of a "warbled" hide fresh from the carcass, must be convinced of the intense suffering which the beasts undergo. Even the pressure necessary to dislodge the grubs causes cattle to shrink in a way that bears convincing testimony as to the pain which they mutely endure.

Not infrequently cattle are killed by blood-poisoning due to the putrid matter which collects within and about the swellings.

The bot-fly of cattle belongs to the same family as the horse bot-fly (*Gastrophilus equi*), the sheep bot-fly (*Œstrus ovis*), and other similar flies, which in the grub state infest deer, squirrels and rabbits.

The adult fly is about one-half inch long, has two smoky wings, and its body is clothed with a yellow or orange-red down. The hind part of the thorax is black ; the base of the abdomen is yellow, the middle black, and the tip orange-red. They are abroad during hot weather in summer, and at this time place their eggs upon the backs of cattle. The meaning of this operation seems to be fully understood by the beasts, and they sometimes become very restless and uneasy when the flies approach them. The flies occur from July to October, after which they are not seen again until the next summer.

Fig. 7. The ox Warble. Natural size. H. Garman, Del.

The young grubs in the skin are at first very small, and are, consequently, not easily detected by ordinary examination. As they grow, the mounds on the back increase in size, and an opening appears in each through the skin. The swellings become as much as an inch in diameter, and are in some quarters known as wormals (wormholes). The fully grown grub is about one inch long, very stout, the body made up of eleven divisions. It is footless, has no developed head, and the segments are roughened with patches of microscopic tubercles, which are doubtless of service to it in creeping up and down in its burrow. At the hind end of the body are the two breathing pores, forming a transverse black spot.

Having attained their growth as larvæ, they leave the swellings, which, up to this time, they have lived in, and dropping to the ground become pupæ, and remain inactive under rubbish or in the ground for some time. Finally the adult flies emerge from these.

REMEDIAL TREATMENT.

The grubs may be removed from the swelling by pressure with the fingers; but where they are abundant, this is a laborious process. When nearly grown, it requires time and care to get them out in this way without crushing them. Miss Ormerod states, after having made a very careful examination of the subject in England, that several washes used by English stock-raisers prevent very effectually the placing of the eggs or the development of the grubs in the skin of stock. These washes are rubbed along the back of cattle at intervals in summer. Train oil is perhaps the simplest and most generally accessible of the materials found useful for the prevention of attack.

For killing the grubs in the skin a mixture consisting of one part of flowers of sulphur to four parts of lard or vaseline, rubbed on the openings, will be found to be effective. Poisons or substances possessing acrid properties should not be used, as there is danger of their aggravating instead of helping the sores.

THE CABBAGE FLEA BEETLE.

(*Phyllotreta vittata.* Fab.)

Order, Coleoptera; family, Chrysemelidæ.

In cabbage and turnip plots not well cared for this small beetle is very abundant and injurious in Kentucky. The injury ordinarily attracting attention is that done by the beetles, which in many fields which I examined last summer were so abundant that as one brushed along the plants the dispersing insects leaping from plant to plant produced a pattering resembling in no slight degree a shower of rain upon the leaves. The insect is closely related to the cucumber flea-beetle, but is somewhat larger (.08–.09 inch in length), is shining black, and is marked with two sinuous yellow stripes which extend from the bases to the tips of the wing covers. It is very much like another flea-beetle (*Phyllotreta zimmermanni*) which sometimes also occurs upon cabbage, but differs in that the yellow stripes turn inward at both extremities, whereas in *P. zimmermanni* the stripes are straight at the bases of the wing covers. Occasionally examples occur with the yellow stripes broken, leaving two spots on each wing cover—one at the base, the other near the tip.

The early history of the cabbage flea-beetle was made out, in 1865, by Dr. Shimer, of Mt. Carroll, Illinois. He found that the larva fed upon the roots of cabbage, in which respect it is different from the very similar turnip flea-beetle of Europe, and also from *P. zimmermanni*, both of which mine the leaves of cruciferous plants when in the grub state. The eggs of the beetles are placed at the bases of the plants. The grubs hatching from these work their way down into the earth, mining and feeding upon the roots, in some cases so completely destroying them that the plants are killed. When fully grown, the grubs are about one-fifth of an inch long. Prof. C. V. Riley describes the grub as "long, slender, sub-cylindrical, tapering but slightly at either end. The general color is yellowish-white; head dark-brown; mandibles still darker, and labrum light brown. The dorsum of every abdominal joint, except the last, is marked with two nearly transverse rows of about ten very small, dark, piliferous warts, the rows separating near the dorsal line, and approximating laterally. * * The tarsi each support an obconical pulvillus, but no claws."

The grubs desert the roots when grown, and pushing their way into the earth a short distance, make a small cell, and change to white pupæ.

Doubtless, several broods occur each summer. The beetles appear with the first warm days in spring, and may be troublesome at that time by eating off the leaves of young cabbage plants as these come up. From this time forth, until cold weather sets in (last season until the 30th of October), the beetles are to be seen in larger or smaller numbers on the plants they feed upon. In this State they are particularly injurious to cabbage, turnips, radishes and mustard, but may occur on almost any member of the family to which these plants belong. They are common at times upon the leaves of cultivated strawberries, but probably do no great harm to such plants.

REMEDIAL TREATMENT.

After discussing the various remedies which have been proposed for the injuries of a similar insect (*Hatica memorum*), which is often very destructive to the turnip crop in England and on the Continent, Curtis concludes that the best that can be done is to counteract the injuries by fertilizing the land on which the crops affected are grown, thus inducing a rapid and vigorous growth of the plants sufficient to bring them to maturity in spite of any injury the leaves may suffer from the mining of the larvæ and gnawing of the beetles. This is in line with the observation of Dr. Shimer on the American species, to the effect that seasonable rains lead to the formation of new roots where the old ones have been destroyed by the grubs, and manuring can be expected to have a similar effect.

Clean culture is here, as in so many other directions, important. I have noticed that where weeds have been allowed to grow up at the edges of cabbage plots the beetles were especially common, and resorted to these very quickly when disturbed at their work of gnawing the cabbage leaves. Such lurking places should not be allowed to them.

Lime water sprinkled on the leaves has been strongly recommended as a preventive of the injuries of the European flea-beetle. This could probably be made useful for the injuries to turnips here. The waxy bloom of cabbage leaves repels any watery preparation so completely that it is doubtful if it could be made to answer for plants of this kind. Paris green or London purple can not be recommended for use on cabbage, but no doubt could be used to advantage to prevent injury to leaves that were not to be eaten. Bordeaux mixture will be found useful for the same purpose, and as prepared, with the addition of ammonia, has the advantage over most preparations of the kind in clinging for a considerable period to the leaves upon which it is spread.

THE POTATO FLEA-BEETLE.

(*Crepidodera fuscula.* Crotch.)

Order, Coleoptera; family, Chrysomelidæ.

Wherever examined last season the potato leaves were found to be gnawed full of small holes, which, from their abundance, and from the fact that the edges of the holes became brown after a time, often gave the leaves a diseased brown appearance. In several fields examined I was not able to find a leaf entirely free from injury. The insect which does the mischief is a small black jumping beetle about .09 inch long, which is very closely related to, and very much like, the cucumber flea-beetle described by Harris in his work on Injurious Insects.

The Kentucky beetle is black, with a few coarse punctures on the front, and with the prothorax above coarsely and densely punctured, with the wing covers coarsely punctate striate and covered with a rather long silken pubescence. The under side of the body and the limbs are also pubescent. The antennæ are loosely jointed, enlarging a trifle toward the tip, yellow, with dusky tip. The femora of all the legs are black, the tibiæ dark brown, the tarsi yellow, excepting the distal segment, which is dark brown.

The larva of the related cucumber flea-beetle feed in galleries which they make in the interior of the leaves of plants attacked by the beetles, and become pupæ without descending into the ground. Several broods are believed to occur each season, the winter finally being passed in the beetle state. We may expect the early history of this species to prove similar to that of *C. cucumeris.*

It was found last summer that a mixture of lime, sulphate of copper and water, saved potatoes from the injury of this flea-beetle very effectually, and I can recommend this mixture with confidence to any one who may be troubled by the injuries of this beetle on potatoes or cucumbers. Some late potatoes experimented on were sprayed once every week after the injury was under way. It was at once checked, and the treated plants soon showed the effect of relief from injury. The Bordeaux mixture will probably be found also useful for the striped cucumber beetle.

THE PIGWEED FLEA-BEETLE.

(*Disonyca glabrata.* Fab.)

Order, Coleoptera; family, Chrysomelidæ.

In the class Insecta we find a good many species like the one here recorded, which aid the farmer by destroying noxious weeds. This insect is very abundant about Lexington, and, in its grub and beetle state, strips the leaves from a coarse species of Amarantus (*A. retroflexus*) everywhere common in rich soil, and commonly known as pigweed. The beetle bears a general resemblance to the striped cucumber beetle, and belongs to the same family, but is to be distinguished at once by the enlarged hind thighs, the presence of brown spots on the prothorax, and by the black outer margins of its wing covers.

It was first observed July 30th, when both larvæ and imagos occurred on the weeds. Larvæ collected at this date had entered the earth provided for them and pupated in small cells by August 8th. Adult beetles emerged from these pupæ August 19th, the period spent in the pupal stage thus covering about ten days. The beetles were subsequently observed until September 13th. In confinement, the beetles placed eggs in a cluster on the leaves of their food plant during the night of July 31st. Unlike several of the small flea-beetles, the larvæ of this insect live exposed on the leaves. Probably more than one brood occurs each summer.

DESCRIPTION.

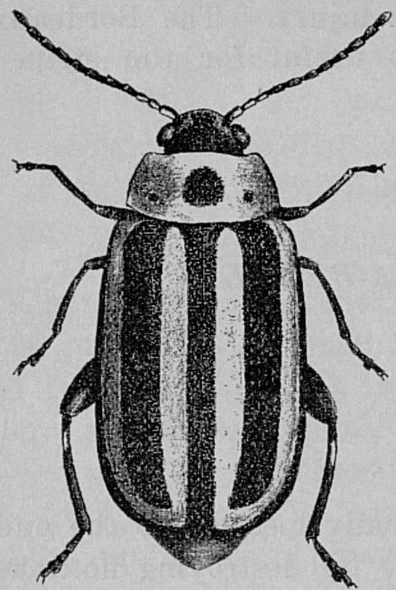


Fig. 8. Pigweed Flea-beetle. Enlarged. H. Garman, Del.

Egg.—Elongated, about .04 inch long by about .01 inch in diameter, yellow, smooth and shining to the eye; under the microscope the surface appears finely reticulated, certain thickened bands of the substance of the shell bounding rather large more or less hexagonal areas, and certain other bands dividing these areas into smaller ones.

Larva.—Body stout, roughened with numerous fleshy tubercles, each surmounted by a single black seta. A single ocellus on each side of the head. Antennæ short, stout, composed of three segments. Free margin of labrum excavated, with a cluster of setæ arising at each side of the excavation, and with four longer ones arising from the surface. Mandibles with three strong denticles. Maxillary palpi with four, labial palpi with two segments. Jointed legs stout, with a strongly curved tarsal claw, and, arising at its side and projecting beyond it, a lanceolate plate with pointed apex. No neck plate. Each segment of the body with a transverse row of fleshy tubercles, which all together form eight longitudinal rows. A sucker-like false foot at the hind end of the body is overhung by a brown plate, from the margin of which arise eight setæ, four on each side. Preceding the false foot beneath are two transverse series of setæ, the anterior of eight, the posterior of four. A double longitudinal row of small setæ beneath. Spiracles, nine on each side, circular, conspicuous.

Head yellowish-brown, darker in young examples. Antennæ white, with a brown annulus. Labrum dark brown, pale at anterior margin. Mandibles pale, with deep brown denticles. Palpi brown, white at the joints. Body behind head whitish, setæ everywhere brownish-black. Jointed legs dark brown, tarsal claws brown distally, black at the base; tarsal plate whitish. Spiracles with dark rims. Length of grown larva (Alcoholic) .23 inch, diameter of same, .08 inch.

Pupa.—White, oval in general shape, with numerous black setæ arising from the surface, as follows:

A pair between the bases of the antennæ on the head; a single seta behind each antennæ; a small cluster of three on each side near the posterior margin of the head; a transverse series of ten near the anterior edge of the prothorax, of which the eight median are in pairs and farthest to the rear; an obliquely-placed series of three at each side of the prothorax; four pairs in a transverse row near the posterior margin of the prothorax, and outside and posterior to these, a single seta on each side; a transverse series of about four on each of the two posterior divisions of the thorax; a pair at the tip of each femur; a double longitudinal row along the middle of the abdominal segments above; two longitudinal rows at each side of the abdomen on the prominent fleshy tubercles, the setæ of the inner row two, a large and a small one, on each tubercle; four between two large spines at the extremity of the abdomen; a series of three preceding each spine below. Spiracles conspicuous, elevated, black-rimmed, ranged between the two lateral rows of tubercles. Terminal spines a little curved, distal two-thirds black. Length, .23 inch.

Imago.—Smooth and shining above, the wing-covers evenly and finely punctulate. Under side and limbs finely pubescent. Head not as wide as the prothorax. Antennæ short, not reaching beyond the middle of the wing-covers, pubescent, not perceptibly enlarged towards the tips. Prothorax wider than long, regularly convex above, narrowly, but distinctly margined at the sides; anterior angles a trifle produced at the sides of the head, faintly angulate behind on each side; posterior margin arcuate in the main, but with a slight median concavity. Head yellow in front, extensively black behind; eyes black; antennæ black, with the outside of the three basal segments pale; labrum dark brown, pale medially; maxillary palpi brown; labial palpi, with brown tips; prothorax pale yellow, with three brown spots above, the median largest, the lateral ones small or wanting. Elytra striped with black and yellow, as follows: A narrow sutural black stripe; next this a pale yellow stripe, about equal to the first in width, not quite reaching the base of the wing-cover; outside the last a broad black stripe joining the sutural stripe at the base of the wing-cover; next, another yellow stripe about equal to the first in width, arising at the base of the wing-cover and joining the other near its apex; still outside is the third black stripe on the margin of the wing-cover. Body beneath largely yellow (orange in life?), with a transverse band of brownish black on the metathorax. Tips of femora, the tibiæ, and tarsi, black; sometimes with the femora nearly all black, and the middle of the abdominal segments deep brown. Length, .25 inch.

A TOBACCO FLEA-BEETLE.

(*Epitrix parvula.* Fab.)

Order, Coleoptera; family, Chrysomelidæ.

This is a small brown beetle very closely related to the cucumber flea-bettle (*Crepidodera cucumeris*), and sometimes to be observed associated with that insect on potato leaves. It is a trifle smaller than the related species, being about .06 inch in length, and is very different in color. Like the other flea-beetles, the thighs of its posterior legs are greatly enlarged, and enable it to take long leaps when disturbed. It was observed on several occasions last summer gnawing small holes in tobacco leaves, in some instances marring their value seriously.

Its early history may be expected to prove similar to that of other flea-beetles. The latter feed in the grub state either in galleries which they gnaw in the interior of leaves, in the roots, or exposed on the leaves. Some pupate in the galleries, others enter the ground for this purpose. The winter is passed by them in the beetle state.

Examined without a magnifier, the beetle appears yellowish brown, with some obscure spots in the wing covers, the posterior femora except the tips, the ventral side of the abdomen and of the two posterior divisions of the thorax, brown. The head is uniform yellowish brown. Eyes dark, antennæ yellowish, except several distal segments, which are dusky, pubescent, each composed of eleven loosely-articulated segments, which increase in size very gradually from the second towards the tip. Prothorax yellowish brown, closely and uniformly punctured, margined at the sides and at the base, angulate each side at the base. Legs, excepting the basal three-fourths of the posterior femora, yellowish brown. Elytra with a large obscure median brown spot at the base, and a broad band of the same color across the middle; pubescent, coarsely punctate-striate.

Lime water has been used successfully for flea-beetles, and could be used for this species were it not that the deposit of lime on the leaves would mar the quality of the tobacco. At any rate, it could not be used late in the season. Dusting with pyrethrum or spraying the infested plants with a solution of this powder is the only thing which seems at all likely to serve.

THE BROWN ROT FUNGUS OF PLUMS, PEACHES, APPLES AND CHERRIES.

(*Monilia fructigena.* Pers.)

Order, Hyphomycetes; family, Mucedineæ.

Fruit-growers in this region are familiar with the brown patches which appear in midsummer on apples and plums, gradually spreading from the starting point, and finally causing the whole fruit to become a brown, rotting mass. The disease is, in, perhaps, the majority of cases, due to the above plant, one of the microscopic fungi. Unlike many other parasitic fungi, it has a wide range of fruits on which it lives, and, when the weather is especially favorable to it, may work considerable harm to blossoms, leaves and twigs.

It is safe to say that 25 per cent. of the apples and plums which set, and would have matured on the trees in the vicinity of Lexington in 1889, were destroyed by this fungus. In some orchards, at least 50 per cent. were thus lost.

LIFE HISTORY.

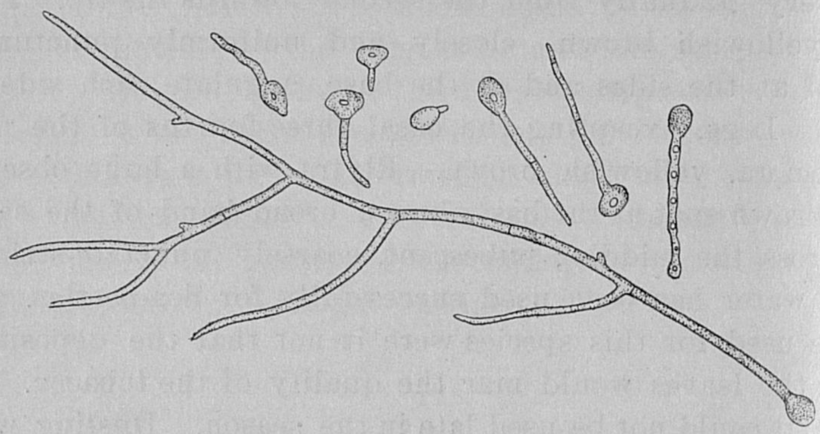


Fig. 9. Germinating spores of the brown rot fungus as seen under the microscope. Greatly enlarged. H. Garman, Del.

The growing part of this parasitic plant consists of a net-work of slender, jointed threads, which penetrate the infested fruit in every direction, and continue to grow as long as there remains suitable nutriment. After a time, certain of the threads send branches towards the exterior, which finally push through the skin, and form small oval spores at their free extremities. These spores are soon detached, scattered by currents of air, and find their way to breaks in the skin of other fruit. Here they germinate, pushing into the tissue, and ultimately produce in the attacked fruit another net-work of jointed threads, with the accompanying decomposition.

On plums and other thin-skinned fruits, the tufts of spore-bearing threads form on the surface numerous gray powdery masses. On apples these gray masses are not so commonly found, and often an apple may rot without yielding any of the fungus spores.

During the spring and summer months the fungus grows rapidly on plums and cherries. The spores get access to these fruits almost entirely through breaks in the skin, most of which are due to the gnawing of insects, or to a spontaneous splitting which seems to follow certain conditions of weather. The spores may, however, send their germ tubes through the unbroken skin of some of these fruits, it being only essential

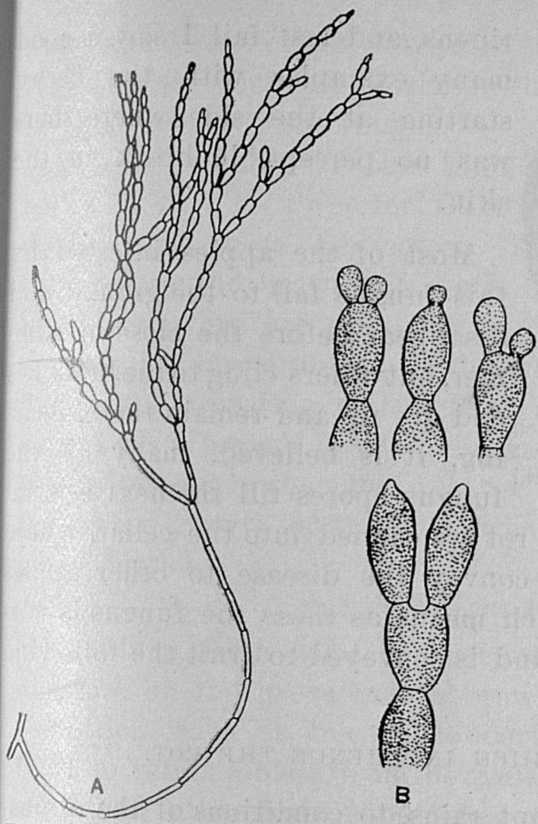


Fig. 10. The fruiting part of the brown rot fungus. A, a complete spore bearing thread; B, the terminal portions of several branches more highly magnified, showing the manner in which new branches and segments are developed. H. Garman, Del.

that moisture should be present long enough (about twelve hours) to give opportunity. When the skin is penetrated in this way it is generally where fruit hangs in contact so as to retain moisture between. By dusting plums with spores, and then wrapping them in moist tissue paper, I have, on several occasions, succeeded in getting the rot started through the unbroken skin. Once in the fruit, nothing can stop the destructive work of the fungus except the destruction of the fruit itself.

In the case of thicker-skinned apples the spores rarely—never, as far as I have observed—get access in the forepart of the season through the unbroken skin. But notwithstanding this, apples are in some localities badly injured at this time by the fungus. I believe that in at least seventy-five per cent. of such apples the fungus will be found to have made entrance at the "eye." Out of one hundred affected apples counted on two trees in the summer of 1889, only one showed the rot starting at the side, and this one had been injured through some accident. Apples do not retain their immunity from attack until mature, however. From some cause the skin becomes more easily penetrable as the fruit

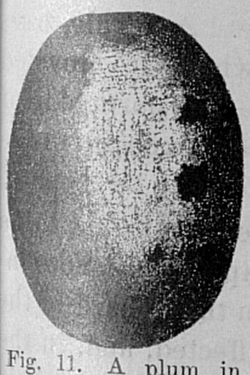


Fig. 11. A plum in which the brown rot has been started artificially, by sowing the spores on the surface, and keeping this moist. H. Garman, Del.

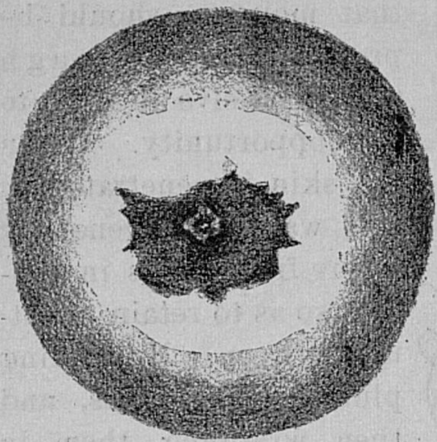


Fig. 12. An apple with brown rot starting at the "eye." Natural size. H. Garman, Del.

ripens, and last fall I saw a good many examples with the decay starting at the side where there was no perceptible break in the skin.

Most of the apples infested by this fungus fall to the ground and disappear before the close of summer, but others cling to the branches and dry up and remain there, bearing, it is believed, many of the fungus spores till the next season. Still others with traces of rot are carried into the cellar, where they are pretty sure to convey the disease to other apples stored with them. By such means as these the fungus is carried through the winter, and is conveyed to fruit the following summer.

CONDITIONS WHICH INFLUENCE THE ROT.

Moisture due to frequent rains, to conditions of the atmosphere, or to temperature unfavorable to evaporation, has a marked effect in accelerating the destruction of fruit by this fungus. Because of its favoring influence, the rot is most prevalent in the spring and autumn, the intervening dry period of August being a time when it is least active. As a rule, trees on which the foliage is thickest, and those which are crowded or shaded by large trees, are worst affected. The north side of some trees is badly affected, while the side most exposed to the sun is much less so.

Certain features in the distribution of the rot are not to be explained in this way. Some varieties of apples are more injured than others. A couple of Janet trees in the orchard of the Experiment Farm were in 1889 especially affected, and, in the early part of October, did not retain one-fourth of their original loads of fruit. It is not easy to determine just what this liability to invasion was due to, since the situation of the trees was as favorable with respect to sunlight and air as that of other trees by their side which showed very little rot. The fungus made its way in always at the eye, and I am inclined to think there is some peculiarity in the eye of this variety which favors invasion by the fungus.

Another instance of this kind which has come under my notice is that of Superior Gage plum on the place of Mr. J. J. Curtis, near Lexington. These are every year badly damaged by the brown rot, while ordinary Green Gage plums in the same yard are relatively but little affected. In this case the peculiar susceptibility of the Superior Gage appears to be due to the crowding of the fruit along the branches. Once started on a branch bearing plums, which grow as these do, it is only necessary that the weather be moist for some time to insure the growth of the rot from plum to plum along the whole branch.

REMEDIAL TREATMENT.

It follows, from what has been said as to the influence of moisture on the prevalence of brown rot, that all unnecessary vegetation, such as trees, shrubbery, weeds, or grasses, calculated to retain moisture on the fruit trees, or to encourage the rotting of fallen fruit, should be removed. By such means as this much can be done to counteract the injurious influence of dampness.

In the case of fruit which is crowded upon the branches, it may sometimes be wise to remove a part in order to save the remainder. I am told that Mr. Curtis saved about half of the Superior Gage plums on his place last summer by removing the plums which became affected. The rotting of fallen fruit is always a source of contamination to that still on the trees. It should, if possible, be destroyed, and can, in many cases, be economically disposed of by allowing hogs to eat it.

It is not well to carry to the cellar for winter keeping any fruit affected in the slightest degree by rot. If the fungus is in an apple, it will destroy that apple at least, and the chances are that it will be the means of contaminating others. Winter apples with rot specks on them should be separated from the sound fruit, and be disposed of as promptly as possible. Unnecessary moisture in a cellar used for storing apples should be avoided for reasons which will be apparent to any one who has followed this paper.

Dusting with air-slacked lime, or other absorbent material, is calculated to keep apples from rotting, by preventing the gathering of moisture on their surfaces. In all probability, the rot may be lessened by passing the fruit, previous to storing, through a weak solution of carbolic acid, thus killing the spores which, during the summer, have lodged upon it.

Boxes and barrels in which fruit has rotted are to be avoided as means of storing. They can be disinfected by spraying thoroughly with a one per cent. solution of carbolic acid. They should, at any rate, be thoroughly dry before putting sound fruit in them.

FUNGICIDES FOR BROWN ROT.

A number of experiments were made during the summer of '89 with the view of getting reliable data as to the effect of poison-bearing fluids on the fungus which causes this rot. Carbolic acid, potassium sulphide and sulphate, hyposulphite of soda, London purple, copper sulphate, and a mixture of copper sulphate, lime and water (Bordeaux mixture) were used. The experiments were directed especially to the purpose of learning what would kill the spores, and at the same time would not damage the foliage of the trees. Spores were sprayed with these preparations from a small atomizer once or twice, and were then introduced under the skin of the fruits. In this way a perfect test of the efficacy of the preparation was obtained, for when the spores were not killed, they would, when thus introduced, invariably grow, and cause treated fruit to rot. The brown rot was conveyed back and forth between plums, peaches, apples, wild cherries and grapes.

With the exception of London purple and the four per cent. solution of potassium sulphide, none of the fungicides killed all the spores when applied but once. The effect of the application was to some extent dependent on the strength of the solution, the use of the stronger ones being followed by a more tardy growth of the rot, and fewer growths relative to the number of inoculations. It is not to be understood, however, from the result of these trials, that a single spraying of trees would be useless. It is to be remembered that the spores are produced in great quantities, and the fact that the growth of the rot was retarded is good evidence that most of the spores had been killed. The experiments are not published as having more than a provisional value. They were made for the writer's own guidance in further experiment.

The following series will illustrate the effects of these fungicides when sprayed on the spores a single time. Green apples were used, each one being punctured and inoculated in four different places. The spores were introduced at 3:15 P. M., August 1st. A check, consisting of apples punctured in the same way, but with untreated spores introduced in each puncture, shows the rot starting from every point of inoculation on August 3rd, the date at which all the treated apples were first examined.

EXPERIMENT 104.

Used a one per cent. solution of potassium sulphide.

Aug. 3, no rot. August 5, some rot starting at punctures 1 and 2. August 6, rot decided at puncture 1; less so at 2. Aug. 7, rot more than one inch in diameter at puncture 1; some rot at 2. Aug. 9, rot at punctures 1 and 2 growing rapidly; no rot at punctures 3 and 4. Aug. 12, fruit of monilia has appeared at punctures 1 and 2.

EXPERIMENT 105.

Used a two per cent. solution of potassium sulphide.

Aug. 3–12, no rot. Aug. 14, a slight appearance of rot at puncture 4. Aug. 19, some rot at punctures 2 and 4.

EXPERIMENT 106.

Used a four per cent. solution of potassium sulphide.

Aug. 3–19, no rot.

EXPERIMENT 107.

Used one per cent. solution of carbolic acid.

Aug. 3–6, no rot. Aug. 7, rot at puncture 1 over a half inch in diameter. Aug. 9, rot at puncture 1 rapidly extending. Aug. 12, rot at punctures 1 and 4—a profuse growth of fungus spores. No rot at punctures 2 and 3.

EXPERIMENT 108.

Used a two per cent. solution of copper sulphate.

Aug. 3, no rot. Aug. 5, some rot at puncture 4. Aug. 7, rot at puncture 4 more than one inch in diameter. Other punctures free. Aug. 9, rot at puncture 4 now fully two inches in diameter. Aug. 12, all the rot has spread from puncture 4—a fine growth of fungus spores.

EXPERIMENT 109.

Used two and a half per cent. solution of iron sulphate.

Aug. 3, no rot. Aug. 5, possibly some rot at puncture 3. Aug. 6–12, appearance as on Aug. 5. Aug. 14, rot 1½ inch in diameter at puncture 3; punctures 1, 2 and 4 free. Aug. 19, rotted throughout. Some fruit of the fungus developed.

EXPERIMENT 110.

Used a five per cent. solution of iron sulphate.

Aug. 3, some rot at puncture 1. Aug. 6, rot decided at puncture 1. Aug. 7, some rot at punctures 1, 3 and 4. Aug. 9, decided growth of rot at all the punctures; about ¼ inch in diameter at puncture 4; ½ inch in diameter at 1 and 2; 1 inch in diamater at 3. Aug. 19, apple nearly all invaded by rot.

NOTE.—It will be observed that the five per cent. solution of iron sulphate has here been less effective than the 2½ per cent. solution used in Experiment 109—a result probably due to repellant properties of the powdery coating of the fruit from which the spores were taken Unless watched closely, the fluids employed were very likely to collect in droplets, so that such of the surface sprayed would not be moistened. This bloom of fruits is a natural protection against the attacks of fungi, the value of which is not commonly appreciated.

EXPERIMENT 111.

Used a five per cent. solution of potassium sulphate.

Aug. 3–5, some rot at all the punctures; decided at 4. Aug. 6, rot decided at punctures 1 and 4. Aug. 7, a large rotted area at punctures 1, 2 and 3. Aug. 9, rot decided at all the punctures. Aug. 12, fruit of the fungus at all the punctures; none elsewhere. Aug. 19, badly rotted, fruit of fungus abundant.

EXPERIMENT 112.

Used a ten per cent. solution of potassium sulphate.

Aug. 3, a trace of rot at all the punctures. Aug. 6, a rotted area $\frac{3}{4}$ inch in diameter at puncture 1; $\frac{1}{4}$ inch in diameter at 4. Aug. 7, a rotted area more than 1 inch in diameter at puncture 1; not fairly started at two; about $\frac{1}{4}$ inch in diameter at 3 and 4. Aug. 12, a good growth of fungus spores like those which appear on plums.

EXPERIMENT 113.

Used Bordeaux mixture (in the proportion of 8 pounds of copper sulphate, 10 pounds of air-slacked lime and 22 gallons of water).

Aug. 3, no rot. Aug. 5, some rot at puncture 1. Aug. 6, rotted area about puncture 1 about one-half inch in diameter. Aug. 7–9, rot at 1 rapidly extending; punctures 2 and 4 free. Aug. 12, some fruit of the rot fungus.

EXPERIMENT 114.

Used a solution of hyposulphite of soda (in the proportion of one pound to ten gallons of water).

Aug. 3, some rot at punctures 3 and 4. Aug. 6, rot one-half inch in diameter at puncture 3; evident rot at 4. Aug. 7, rot at 3 and 4; none at 1 and 2. Aug. 9, rot growing rapidly at 3 and 4; evident start now at 1 and 2 also. Aug. 19, entirely rotted—no fruit of fungus.

EXPERIMENTS 133–143.

These tests were repeated in experiments 133–143, the only difference being that, in the latter, the spores were sprayed twice with an interval of twenty hours between sprayings. The last spraying for experiments 133–140 was done on August 9. The spores used for experiments 141–143 were sprayed last on August 10. In each case the spores were used as soon as dry from the last spraying. The inoculated apples were observed continuously up to August 19, and in no case was the rot developed at the punctures. Later some of the apples were contaminated from rotting fruit in the same room; but I am satisfied that none of the introduced spores germinated. A part of the apples were kept until October, and showed no rot at the punctures.

EXPERIMENTS 68–78, 79–89, 92–102, AND 115–125.

These are series intended to show the effect upon foliage of the fungicides employed in the preceding experiments. Leaves of growing plants were sprayed with the solution by means of an atomizer, and the effect watched for several days afterwards. Experiments 68–78 were made on the leaves of a plum tree; Experiments 79–89, and 92–102 were made on the leaves of apple trees; Experiments 115–125 were made on potato leaves. The Table below gives the result:

Fungicide Used.	Experiments 68–78.	Experiments 79-89.	Experiments 92-102.	Experiments 115-125.
Potassium sulphide, 1 per cent. .	No injury	No injury.	No injury.	No injury.
Potassium sulphide, 2 per cent. .	No injury	No injury.	Leaves a little discolored.	No injury.
Potassium sulphide, 4 per cent .	Leaves injured at edges.	No injury	Leaves brown at edges.	Leaves a little discolored.
Carbolic acid, 1 per cent.	No injury.	No injury.	No injury.	No injury.
Copper sulphate, 2 per cent . . .	Injured and fallen.	A nut brown discoloration.	Badly injured.	Badly injured.
Iron sulphate, 2½ per cent. . . .	Discolored.	A faint discoloration.	No injury.	No injury.
Iron sulphate, 5 per cent . . .	Injured badly.	Leaves discolored.	Leaves discolored but not much injured.	Badly injured.
Potassium sulphate, 5 per cent. .	Injured at edges.	No injury.	No injury.	No injury.
Potassium sulphate, 10 per cent .	Badly injured.	No injury.	No injury.	Badly injured.
Bordeaux mixture.	No injury.	No injury.	No injury.	No injury.
Hyposulphite of soda	Leaves a trifle injured.	No injury.	No injury.	No injury.

CONCLUSION.

The potassium sulphate solutions were on the whole least effective in destroying the vitality of the spores, as will be seen by reference to the record under experiment 111 and 112. The 10 per cent. solution injured the leaves severely in two out of four trials, and the 5 per cent. solution in one out of four trials. Judging from the record, it would seem probable that this material would not prove useful for preventing rot.

The iron sulphates are perhaps not fairly tested in experiments 109 and 110, inasmuch as the stronger solution has been least effective, very probably, as already explained, because of some failure in the manner of applying the solution used in experiment 110. A glance at the result of tests of this substance on foliage, however, shows it to be one of the most injurious of those used, the 5 per cent. solution having damaged the leaves in every one of the four trials, while the 2½ per cent. solution injured them slightly in two out of four trials. It is possible that iron sulphate can be made useful in some cases, but these tests would indicate that it should not be used stronger than in 2 per cent. solutions.

The 2 per cent. copper sulphate solution (Exp. 108), while one of the most effective in destroying the spores, was also one of the most injurious to foliage, having in every one of the four tests injured the sprayed leaves badly. A weaker solution would perhaps prove sufficiently destructive to the spores, at any rate would be required to avoid injury to the trees.

The hyposulphite of soda (see Exp. 114) was one of the least effective of those used, and seems capable of some injury to foliage.

The three remaining preparations seemed to be about equally effective. The potassium sulphide of 4 per cent. strength is, however, too strong to be used safely on foliage. The 2 per cent. solution injured the leaves in one out of four tests, and should perhaps be avoided for the same reason, especially since in ordinary spraying the quantity of material used is less completely under control than in the case of experiment work. The 1 per cent. solution did not injure the foliage in any instance, and from the work I have done with it I am led to consider it one of the most promising remedies for brown rot.

The carbolic acid is one of the most harmless materials used, and is not so disagreeable to work with as some of the others. It does not deter insects from growing fruit upon which it has been sprayed, and hence is not as complete a remedy as the next.

Bordeaux mixture is in some respects the most valuable preparation that has been devised for use against parasitic fungi. Not the least of its valuable properties in preventing invasion by fungi is its indirect action by repelling injurious insects. An eminent economic entomologist wrote nearly twenty years ago: "It is now a well established fact that the common Plum Curculis causes the dreaded rot of plums and peaches to spread at a fearful rate by the punctures and gougings which it makes in the ripening fruit, and that where this predisposing influence is guarded against, such rot is generally confined to comparative narrow limits, or does not occur at all. Many varieties of apples are disposed to rot in a similar manner, and to fall from the tree just as they are ripening. This rot in apples, as may be seen from the transactions of our State Horticultural Society, was very prevalent last fall, the Rawles Janet being especially predisposed to it, and there can be no doubt but that the punctures and gnawings of the little Turk, combined with those of the apple curculis, are likewise the principal agents in producing it." From my own observations, made during the summer of '89, I can bear witness to the part taken by insects in causing the rot to spread. Of all the rotting plums which I examined, there was not one but had the skin broken by insects or other agencies. In several instances I succeeded in getting the rot started through the unbroken skin by keeping plums wrapped with moist tissue paper and under a bell jar. While it is possible, therefore, for the spores to penetrate the unbroken skin, it is evident that this is not the usual method of invading the tissues. Any fungicide consequently which does not take into account the influence of insects in spreading brown rot, is seriously defective. Bordeaux mixture, as I have shown elsewhere, answers this purpose admirably. It remains upon the leaves for some time after being sprayed, apparently retaining, in a large degree, its original properties, both as a fungicide and insecticide. Its action is decided in killing the spores of fungi, and it is not less efficient in preventing the depredations of gnawing insects. It probably acts to some extent as a preventive of fungus attacks after it has been dried upon the leaves; but from some recent experiments I am disposed to believe that spores of the brown rot fungus falling upon the dry mixture are not merely prevented from germinating, but are deprived of their vitality.

THE BITTER ROT FUNGUS OF APPLES.

(*Glœosporium versicolor.* B. & C.)

With the brown rot fungus another very different species was occasionally observed last summer, sometimes on the same trees, and in the fall it was found to be frequent in some orchards. Its presence is to be known when the fruit is pretty well rotted by the appearance of minute, scattered, dark-colored pustules beneath the cuticle. Apples rotted by the brown-rot fungus are brown at first, but later blacken, become shriveled, and finally dry out, but always retain a smooth, shining surface. In the early stages of rot caused by the bitter rot fungus, it is often so like the other that it can not be distinguished by ordinary methods of examination, and it is not until the characteristic pustules push up the cuticle that it may be known, and I am unable at present to give any characters other than the presence of these bodies which is available for the purpose. The rot under consideration has been named the "bitter rot" by

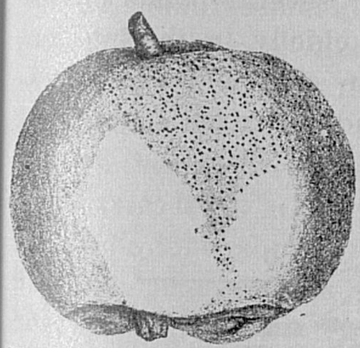


Fig. 13. An apple invaded by the bitter rot fungus, the black dots representing the fruiting pustules as they appear to the naked eye. Natural size. H. Garman, Del.

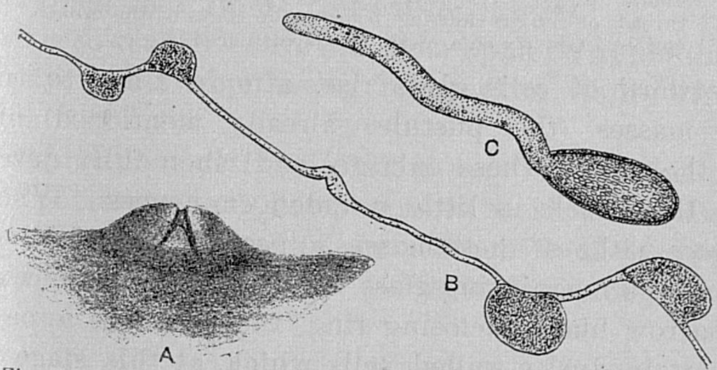


Fig. 14. The reproductive bodies of the bitter rot fungus (*Glœosporium versicolor*). A, a surface view of one of the pustules which develop beneath the cuticle of apples, eventually pushing up and breaking it; B, growing thread of bitter rot fungus, with spore-like knots at intervals; C, germinating spore. H. Garman, Del.

our best authorities in such matters, and it is probable, therefore, that it has under some circumstances an unpleasant taste. I have been unable to distinguish it by this means. The apples used by me for cultivation of the spores were, when rotted, as spongy and sweet as dried apples, quite like the apples in which the brown rot fungus had been introduced.

The rot is produced in apples, as in the case of brown rot, by the invasion of the tissues by the fungus, and the subsequent development among the cells of a network of jointed threads, the activities of which cause a softening of the previously sound and crisp fruit, and ultimately change to a dull brown color. The rot may start from one or several points on the same apple, and in some cases works chiefly in the interior, leaving intact the part just within the skin and the colors, until the heart is completely invaded and destroyed.

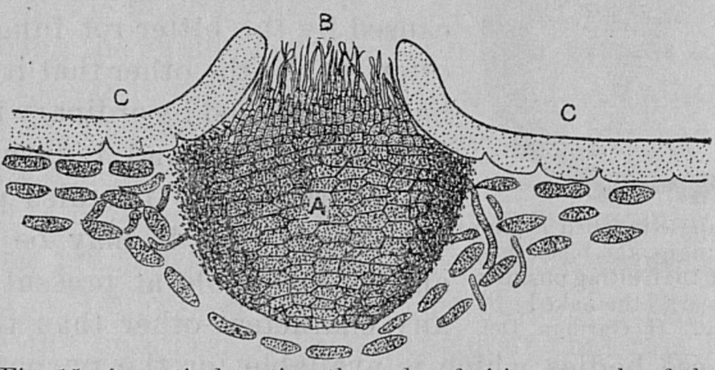


Fig. 15. A vertical section through a fruiting pustule of the bitter rot fungus. A, cells of which the mass is chiefly made up; C C, cuticle of the apple; B, spore-bearing threads of fungus showing beneath the edges of the broken cuticle. Greatly enlarged. H. Garman, Del.

The network of cells gives rise, after a time, to compact rounded masses (the pustules already mentioned) of cells beneath the skin. These enlarge, and when fully developed, push up the cuticle in little rounded eminences. When first visible from without, these masses appear as small dark specks, which, under a magnifying glass, are seen to be white centrally, with a narrow black inclosing ring, the latter, in appearance, due to certain dusky-walled cells which at this stage inclose the mass beneath. Finally the cuticle over each mass is ruptured, and the cells crowd into the break, the outermost ones becoming serially disposed, and at the last giving rise to slender projecting threads, each bearing a single elongated spore at its tip. These little spores, set free and carried away by currents of air, convey the rot to other apples upon which they may find lodgment.

In addition to reproductive bodies such as these, the threads in the interior of rotting fruit become swollen at intervals, and give rise to spore-like bodies that become the centers of a renewed growth of threads. The presence of such bodies in the decaying fruit renders it very easy to convey the rot by means of bits of rotting apple introduced in punctures made in good fruit.

REMEDIAL TREATMENT.

The general resemblance in the habit of the two fungi makes it probable that remedial measures which are successful for one will prove efficient for the other. It is evident that the rotted fruit, which is commonly left clinging to trees or on the ground beneath them, is a source of danger to fruit which will be borne on the trees later, and it goes without saying that this, if nothing else is done, should always be removed and destroyed. As has been suggested in notes presented on the other species, hogs can be profitably employed for the purpose. I would not suggest that hogs be allowed the freedom of an orchard. The ripened fruit which falls in the natural course, or is brought down by storms, is often too valuable to be spared, but turned in at intervals after the fruit of value has been picked up, they cannot fail to prove a benefit, both as regards injury from rot fungi and from fruit-eating insects.

The rot is so readily conveyed from apple to apple that harm must always result from saving rot-specked apples with sound fruit.

As to applications of fungicides, it may be said that preparations of potassium sulphide, carbolic acid, or of Bordeaux mixture, may be expected to serve a beneficial purpose; but, as far as I know, they have not yet been used for this species.

THE APPLE SCAB FUNGUS.

(*Fusicladium dendriticum.* Wallr.)

Order, Hyphomycetes; family, Dematicæ.

The apple scab is another fungus disease which is common in many Kentucky orchards. It is not as uniformly present as the brown rot fungus, but, judging by the frequency with which badly scabbed apples appear in the markets, is in some localities very injurious. During certain favorable seasons this fungus becomes locally abundant in the apple-growing States everywhere, and occasions much loss to orchardists by marring the appearance and dwarfing the growth of fruit. It was especially common in 1889, a fact which may be safely attributed to the frequent rains.

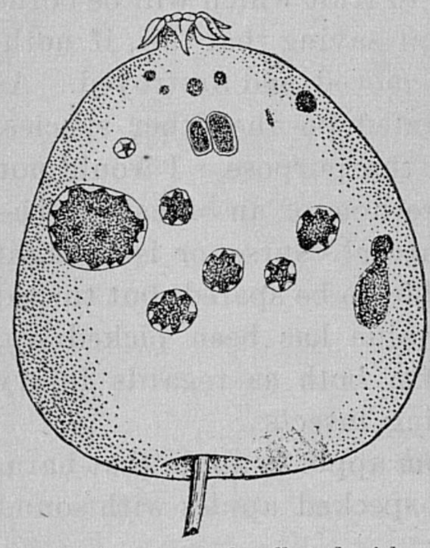


Fig. 16. An apple affected with "scab." (After Sorauer.)

As a general thing, it is more common in old neglected orchards than in those which are younger and better cared for. It is sometimes confined chiefly to one or two trees in an orchard, and affects some varieties more than others. It is believed to be especially common on trees next wooded land. I have several times found trees which overhung old lichen-covered fences much worse affected than others in the neighborhood.

The scab fungus of itself causes no rot to appear. It is confined to the tissues immediately beneath the cuticle of fruit. When it invades one side of an apple, the growth of that side is, to some extent, checked, with a final effect of misshapen fruit of small size. Ordinarily this checking of growth and impairing of appearance is the chief injury done, the quality of the affected apples not being especially inferior to that of uninjured fruit. But some varieties, when scabbed, have a tendency to split, thus permitting access to insects and rot-producing fungi, and in this way the scab may result in the complete destruction of fruit. In addition to apples and apple leaves, the fungus attacks the pear, infesting fruit, leaves and twigs. In Europe it has been found on various thorn trees, the mountain ash, etc.

The scab-like growths start each from a single center soon after the fruit sets, and, if isolated, grow to a diameter of about one-fourth of an inch. While thus not invading much of the tissue, the injury caused by one of these spots extends over a considerable region, as may be seen by the effect upon the side on which the spot occurs. Where numerous centers of growth occur, the greater part of the surface is ultimately invaded and coated. The spots are generally blackish at first, but vary to some extent, and when old, are often denuded, nearly smooth, and of a reddish-brown color. The growing part of the fungus is at the margin of each spot, and, as the surrounding tissue is invaded, the cuticle of the fruit is lifted up, and often remains as a pale rim. The center of old spots consists very largely of a corky substance formed by the fruit to resist the injury done by the parasite.

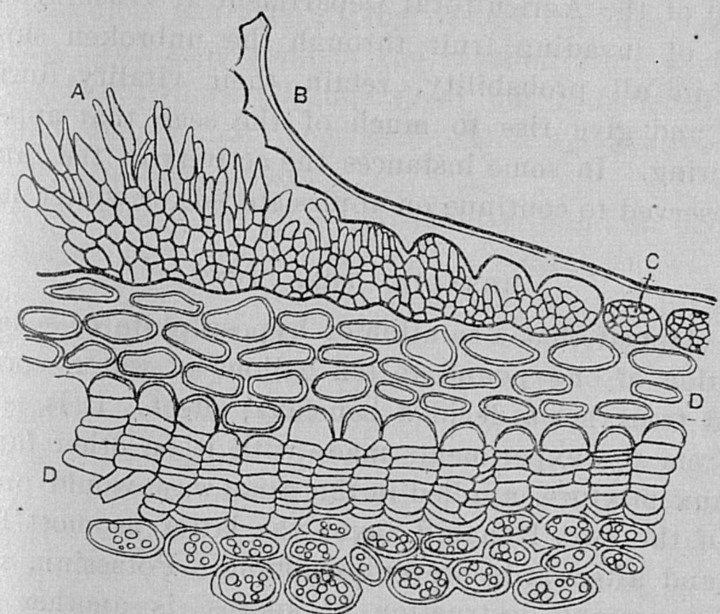


Fig. 17. A section through one edge of a scab spot. A, developed spores; B, the upturned cuticle; C, the parenchyma like cells of the parasite occupying the epidermal cells of the apple; D D, tissues of the apple. Greatly enlarged. (After Sorauer.)

On the leaves of apple trees the effect of injury by the apple scab fungus is so different from that on fruit that, judged by this alone, it would not be supposed to have any relation with that which produces scab on fruit. The examples of affected leaves before me show the fungus in early stages of growth as forming scattered, sooty spots from .06 to .25 inch in diameter. In examples with the injury farther along many of the spots have united, or the growth forms conspicuous sooty bands along the midrib and veins, and the injury is now perceptible on the under side in brown areas of dead tissue, which correspond in the main to sooty spots of the upper side.

The growing part of the fungus is in the form of a tissue, made up of numerous small cells, which may completely fill the epidermal cells of the apple. As the cuticle is pushed up at the margin of a spot, the cells, which, by this process, are exposed, send up little stalks, which bear each a spore at its tip. The latter are brown in color, and very variable in size and shape. Very frequently they are oval, and when old may be divided into two cells by a cross partition. The spores germinate readily, and have been proved by Dr. Galloway, Botanist of the Agricultural Department at Washington, to be capable of invading fruit through the unbroken skin. The spores, in all probability, retain their vitality during the winter, and give rise to much of the scab that appears the next spring. In some instances the activity of the fungus has been observed to continue on apples stored for winter use.

REMEDIAL TREATMENT.

It is claimed that a solution of hyposulphite of soda, in the proportion of one pound to ten gallons of water, sprayed on affected trees, has a decided beneficial effect. It is very probable, from the experiments made with it on other fungi, that Bordeaux mixture, applied in the same way, would prove useful. Of the two, I should favor the latter as most likely to check and afterwards prevent scabbing. Potassium sulphide, from its prompt destruction of spores, is another material which could be depended on to check growth already started, but its preventive action is not equal to that of Bordeaux mixture, and we should expect better results from the use of the latter.

During most seasons attention to the removal of any thing which retains moisture or prevents a free circulation of the air, will be found to have a good effect on trees which are especially subject to attack. Grass or shrubbery should not be permitted to grow rankly. In weather favorable to scabbing, the preparations mentioned are the only resort left which promises relief.

THE BLACK ROT OF TOMATOES.

This is a widespread disease, which often destroys a large part of the fruit on vines. In its early stage a small gray, or brown, discoloration appears in the depression usual at the apex of the fruit, or elsewhere, in green tomatoes, and, as it extends, the affected tissue becomes sunken and blackened. From the succulent character of the tissues, the decay extends very quickly, and soon renders the invaded fruit worthless. The disease is not very well understood, but is believed to be due to fungi, one or more species of which are always to be found in the blackened tissues.

The fungus which I have most frequently found on decaying tomatoes is, perhaps, *Hypomyces solani*, better known under the name *Fusisporium solani*, from its almost invariable presence on rotting potatoes. Of this species Worthington G. Smith writes: "The mycelium appears to have the property of breaking up the cell walls, of injuring the contained starch, and speedily reducing the potato to a loathsome mass of putridity." This view of the activity of this fungus in causing rot in sound vegetable tissue is not held by others who have given the subject study. It seems very probable, at least, from the behavior of its spores when introduced artificially into either sound tomatoes or potatoes, that the rots of these vegetables are not caused by it. Like the numerous bacteria which live in the decaying tissues, it is almost certainly dependent on decaying vegetable matter for sustenance.

If the fungus on tomatoes is identical with that occurring on rotting potatoes, its ordinary spores germinate in several very different ways. These spores appear on the surface in dense whitish tufts. Individual spores are long, spindle-shaped, pointed at each end, slightly curved, and are made up of from four to six segments. In the summer these spores, taken fresh from rotting potatoes and transferred to moist cells, lost the cross partitions separating the segments, and sent out from each pointed extremity a slender germ tube. Wherever one of these latter came near another spore or another germ tube, small branches pushed out at right-angles to the primary tubes, and ultimately united the two.

During the winter dry spores of this sort taken from tomatoes which have rotted in the fall, germinate in moist cells very readily, but do not lose the cross partitions previously. When placed in water, the central cells swell up, sometimes a single one at first, but finally all except the pointed terminal ones become rounded, the whole resembling a chaplet of thin-walled, almost spherical spores. Then rather thick germ tubes push out, commonly one for each cell; but, unlike the threads of summer spores which I examined, germ tubes of the different cells show no attraction for each other, and, as far as observed, always remain separate.

A second fungus which occurs in rotting tomatoes is *macrosporium tomato.* I can say nothing of it from personal experience. Prof. B. T. Galloway, who has probably given it closer attention than any one else, reports it capable of inducing rot in either green or ripe tomatoes. Since the fungus nature of the disease is pretty well established, it is safe to assume that benefit will result from employing trellises for vines, and from planting them well apart. Some years ago tomatoes (acmes) in in my own garden were badly injured, probably half of the fruit being destroyed. With the idea that the rot might vary with the variety, or was encouraged by the plants being allowed to lie upon the ground, the next two years the trophy was planted and the vines were supported on trellises. Very little rot appeared upon these vines. Just how much of the resulting immunity was to be ascribed to the variety, and what to trellising, can not be stated. The object at the time was not a scientific experiment, but to get tomatoes free from rot. The fact seems to be that smooth varieties are less likely to rot than rough ones, a fact worth keeping in mind in getting seed to plant on ground in which the disease has appeared. This, together with care in the matter of cultivation, is about all that can be recommended in the light of present knowledge of the disease.

BULLETIN No. 17.

Field Experiments With Corn.

This year a series of experiments with corn was begun upon the farm of the Experiment Station, having for its object the study of many questions, mainly as follows:

1. *The effects of the leading elements of plant food, used in various combinations, on the production of corn.*
2. *The financial results which follow the use of commercial fertilizers on a worn soil such as ours.*
3. *The effect of barn-yard manure on corn compared with that of the leading ingredients of commercial fertilizers used in various combinations.*
4. *Comparative effect of different forms of phosphoric acid.*
5. *The effect of sulphate of iron on the growth and yield of corn.*
6. *The value of tobacco stems as a fertilizer.*
7. *The permanency of effect of different fertilizers.*
8. *The relation of fertilizers to shrinkage and to the proportion of cob to kernel.*
9. *Does the application of various fertilizers have any relation to the amount of phosphoric acid, nitrogen and potash taken up by the corn crop?*

When these experiments were planned it was not expected that the results this year would solve the problems laid down. In fact, they were planned with the idea in view to continue them a series of years, that variations of seasons might not be a source of error in reaching conclusions. It is evident that some

If the fungus on tomatoes is identical with that occurring on rotting potatoes, its ordinary spores germinate in several very different ways. These spores appear on the surface in dense whitish tufts. Individual spores are long, spindle-shaped, pointed at each end, slightly curved, and are made up of from four to six segments. In the summer these spores, taken fresh from rotting potatoes and transferred to moist cells, lost the cross partitions separating the segments, and sent out from each pointed extremity a slender germ tube. Wherever one of these latter came near another spore or another germ tube, small branches pushed out at right-angles to the primary tubes, and ultimately united the two.

During the winter dry spores of this sort taken from tomatoes which have rotted in the fall, germinate in moist cells very readily, but do not lose the cross partitions previously. When placed in water, the central cells swell up, sometimes a single one at first, but finally all except the pointed terminal ones become rounded, the whole resembling a chaplet of thin-walled, almost spherical spores. Then rather thick germ tubes push out, commonly one for each cell; but, unlike the threads of summer spores which I examined, germ tubes of the different cells show no attraction for each other, and, as far as observed, always remain separate.

A second fungus which occurs in rotting tomatoes is *macrosporium tomato.* I can say nothing of it from personal experience. Prof. B. T. Galloway, who has probably given it closer attention than any one else, reports it capable of inducing rot in either green or ripe tomatoes. Since the fungus nature of the disease is pretty well established, it is safe to assume that benefit will result from employing trellises for vines, and from planting them well apart. Some years ago tomatoes (acmes) in in my own garden were badly injured, probably half of the fruit being destroyed. With the idea that the rot might vary with the variety, or was encouraged by the plants being allowed to lie upon the ground, the next two years the trophy was planted and the vines were supported on trellises. Very little rot appeared upon these vines. Just how much of the resulting immunity was to be ascribed to the variety, and what to trellising, can not be stated. The object at the time was not a scientific experiment, but to get tomatoes free from rot. The fact seems to be that smooth varieties are less likely tc rot than rough ones, a fact worth keeping in mind in getting seed to plant on ground in which the disease has appeared. This, together with care in the matter of cultivation, is about all that can be recommended in the light of present knowledge of the disease.

BULLETIN No. 17.

Field Experiments With Corn.

This year a series of experiments with corn was begun upon the farm of the Experiment Station, having for its object the study of many questions, mainly as follows:

1. *The effects of the leading elements of plant food, used in various combinations, on the production of corn.*
2. *The financial results which follow the use of commercial fertilizers on a worn soil such as ours.*
3. *The effect of barn-yard manure on corn compared with that of the leading ingredients of commercial fertilizers used in various combinations.*
4. *Comparative effect of different forms of phosphoric acid.*
5. *The effect of sulphate of iron on the growth and yield of corn.*
6. *The value of tobacco stems as a fertilizer.*
7. *The permanency of effect of different fertilizers.*
8. *The relation of fertilizers to shrinkage and to the proportion of cob to kernel.*
9. *Does the application of various fertilizers have any relation to the amount of phosphoric acid, nitrogen and potash taken up by the corn crop?*

When these experiments were planned it was not expected that the results this year would solve the problems laid down. In fact, they were planned with the idea in view to continue them a series of years, that variations of seasons might not be a source of error in reaching conclusions. It is evident that some of the problems, as, for instance, *No.* 7, *the permanency of effect of different fertilizers*, could only be begun this year. It might be two, three, four or more years before the fertilizers applied this year would be exhausted, and until that time these experiments must be continued before a definite conclusion could be reached.

Explanations.—By the *leading elements of plant food* are meant *nitrogen*, *phosphoric acid* and *potash*. Plants feed on other soil-elements besides these, and they are just as essential to plant life as these three ; but, generally speaking, all but these ingredients are furnished to plants in abundance, and therefore, in studying what to put on our soils to make them more productive, we need concern ourselves with only these three. Commercial fertilizers are manufactured and sold for the purpose of supplying nitrogen, phosphoric acid and potash, and the market prices depend upon these ingredients. Some fertilizers contain one of these ingredients, some two, and some all. Generally speaking, a commercial fertilizer is a mixture containing two of these ingredients, and sometimes all; the proportions varying greatly in the various brands and often in the same brand. It is at once seen to be a very difficult, if not an impossible, task to test all the various brands sold on a given soil in order to find out those that produced the best effect. It is an easy matter, however, to find out whether a given soil needs potash, phosphoric acid or nitrogen, or any combination of these elements for a given crop. Having found out this by experiment, we have only to look to the analysis of the various fertilizers to tell which brands, if any, could be used to advantage on the soil and crop tested. If the experiment proved that potash was all that was needed on a given soil for the corn crop, all those fertilizers whose analyses show little or no potash would not produce favorable results, under whatever name sold.

The effects of the leading elements of plant food, used in various combinations, on the production of corn.

The land used for the experiment was high, gently sloping toward the middle of each plot. The soil is derived from the Lower Silurian limestones. These beds are fossiliferous, ranging in character from thin-bedded blue limestone with rich phosphatic layers, to thick-bedded, semi-crystalline grey limestone The subsoil is a light colored clay, so retentive as to make the soil deficient in natural drainage. The land has been in cultivation a long time, the exact length not known. It was in hemp before the war. In 1863 it was in corn ; in '70 and '71 in wheat ; in meadow in '72 ; '79 in potatoes ; '81 in clover ; '82 in millet, and in '87 in rye. It is believed that no stable manure or other fertilizers were applied before these experiments.

The Season.—The season, especially after the middle of July, was very favorable for a large yield of corn. While silking and earing there were a number of heavy rains. The continued wet fall prevented the corn from maturing well, and in consequence it was much softer than usual.

For this experiment the plots were $\frac{1}{10}$ acre each, 181½ feet long by 24 feet wide, except plots 7a and 7b, which were $\frac{1}{20}$ acre each. The ground was plowed in the early part of May, but the cut-worms were found to be so numerous that planting was delayed until May 21st. Before the planting, the ground was thoroughly harrowed, and then marked off in such a manner that the hills were three feet apart each way, and the outside row was 1½ feet from the boundary line of the plots. The corn was planted by hand May 21st. To insure a perfect stand, six to eight kernels were put in the hills. The variety planted was white Dent. It came up well, and was thinned at hoeing time to two stalks to a hill. So carefully was this done that a perfect stand was obtained. The corn was cultivated four times with a Kalamazoo Spring-toothed Cultivator, and hoed twice. Each plot received the same treatment in every respect except as to the fertilizer used.

The fertilizers were applied May 10th, broadcast, except where otherwise stated. In order to insure even distribution they were mixed with dirt before applying. On plot No. 7a, after the general fertilizer was applied broadcast, three pounds of sulphate of potash were applied in the hill at time of planting, care being taken to mix the potash with the surrounding soil so as not to injure the corn or young plant.

Plot No. 7b received only three pounds of sulphate potash applied in the hill, with the same precautions as were used in applying it on plot No. 7a.

The following plan shows the arrangement of the plots and the kind and amount of fertilizer used :

Plot	Fertilizer	Amount
1	No Fertilizer.	
2	Acid Phosphate, Sulphate of Potash, Sulphate of Ammonia,	30 lbs. 10 '' 15 ''
3	Acid Phosphate, Sulphate of Potash,	30 lbs. 10 ''
4	Acid Phosphate, Sulphate of Ammonia,	30 lbs. 15 ''
5	Sulphate of Potash, Sulphate of Ammonia,	10 lbs. 15 ''
6	No Fertilizer.	
7a	*	
7b	†	

*Acid phosphate 15 lbs.
Sulphate of potash 5 lbs.
Sulphate of ammonia 7½ lbs.
Sulphate of potash in hills 3 lbs.
† Sulphate of potash in hills 3 lbs.

In these experiments sulphate of ammonia containing 20.6 per cent. nitrogen was used to furnish nitrogen ; acid phosphate to furnish phosphoric acid, containing $14\frac{3}{4}$ per cent. of this ingredient, and sulphate of potash containing 53 per cent. potash to furnish potash.

When the corn first came up no immediate effect was noticed from the application of any of the fertilizers. The corn on all the plots grew slowly until after a heavy rain, about the middle of June, when it seemed to take a vigorous start. Soon after, the two unfertilized plots showed to great disadvantage.

Some two weeks thereafter it was noticed that plot No. 4, while looking fairly well, was not doing as well as plots 2, 3 and 5.

When the ears were well formed the following observations were taken :

Plot 1. Stalks slim and short; tassels short and imperfectly developed ; ears very short and clinging close to stalks ; foliage green, with yellow cast.

Plot. 2. Stalks large, thick at base, tall ; foliage dark green; tassels well developed ; ears long, falling from the stalk. The contrast between plots 1 and 2 was very marked.

Plot 3. Had the same appearance as No. 2 in every respect.

Plot 4. Stalks a little taller than No. 1, and color a little darker green, but nothing like the vigorous appearance of 2, 3 and 5.

Plot 5. Compared favorably with 2 and 3. Not quite so marked.

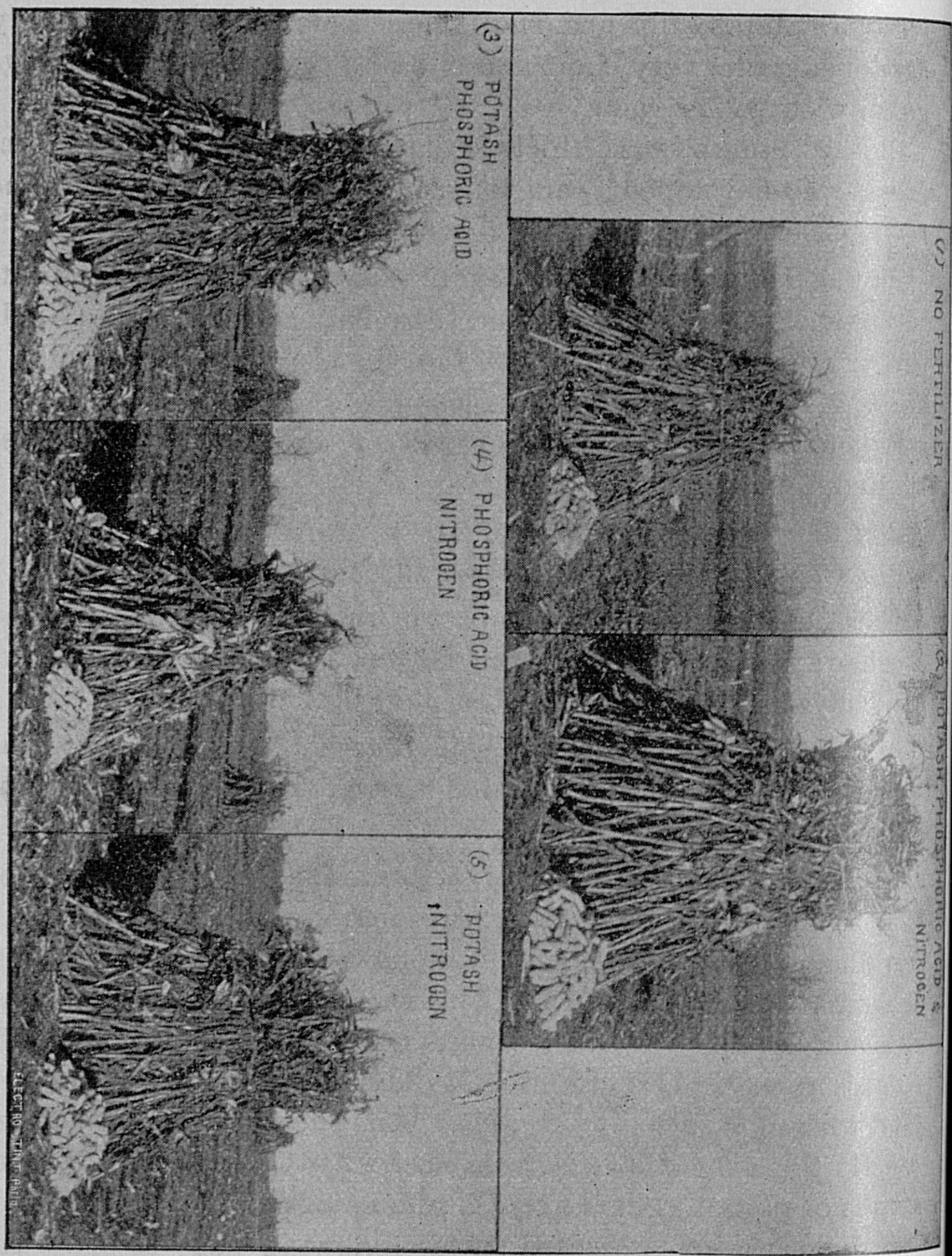
Plot 6. Same appearance as No. 1.

Plots 7a and 7b. To all appearances like Nos. 2 and 3.

These observations were kept up until the corn was cut and shocked; but all through the season a marked difference to their advantage could be seen on plots 2, 3, 5, 7a and 7b.

In September a continued rain together with a wind storm blew the corn down badly, which marred the appearance of the field but did no great damage.

After the corn was cut it was shocked, three shocks to the $\frac{1}{10}$ acre plot, each containing an equal number of hills. This was done in the latter part of September and early in October, as soon as the corn ripened. Afterward it was allowed to stand and mature until about November 20th, when it was husked. At this time a photograph was taken of the end shock of each plot with the corn by its side. All photographs were taken exactly the same distance from each shock. From the photographs of plots 1, 2, 3, 4 and 5 a photo-engraving was obtained, and the prints are presented on the following page to show the marked difference in the appearance of the corn on the different plots. It will be observed at once that plots upon which potash was applied showed to advantage not only in fodder but in size and quantity of ears as well.



FROM PHOTOGRAPHS.—SHOWING EFFECT OF FERTILIZERS on CORN.

The following table shows the yield of field-cured ear corn and fodder, calculated per acre. The corn is given in bushels, counting 70 pounds per bushel. Under "Yield of Fodder" we include the whole amount of stalks, leaves, etc., left after removing the ears, and it should be noted that the corn was cut within six inches of the ground for the sake of uniformity :

TABLE 1.

Application of Fertilizers to Corn.

No. Plot.	Fertilizer Used.	No. Pounds of Fertilizer applied per Acre.	Yield of Ear Corn per Acre in Bushels of 70 Pounds.	Yield of Fodder in Pounds per Acre.	Increased Yield of Corn in Bushels per Acre.	Increased Yield of Fodder in Pounds per Acre.
1	None	....	26.8	3,360	....	....
2	Potash Sulphate Acid Phosphate Ammonia Sulphate	100 300 150	63.4	5,420	34.2	2,015
3	Potash Sulphate Acid Phosphate	100 300	69.9	5,210	40.7	1,805
4	Acid Phosphate Ammonia Sulphate	300 150	29 1	3,695	....	290
5	Potash Sulphate Ammonia Sulphate	100 150	60.3	4,580	31.1	1,175
6	None	....	31.6	3,450	....	....
7a	Potash Sulphate Acid Phosphate Ammonia Sulphate Potash Sulphate in hill	100 300 150 60	80.0	5,970	50.8	2,565
7b	Potash Sulphate in hill	60	63.7	6,420	34.5	3,015

In examining these results it will be noticed :

1. That in those plots where potash was one of the ingredients of the fertilizer applied, there was a marked increase in the yield of corn and fodder.

2. That in plot 4, where both phosphoric acid and nitrogen, in the form of ammonia sulphate, were used, there was no increased yield of product.

3. That nitrogen produced no increased yield, for plot 3, without nitrogen, but with phosphoric acid and potash, produced as great a yield as plot 2, where all three were present.

4. That phosphoric acid was not essential, either alone or in combination; for plot 5, without phosphoric acid, produced nearly the same yield as did plot 2, where all were present, and plot 3, where phosphoric acid was mixed with potash.

5. That therefore potash was what caused the great increase in both yield of corn and fodder. This is further shown by comparing the yield of plot 7b, where potash alone was used with other plots.

6. The results show that a greater yield was produced on plot 7a than on plot 2, where all conditions were the same, except that plot 7a received, in addition to the fertilizer applied to plot 2, 3 pounds of sulphate of potash applied in the hill. Plot 2 received at the rate of 100 pounds of potash per acre, and the yield of corn was 63.4 bushels. Plot 7a received at the rate of 160 pounds of sulphate of potash per acre, and the yield was 80 bushels. This would indicate that 100 pounds sulphate of potash per acre was not sufficient to produce a maximum crop. It is probable that even 160 pounds was not sufficient to produce the best results.

7. It would seem, by comparing the yield of plots 2, 3 and 5 with 7b, that 60 pounds sulphate of potash per acre, applied in the hill, produced as great an effect as 100 pounds sowed broadcast. It is very doubtful whether this would have been true if the latter part of the growing season had been dry.

While general conclusions should not be based on the experiments of a single year, the results are so marked as to strongly indicate that, *for corn, potash is the fertilizer needed on the soil of the Experiment Station farm.*

This holds true for potatoes also, as shown in Bulletin No. 16. The results on hemp and tobacco prove the same to be true of these crops, and there are strong indications that the wheat will be greatly benefited by the application of potash. This would indicate also that soils of like character in the Blue Grass Region would be benefited by potash fertilizers, but this actual trials only can demonstrate.

The conclusions reached show no indications for soils of the other geological formations of the State, but the experiments should be an object lesson as to the intelligent use of commercial fertilizers. They show that we should know beforehand what our soil needs, and then apply a fertilizer which we know, from its analysis, will furnish the element or elements needed.

There were last year, legally, on sale in this State, 43 different brands of fertilizers containing less than 2 per cent. of potash; should we have applied any one of these to our soil for corn, no marked increased yield would have been apparent, not because the fertilizers were worthless (as they undoubtedly would have produced good results on soils deficient in phosphoric acid and nitrogen), but because they did not contain the potash necessary for the corn crop on our soil.

The following table gives the results of another set of experiments on a series of 1-10 acre plots adjoining those first described. The series was planned to test the comparative value of the different forms of phosphoric acid, but the phosphates were not applied this year. The corn was planted and cultivated at the same time and in the same manner as described above. Each plot received 16 pounds sulphate of potash, 6 pounds sulphate of ammonia, and 10 pounds dried blood, except plots 1 and 10, which received no fertilizer. The results serve to confirm the conclusions already stated as to the effect of fertilizers containing potash, and to show the uniformity in yield on the various plots. Leaving out of consideration the results from plot 2, the results are quite satisfactory, and show the land to be well adapted to plot experiments. It will be observed that the greatest difference in yield between any two of the plots between Nos. 3 and 9 is about 7 bushels. The small yield of ear corn on plot 2 cannot be explained. This difference was not observed in the growth of the corn on this plot. A satisfactory agreement is to be observed also in the results from the four unfertilized plots used for comparison in this and the preceding experiments. In these the variation is from 25.3 bushels to 31.6 bushels, or an extreme difference of 6.3 bushels corn per acre.

TABLE 2.

Application of Fertilizers to Corn.

No. Plot	Fertilizer Used.	No. Pounds of Fertilizer applied per Acre	Yield of Ear Corn per Acre in Bushels of 70 Pounds	Yield of Fodder in Pounds per Acre	Increased Yield of Corn in Bushels per Acre	Increased Yield of Fodder in Pounds per Acre
1	None		27.9	3,500		
2	Potash Sulphate Ammonia Sulphate Dried Blood	160 60 100	64.1	5,150	37.5	1,580
3	Same as No. 2		79.9	5,920	53.3	2,350
4	Same as No. 2		73.6	5,200	47.	1,630
5	Same as No. 2		75.4	5,465	48.8	1,890
6	Same as No. 2		73.	5,460	46.4	1,890
7	Same as No. 2		76.7	6,090	50.1	2,520
8	Same as No. 2		75.1	6,115	48.5	2,540
9	Same as No. 2		77.6	6,310	51.	2,740
10	None		25.3	3,640		

The financial results following the use of the leading elements of plant food on corn.

In taking into consideration whether there followed a profit by the use of the fertilizers on the various plots, the fodder was not considered, although in some instances there was a marked increased yield. As the corn could have been sold at the time it was cribbed for 32 cents per bushel of 70 pounds, our calculations were based on this valuation. The acid phosphate applied cost at the rate of $2.70 per acre, the ammonia sulphate $4.50, and the sulphate of potash $2.00, except on plots 7a and 7b, for which it cost $3.20 and $1.20 per acre respectively.

The average yield of the two unfertilized plots was deducted from the yield of each of the other plots to find the increased yield. From these data the following table has been compiled:

TABLE 3.

Financial Results.

No. Plot.	Fertilizer Used.	Cost of Fertilizer Used per Acre.	Value of Corn per Acre.	Value of Increased Yield of Corn per Acre.	Profit by Using Fertilizer per Acre.
1	None	....	$8 57	....	....
2	Potash Sulphate. Acid Phosphate. Ammonia Sulphate	$9 20	20 28	$10 94	$1 74
3	Potash Sulphate. Acid Phosphate.	4 70	22 36	13 02	8 32
4	Acid Phosphate. Ammonia Sulphate	7 20	9 31	....	*
5	Potash Sulphate Ammonia Sulphate	6 50	19 29	9 95	3 45
6	None	....	10 11	....	....
7a	Potash Sulphate. Acid Phospate. Ammonia Sulphate. Potash Sulphate in hill	10 40	25 60	16 26	6 26
7b	Potash Sulphate in hill	1 20	20 38	11 04	9 84

* Loss, $7.20.

Proceeding to a discussion of the results, it appears:

1. That there was a profit in every instance where potash was used, potash used alone on plot 7b yielding the largest net profit.

2. On plot 4, where no potash was used, but phosphoric acid and nitrogen were supplied, none of the money advanced for the fertilizer was recovered.

3. It is probable that the phosphoric acid and the nitrogen applied on plot 2 did not cause any increased yield of crop, the potash alone causing it. The money expended, therefore, for the acid phosphate and the ammonia sulphate, viz: $7.20, was lost, and decreased the net profits just that amount.

The effect of barn-yard manure as compared with that of the leading ingredients of commercial fertilizers used in various combinations.

The plots selected for the experiments with barn-yard manure were separated from plot 7b of the previous experiments by two intervening 1-10 acre plots, and a road 14 feet wide. The intervening plots had received an application of commercial fertilizers at the rate of 200 pounds per acre; neither of these fertilizers contained over 1.5 per cent. of potash. The yield was, respectively, at the rate of 26 and 31 bushels per acre.

As the land had been previously richly manured where we desired to make the manure trials, no fresh quantities of manure were applied at the time of planting. An unmanured plot at the end of these plots was selected for comparison. The following results were obtained:

TABLE 4.

Application of Barn-yard Manure to Corn.

No. Plot	Fertilizer Used.	Yield of Ear Corn per Acre in Bushels of 70 Pounds	Yield of Fodder per Acre in Pounds	Increased Yield of Corn per Acre in Bushels	Increased Yield of Fodder per Acre in Pounds
10	Manure	64.0	6,080	38.7	2,440
12	Manure	73.1	5,420	47.8	1,780
13	No Fertilizer	25.3	3,640	....	...

By comparing these results with those given in Table 1, it will be seen that the barn-yard manure produced an increase in yield slightly greater than was obtained on the plots which received 100 lbs. sulphate of potash per acre, but less than on the one receiving 160 lbs. per acre.

The effects of Copperas (Sulphate of Iron) on the Growth and Yield of Corn.

Some remarkable results have been reported from the use of copperas on crops. As to its real value as a fertilizer, either directly or indirectly, there is a difference of opinion. In order to study its effect on the growth and yield of corn on our soil, the following experiment was begun: Our soil is evidently well supplied with iron, and it was believed that if it had any effect it would be an indirect one, and not as a supplier of plant food. The experiment was made on two plots that had been enriched previously by barn-yard manure. The plots were 1-10 acre each in size. On one plot a complete fertilizer was applied before planting the corn, consisting of 30 pounds of acid phosphate, 15 pounds ammonia sulphate, and 10 pounds of sulphate of potash. Six pounds of copperas was mixed with dirt, so that the whole weighed 40 pounds, and the mixture applied in the hill when the corn was planted. The other plot received no fertilizer except the same amount of copperas applied in the same way. Adjoining these was a plot of corn receiving no fertilizer of any kind. The manner of planting and cultivation was the same as described in the preceding experiments. During the early growth of the corn, it was noticed that the corn had a much darker green appearance on the plots containing the copperas than on the other plot. In the latter part of the growing season no distinction could be observed.

The following results were obtained on the above plots:

TABLE 5.

Application of Copperas.

No. Plot	Fertilizer Used.	No. of Pounds of Fertilizer Applied per Acre	Yield of Ear Corn in Bushels of 70 Pounds per Acre	Yield of Fodder in Pounds per Acre . .
1	Potash Sulphate . . . . Ammonia Sulphate . . . . Acid Phosphate . . . . Copperas in hills	100 150 300 60	76	4,860
2	Copperas in hills	60	68	4,920
3	No Fertilizer	. . . .	73.1	5,420

Observing the results in the table, we are led to believe that the conditions which make the application of copperas of benfit were not present in our experiments.

The value of tobacco stems as a fertilizer on corn.

There are thousands of tons of tobacco stems wasted in Kentucky annually. It is stated that the stems are got rid of by dumping them into the rivers, or other waste places, or by burning. At one of the tobacco factories in Lexington, the Station is in the habit of sending every morning for the stems made the previous day, otherwise they would be taken to the engine-room and burned. It was to call the attention of the farmers of the State to this waste product that several experiments were planned to show the effect of tobacco stems as a fertilizer. We did not attempt to carry out many of the experiments last year, as we desired to become better acqauinted with the productiveness of our soil first, and to find what elements it really needed. Tobacco stems are valuable as a fertilizer for the nitrogen, and especially potash, which they contain. If it was found upon trial that the soil needed phosphoric acid, it would not be expected that tobacco stems would be of much benefit if applied alone, so that but one plot was given to this test on corn, more to show indications than conclusions. Unfortunately, the experiment was made on a plot near a pasture lot, where it was found out afterward that manure had been scattered. The second plot in this experiment, intended for comparison, received no fertilizer of any kind at our hands, but whether it had received the same treatment as to manure it is impossible to state.

It is certain, however, that the corn on the plot receiving the tobacco stems, during all periods of growth, had the finest appearance of any corn in the whole series of experiments.

The following table gives the yield of corn and fodder of the two plots, calculated per acre :

TABLE 6.
Application of Tobacco Stems.

Fertilizer Used.	Pounds Applied per Acre.	Yield of Ear Corn, Bushels, per Acre . .	Yield of Fodder in Pounds per Acre. .
Tobacco Stems	4,000	80.1	6,270
No Fertilizer	. . . .	47.6	3,940

The relation of fertilizers to shrinkage, and to the proportion of cob to kernel.

In all our previous calculations we have based our calculations on the weights of field-cured corn ; that is, the weight of corn as it was husked after curing in the shock. We did this because corn is marketed here in the ear, and is often sold before cribbing. At the time of husking we were offered 32 cents a bushel for the crop, and from this we had a basis for calculating profits by use of the fertilizers. It is evident, however, that the true value of corn for feeding purposes depends upon the dry matter it contains and the proportion of corn to cob. In studying the effects, then, of the various fertilizers, this question should be considered : What is the effect of fertilizers on shrinkage, and upon the yield of cured shelled corn ? In order to study this question, after the corn was husked from shock it was weighed and spread over the floor of the barn loft. This loft is well ventilated for the purpose. The corn from each plot was separated by appropriate partitions. It was put in the loft November 17, and on December 17 it was weighed and shelled, and samples taken to the laboratory for analysis. Moisture determinations of the laboratory samples showed that the corn was not as well cured as was expected, but in all probability the experiment was carried far enough to show any difference in shrinkage between the corn of the various plots. Tables 7 and 8 show the data obtained on this point, and also give the average weight of the ears from the different plots taken at this time:

TABLE 7.

Loss by Curing.

No. Plot	Fertilizer Used.	Average Weight of One Ear in Ounces.	Weight of Field Cured Corn in Pounds	Weight of Ear Corn after Curing	Per Cent. of Shrinkage
1	Unfertilized	5½	188	171.5	8.7
2	Acid Phosphate 30 Sulphate of Potash 10 Sulphate of Ammonia 15	8½	444	411	7.4
3	Acid Phosphate 30 Sulphate of Potash 10	9	489.5	443.5	9.1
4	Acid Phosphate 30 Sulphate of Ammonia 15	5¾	204	183.5	10
5	Sulphate of Potash 10 Sulphate of Ammonia 15	7½	422.5	388	8.1
16	Manure	8¾	512	418	18.3
19	Tobacco Stems 400	10¼	560.5	509.5	9

TABLE 8.

Proportion of Cob to Kernels, and Bushels Shelled Corn Per Acre.

No. Plot.	Fertilizer Used.	Weight of Shelled Corn in 70 Pounds Ear Corn.	Weight of Cobs in 70 Pounds Ear Corn.	Per Cent. of Cobs in Ear Corn.	Bushels Shelled Corn Per Acre.
1	No Fertilizer	55	15	21.4	24.1
2	Acid Phosphate . . . 30 lbs. Sulphate Potash . . . 10 lbs. Sulphate Ammonia . . . 15 lbs.	56	14	20	58.6
3	Acid Phosphate . . . 30 lbs. Sulphate Potash . . . 10 lbs.	55.5	14.5	20.7	62.8
4	Acid Phosphate . . . 30 lbs. Sulphate Ammonia . . . 15 lbs.	55	15	21.4	25.7
5	Sulphate Potash . . . 10 lbs. Sulphate Ammonia . . . 15 lbs.	55.5	14.5	20.7	54.7
16	Manure	55	15	21.4	58.6
19	Tobacco Stems . . . 400 lbs.	55.5	14.5	20.7	72.1

Does the application of fertilizers have any relation to the amount of phosphoric acid, nitrogen and potash taken up by the crop?

In the foregoing experiments an interesting question arises as to the amount of phosphoric acid, nitrogen and potash taken up by the corn crop on the various plots differently fertilized.

In order to determine this question as far as the harvested parts of the corn-plant are concerned—that is, all parts of the corn-plant except the roots and about four inches of the butt of the stalk—samples of fodder, kernel and cob were taken for analysis from plots 1 to 5 inclusive, in the first series of experiments, and from plots 16 and 19, which had received barn-yard manure and tobacco stems respectively. These samples were carefully selected in order to have average results.

In each plot there were three shocks of corn. For the fodder samples, stalks from each shock were selected that had lost none of their leaves or tassels or any part of them. Each sample thus taken, weighing from 25 to 35 pounds, was cut up in a feed mill, and taken directly to laboratory, where it was again weighed; after drying, a sub-sample of about 2 pounds was finely ground, and after standing about a day in the open air was bottled, and the analysis of the fodder made from this sample. One bushel (70 pounds) of the cured ear corn, sampled by selecting the number of ears to correspond to the weight, was shelled, and samples of the cobs and kernels taken for analysis after being ground.

Analyses of these samples were made, and from the results the following table was prepared, showing the amounts of potash, nitrogen and phosphoric acid contained in the crop from each plot, and also, for comparison, the amounts applied to each of the fertilized plots:

TABLE 9.

Fertilizing Elements Taken up by the Corn Crop.

No. Plot	Potash. Pounds Per Acre.		Phosphoric Acid. Pounds Per Acre.		Nitrogen. Pounds Per Acre.	
	Applied in the Fertilizer	Taken up in the Crop.	Applied in the Fertilizer	Taken up in the Crop	Applied in the Fertilizer	Taken up in the Crop.
1	None.	20.9	None.	23.7	None.	49.4
2	53.	36.8	44.	57.0	30.9	92.4
3	53.	36.7	44.	44.4	None.	83.7
4	None.	24.4	44.	35.3	30.9	38.3
5	53.	35.3	None.	43.4	30.9	93.9
16	.....	31.3	.....	41.5	.....	68.6
19	240.	52.8	40.	56.4	90.	112.3

From the results obtained it will be seen that in no instance was as much potash taken up in the crop as was applied in the fertilizer. This is true also in regard to phosphoric acid, except on plots 2 and 19, on which the crop contained more of this substance than was applied in the fertilizer. In the case of nitrogen, we find that in every instance the amount contained in the crop was greater than that applied to the plot. It is to be noted, however, that in the case of plot 4, *which received no potash*, the difference is but slight. No comparison can be made for plot 16, as we do not know the composition or amount of the barn-yard manure applied. These results give additional support to the conclusions already stated, that our soil is deficient in potash, but is capable of supplying enough phosphoric acid and nitrogen for the corn crop.

M. A. SCOVELL, Director,
A. M. PETER, Ass't Chemist.

BULLETIN No. 18.

1. Hemp Experiments.

It is a well known fact to those familiar with the crop, that hemp requires to be grown on rich land. The custom in Kentucky is to grow hemp only on new land—that is, land that has been in pasture—and preferably on woodland which has been in pasture for years. Worn land—or even land that is comparatively rich, but which has been in cultivation with other crops—is considered unsuitable for hemp-raising. Old land can not be "brought up" by applying fresh barn-yard manure; as, while a rank growth may be obtained, the fibre is generally coarse, and of an inferior quality.

The object of our experiments with hemp this year was to try whether hemp could be grown successfully on old ground by means of commercial fertilizers. Only a beginning at solving the problem was attempted. We were not prepared to undertake the work, except in a preliminary way at the time, as the Station farm was purchased only the fall previous, and a great amount of surveying and other preliminary work had to be done before it was available for experimental purposes. Nothing was known of the productiveness of the land or evenness of fertility. It was thought best to study the requirements of our land before using fertilizers extensively on it. In consequence, but seven-fortieths of an acre were given to the hemp experiments. The plots were adjacent to plots No. 1, Table I, and No. 1, Table II, of the corn experiments (Bulletin 17). On these last plots there were produced, respectively, 26.8 and 27.9 bushels of corn, without fertilizers, as may be seen by reference to Bulletin No. 17. This shows that the hemp experiments were made on well worn land.

The land used for the experiments is of the same character, and had received the same treatment previously, as the land on which the corn experiments were made, and is described in Bulletin No. 17, as follows :

"The soil is derived from the Lower Silurian limestones. These beds are fossiliferous, ranging in character from thin-bedded blue limestone, with rich phosphatic layers, to thick-bedded semi-crystalline grey limestone. The subsoil is a light-colored clay, so retentive as to make the soil deficient in natural drainage. The land has been in cultivation for a long time, the exact length being unknown. It was in hemp before the war. In 1863 it was in corn ; in '70 and '71 in wheat ; in meadow in '72 ; '79 in potatoes ; '81 in clover ; '82 in millet ; and '87 in rye. It is believed that no stable manure or other fertilizers were ever applied before the experiments."

The ground was plowed and harrowed about a week before planting. The hemp was sown April 22d. After the hemp was some six inches high, the various fertilizers were applied to four of the plots, leaving three unfertilized, as follows :

Plot 1.	No fertilizer.	
Plot 2.	Sulphate Potash	5 pounds.
	Sulphate Ammonia	7½ pounds.
	Acid Phosphate	15 pounds.
Plot 3.	Acid Phosphate	15 pounds.
	Sulphate Ammonia	7½ pounds.
Plot 4.	Sulphate Ammonia	7½ pounds.
	Sulphate Potash	5 pounds.
Plot 5.	No fertilizer.	
Plot 6.	Sulphate Ammonia	3¾ pounds.
	Sulphate Potash	2½ pounds.
	Acid Phosphate	7½ pounds.
	Sulphate Iron	3 pounds.
Plot 7.	No fertilizer.	

It was the intention to have the fertilizers applied just before planting, but unavoidable delay in receiving the various ingredients prevented the application of the fertilizers until after the hemp was up. It was then thought best not to have the fertilizers come in contact with the very young plants, and, therefore, the application was delayed until the hemp was well started. The plan was to apply the following mixture on plot No. 5, but through some misunderstanding it was not applied, viz:

Sulphate potash..............	5 pounds.
Acid phosphate...............	15 pounds.

It will be noticed that the fertilizers were so applied, except on plot No. 6, as to have in the series the various combinations of the leading elements of plant food. By comparison of yield and quality of fiber at the end of the experiment, this method would enable us to tell what effect nitrogen, potash and phosphoric acid, and their various combinations, would have on hemp on our soil. It is essential that this point be understood, and for this purpose I quote the explanations of Bulletin No. 17.

Explanations.—By the *leading elements of plant food* are meant, *nitrogen*, *phosphoric acid* and *potash*. Plants feed on other soil elements besides these, and they are just as essential to plant life as these three; but, generally speaking, all but these ingredients are furnished to plants in abundance, and, therefore, in studying what to put on our soils to make them more productive, we need concern ourselves with only these three. Commercial fertilizers are manufactured and sold for the purpose of supplying nitrogen, phosphoric acid and potash, and the market prices depend upon these ingredients. Some fertilizers contain one of these ingredients, some two and some all. Generally speaking, a commercial fertilizer is a mixture containing two of these ingredients and sometimes all; the proportions varying greatly in the various brands and often in the same brand. It is at once seen to be a very difficult, if not an impossible task, to test all the various brands sold on a given soil in order to find out those that produced the best effect. It is an easy matter, however, to find out whether a given soil needs potash, phosphoric acid or nitrogen, or any combination of these elements, for a given crop. Having found out this by experiment, we have only to look to the analysis of the various fertilizers to tell which brands, if any, could be used to advantage on the soil and crop tested. If the experiment proved that potash was all that was needed on a given soil for the corn crop, all those fertilizers whose analyses show little or no potash would not produce favorable results, under whatever name sold.

The fertilizers were applied broadcast, care being taken to have them distributed over their respective plots as evenly as possible. At the time the fertilizers were applied, the hemp appeared far from thrifty. The plants had a yellowish, sickly appearance, and the plots were foul with weeds. A few days thereafter, the leaves on the hemp of plots 2, 3, 4 and 6 were noticed to be considerably scorched by the fertilizers. It was thought at the time that the fertilizers would injure the hemp on these plots, but when inspected about two weeks thereafter, no injury could be noticed by use of the fertilizers, and the hemp on plots 2 and 4 showed a marked change. The hemp was at least an inch higher than that on the other plots, and it had a thrifty appearance, while no change could be noticed on the other plots. This same difference appeared throughout the growth of the hemp. When cut, the hemp was shocked, making one shock of each plot. Photographs were then taken. All photographs were taken exactly at the same distance from the shocks. The photographs were grouped and an electroplate made and prints taken. These prints are inserted on the following page, to show the marked difference in the growth of hemp on the various plots caused by the use of fertilizers.

As will be seen, plots 2 and 4 show to a great advantage.

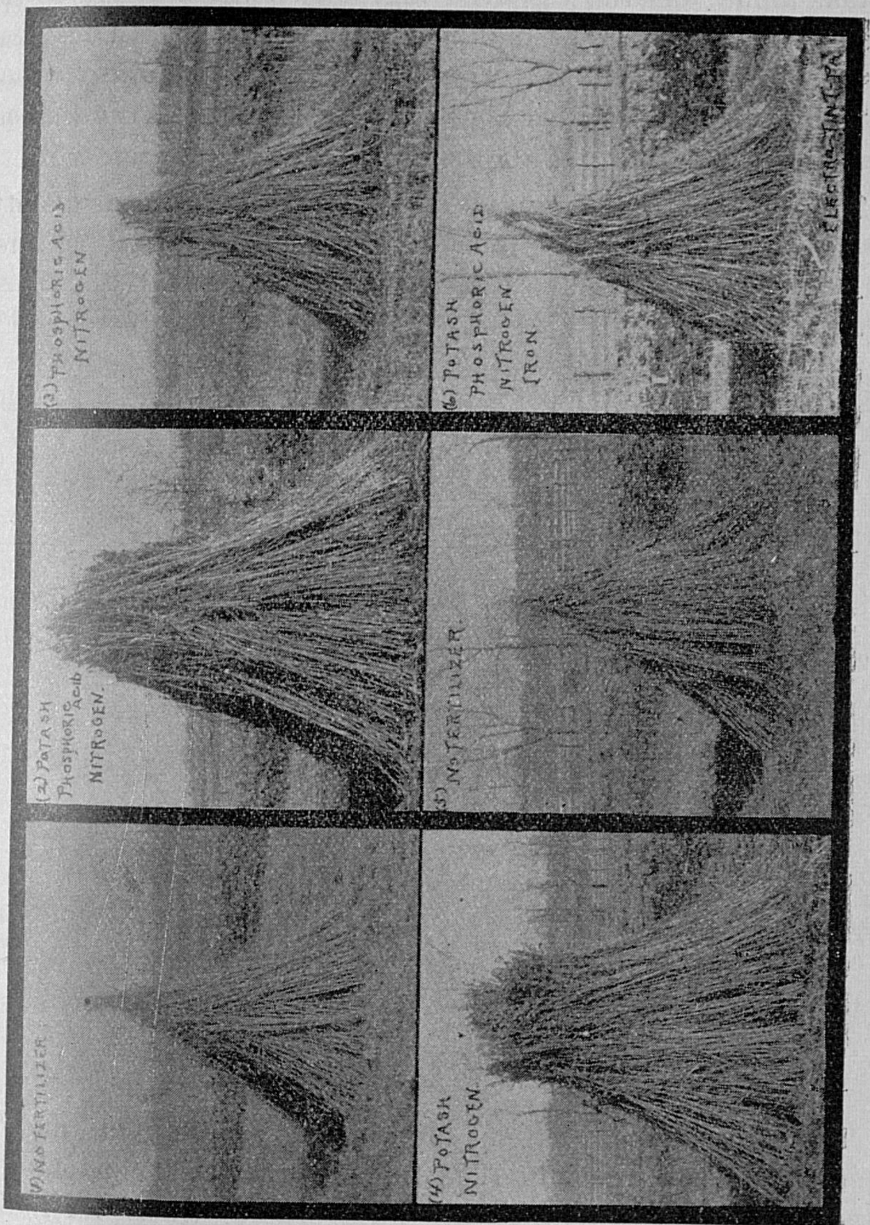
As to growth, it will be observed:

1. That the growth of hemp on plot 4, where potash and nitrogen, in the form of sulphate of ammonia, were the fertilizer ingredients used, was about equal to that on plot 2, where phosphoric acid was also used. This would indicate that phosphoric acid is not an essential ingredient of a hemp fertilizer on our soil.

2. That no marked increase in the growth of hemp followed from the use of phosphoric acid and nitrogen, without potash.

This would indicate that nitrogen, in the form of sulphate of ammonia, alone did not materially increase the yield of hemp.

3. It follows that potash was an essential ingredient of the



FROM PHOTOGRAPHS SHOWING THE EFFECT OF FERTILIZERS ON HEMP.

fertilizers which produced the marked increased growth of hemp. Whether it made this marked growth without the aid of nitrogen it is impossible to state. If the fertilizer had been applied as planned to plot 5, and the growth had been as marked as that of plot 4, then it would have indicated that potash alone was the essential ingredient which produced the increased growth. On the other hand, if the growth had been less than that of plot 4, it would have shown that nitrogen and potash both were needed for hemp on our soil. We will endeavor to find this out the coming year.

The following table gives the yield of fiber and its quality, as grown on the various plots. The yield is calculated per acre:

No. Plot.	Fertilizer Used.	Amount Fertilizer Per Plot.	Yield of Fiber—Pounds.	Quality.
1	No Fertilizer	....	310	Trashy, rough, short.
2	Sulphate Potash Sulphate Ammonia Acid Phosphate	5 7½ 15	550	Fair quality.
3	Acid Phosphate Sulphate Ammonia	15 7¾	210	Rough and short.
4	Sulphate Potash Sulphate Ammonia	5 7½	590	Good—not first-class.
5	No Fertilizer	....	150	Trashy.
6	Sulphate Ammonia Sulphate Potash Acid Phosphate Sulphate Iron	3¾ 2½ 7½ 3	370	Little better than trash.
7	No Fertilizer	....	190	Trashy.

The yield was not satisfactory on any of the plots, and the quality is very inferior. The inferior quality is undoubtedly due, to a great extent, to the unfavorable winter for rotting hemp, and to our being unable to stack such small quantities. The hemp was not "broke" until April.

The experiments will be continued, as no general conclusion can be reached from the results obtained so far.

2. *Notes on the Treatment of an Old Apple Orchard.*

The apple orchard on the Experiment Station farm was in very poor condition. Many of the trees were old, and full of suckers and dead limbs; the trunks were rough; the tops were almost matted with branches, and many of the branches were so low as to prevent proper cultivation. The situation was on a very wet, thin, clay soil, which had been seeded to English blue-grass (*Festuca Pratensis*). So far as known, the orchard had been an entire failure heretofore, so far as apples were concerned. Sometimes the trees fruited heavily; but the apples dropped prematurely, and were said to be always very wormy. This falling of the apples was supposed to be from the ravages of the codling moth. This pest has about destroyed successful apple culture in this locality. It was concluded to make an attempt to see what could be done with the orchard by proper training, fertilizing and cultivation, and to attempt to destroy the codling moth with London purple. Accordingly, all dead limbs and suckers were removed, and the tops of the trees were trimmed considerably, though not to such an extent as to allow the main branches to be exposed too much to the sun. Tobacco stems were placed around the trees and the ground was plowed. Where the plow could not reach the ground was spaded.

After the blossoms had fallen, and the young apples were just beginning to turn over on the stem, the trees were sprayed with a mixture of London purple and water. The spraying was too late for the best results, as the young apples should all be standing flower end up when the trees are sprayed, in order that the poison may lodge in the depression in the blossom end before the apple turns down on its stem.

The spraying was done as follows: Four ounces of London purple were mixed to a thick paste in water; this mixture was put into a barrel holding about 40 gallons; then the barrel was filled with water; a spraying pump, manufactured by the Field Force Pump Co., Lockport, N. Y., was attached to the barrel, and by means of the pump the contents of the barrel were thrown on the trees in the form of a fine spray. This pump has two outlets. On one outlet a hose and nozzle were attached, through which the liquid was sprayed, while to the other outlet a hose about the length of the barrel was attached and conveyed down into the barrel, so that whenever the pump was working, the liquid forced through this tube kept the contents of the barrel constantly stirred; this prevented the London purple from settling to the bottom.

In operating the spraying outfit, we mounted it in a cart. The cart was driven to the windward side of the tree, and as one man pumped, another held the nozzle in such a manner as to cause the spray to go just above the tree and fall down on the leaves. This was continued until the water just began to drop from the leaves, when the pump was stopped. In like manner each tree was treated in turn.

Most of the trees in the orchard bore fruit. Many of the trees were loaded down. Very few of the apples dropped prematurely. Of those that did, but few were wormy. In one instance, one hundred of the fallen apples were cut in two, and fourteen were found to be wormy. At another time, fifty Jennetings were cut in two, and nine were found wormy. Another trial of all the varieties was made, and the per cent. of wormy apples found on the ground ranged from five to thirty.

Of the apples on the trees, but very few could be found which had been attacked by the codling moth. It was rare to find a wormy apple, while in neighboring orchards, in most instances, it was as rare to find a sound apple. Spraying our trees undoubtedly prevented the codling moth from attacking our apples and destroying the crop.

The method of spraying with arsenites to prevent the depredations of the codling moth, or apple worm, is not new. It has been practiced successfully for years. To show the success others have had in this line, I quote from Bulletin No. 3 of the Ohio Agricultural Experiment Station, the following:

SOME PRACTICAL EXPERIENCE.

To convince the fruit-growers of Ohio that this remedy is a practical one for use by practical men, I present below the experience of some of the prominent fruit-growers who have tried it.

A. C. Hammond, Esq., Secretary of the Illinois State Horticultural Society, a fruit-grower of long experience in one of the largest fruit regions in the west, in a recent letter to me says:

"I have been experimenting with liquid poisons in the orchard this season with wonderful success. I have just been gathering the apples from an orchard which was sprayed twice with London purple, and have between 400 and 500 bushels of high-colored, perfect fruit. And if all the perfect apples within ten miles of me were collected, they would not make as many bushels as this orchard, which seems plainly to indicate that there can be no other cause for my success."

A Michigan correspondent of the *Farmers' Review* (April 6, 1887) says:

"* * * We sprayed at the time when the fruit was the size of peas, no larger, and it was emphatically the thing. The yield was immense of good sound fruit, and bushels of apples with never a worm. It seemed miraculous. I advise every one who owns an apple tree to spray it with a solution of Paris green."

An Ohio correspondent of the *Ohio Farmer* writes:

"Being fully convinced of the necessity of combating insects injurious to the apple last spring, such as codling moths and canker worms, I procured a Little Giant Atomizer with Climax nozzle and went to work. This machine is nicely mounted upon three wheels, and the tank holds about 40 gallons of water, so it may be drawn about by hand or placed in a wagon box, and one or two horses used. I used London purple instead of Paris green on most of the orchard, as it is lighter and remains in suspension in the water much better than the green, and answers every purpose. I used three-fourths of a pound to a tank full of water (40 gallons), which I found to answer the purpose very well. Where the canker worm was very bad I used one pound. I used the atomizer in a wagon, as I could do my work much more quickly this way. Myself and assistant sprayed 200 very large trees in three-quarters of a day in this way."

"I only applied the poison once (11th of May), but the good effect was very noticeable all summer, and especially in the fall; for while my crop of apples was not as large as it would have been if I had sprayed them earlier and oftener, the apples were very fine and perfect in appearance, not being stung by insects, causing hard lumps or wormy and rotten. I took ten premiums at the State Fair last fall, while my neighbors had no apples worth mentioning. I attribute my success wholly to the use of the poison before mentioned, and believe that this is a sure way, as far as insects are concerned, to raise a good crop after they have once formed upon the tree."

Professor E. A. Popenoe, of the Kansas Agricultural College, writes:

"The bearing trees throughout [the college orchard] were sprayed in spring with London purple, and were afterwards banded to test again the value of this treatment in reducing the number of the codling moth larvæ and wormy apples. The result confirmed the conclusions drawn from our previous tests in the same line, that over seventy-five per cent. of the crop is thus saved from this insect."

Mr. Frank Dill, of Franklin county, Ohio, has sprayed, under the direction of this Station, an orchard of some twenty-five acres for the last two years, and informs me that he has thus been very successful in raising fine, sound fruit, which competes successfully with New York apples in the Columbus market. Mr. A. J. Gantz, of the same county, has also sprayed his orchard, at the advice of this Station, and reports similar gratifying results.

And, finally, of the many other similar experiences at our command, we have only space to mention the conclusive experiments made in Illinois by Professor S. A. Forbes, covering a period of two years, in which nearly 40,000 apples were examined separately, the result arrived at being that "at least seventy per cent. of the loss commonly suffered by the fruit-grower from the ravages of the codling moth, or apple worm, may be prevented at a nominal expense, or practically, in the long run, at no expense at all, by thoroughly applying Paris green in a spray with water once or twice, early in spring, as soon as the fruit is fairly set, and not so late as the time when the growing apple turns downward on the stem.

BULLETIN No. 19.

Experiments in Pig Feeding.

J. H. CONNELL.

The live stock interest of this State is one of such prime importance that the work of the Station must largely tend toward questions of interest to owners of stock. The experiments here given are upon a prominent branch of the stock industry, and the simple questions treated are of practical utility to the owners and breeders of swine.

It is very generally believed that our hogs are so artificial now that healthy animals cannot be found in the improved breeds, and that this weakening of constitution is due to the continued use of corn as a hog food, since it is too rich in the fat-forming elements, and lacking in muscle (lean) and bone-producing materials. But since hogs are grown to be fattened, corn must be the food used for this purpose. The constitution of breeding sows, and of pigs before fattening, may be kept strong by feeding foods containing large amounts of proteins, such as green clover, buttermilk, skim milk, shipstuff (shorts), bran, beans, peavines, turnips, etc. (See table of Digestive Nutrients.) If such foods are given to breeding animals it will have great effect in producing strong, healthy offspring.

The objects of the experiments which are detailed in the following pages were: 1st, to test the relative values of our most common hog feeds—shelled corn and corn meal—in the cost of pork per pound; and also to try corn-cob meal thoroughly, to find whether or not it was as profitable for fattening as the two foods first mentioned. 2d, to find the various lengths of time that these feeds would produce pork at a paying figure. The compound foods were fed in order to find a feeding ration which would not fatten but keep the hog in good condition for development and growth, and to prove the weakening effects of fattening foods (corn and its products) upon the bone and muscle—and therefore upon the entire system. As our facilities were limited at the time the experiments were begun, we have not attempted trials of cooked and uncooked foods, but have dealt with simple and compound rations of uncooked feed. Photographs of cross-sections were not taken, because the feeds were crossed on the several lots in such a way as to disturb, at the close of the trial, the effect of foods as shown in fat and lean meat.

For two months preceding the beginning of the experiment, all of the pigs were fed on kitchen slops, thus giving an even condition to all. In the first three pens were six Chester Whites, two in each. In pens Nos. 4 and 5 were five "Thin Rinds" and one "Red Berkshire"—all mixed breeds. The pens were built of boards each 8x16 feet, with two partitions, making two apartments 4x8 feet each, and one 8x8. The larger was the one in which exercise was taken, and the two smaller were used for feeding and sleeping rooms. All were floored with plank, and the sleeping pen was covered to protect from snow and rain. All conditions were the same in similar systems of foods, and all points of interest noted. The meal in all cases was fed dry, so that it necessitated chewing before swallowing, thus avoiding the indigestion which might follow from the entrance of the meal into the stomach in a dry state. Accurate weights of foods used were taken, and the hogs of each pen were fed all that they would eat up clean. All weights given are live weights, and calculations on feeding at paying or losing rates are made, rating pork at 5 cents per pound on foot.

Experiments With Simple Feeds.

FIRST SERIES.

Feeding was begun on January 21st, '89, with six Chester Whites of almost uniform size and style. Two pigs were placed in each pen and arranged with reference to size, so that the total weight of each pen was about the same as that of any other. No. 1, 204 lbs.; No. 2, 199 lbs.; No. 3, 199 lbs. Since these six pigs were of one breed and of average size, any variation in the amount of flesh laid on each can be attributed to the various feeds used: No. 1, corn cob meal; No. 2, corn meal; No. 3, shelled corn. This experiment was conducted to learn the relative feeding values of the three feeds mentioned, and the cost of pork per pound of each.

AMOUNTS OF FEED CONSUMED AND PROPORTIONAL GAINS.

Pen No. 1:	Total weight January 21st	204 pounds.
	" " March 25th	323 pounds.
	Total gain in 63 days	119 pounds.
	Total amount corn cob meal eaten	892 pounds.

Gain of 58 per cent. on the original weight of January 21st, at a cost of 5.2c per pound.

Average amount of feed consumed per week, 99½ lbs. Actual weight of feed consumed one week, 94 lbs.; average gain of pigs per week, 13.2 pounds.

Pig No. 1 gained 1 pound on every 9.3 pounds of corn cob meal eaten; Pig No. 2 gained 1 pound on every 6.3 pounds of same feed; average for pen, 1 pound of flesh to 7.5 pounds corn cob meal.

Pen No. 2: Total weight January 21st ....199 pounds.
" " March 25th..............374 pounds.
Total gain in 63 days..................175 pounds.
Total amount of corn meal eaten ......753 pounds.

Gain of 88 per cent. on the original weight of January 21st, at a cost of 4.4c per pound.

Average amount of feed consumed per week, 84 pounds; actual weight of feed consumed one week, 82 pounds; average gain of pigs per week, 19.5 pounds.

Pig No. 1 gained one pound on every 3.6 pounds corn meal eaten; No. 2 gained 1 pound on every 5.3 pounds of same feed. Average for pen, 1 pound of flesh to 4.3 pounds of corn meal.

Pen No. 3: Total weight January 21st ....199 pounds.
" " March 25th..............381 pounds.
Total gain in 63 days ....182 pounds.
Total amount shelled corn eaten ......780 pounds.

Gain of 92 per cent. on the original weight of January 21st, at a cost of 2.6c per pound.

Average amount of feed consumed per week, 86.5 pounds; actual weight of feed eaten one week, 76 pounds; average gain of pigs per week, 20.2 pounds.

Pig No. 1 gained 1 pound on every 3.9 pounds of corn eaten; No. 2 gained 1 pound on every 4.7 pounds of same feed; average for pen, 1 pound of flesh to 4.3 pounds shelled corn.

Description.—Pen No. 1. Pig 1, a white barrow of good length, with small ear and thin body. Pig 2, long, compact sow, with small ear.

Pen No. 2. Both large compact sows, with small ears.

Pen No. 3. No. 1, large barrow. No. 2, smaller sow. Both short and compactly built, with small ears.

Results.—Shelled corn caused the greatest per cent. of gain on original weight (92 per cent.); corn-meal was second in effect (87 per cent.); and corn-cob meal, which was intended for a flesh, rather than a fat-producer, made a gain of 58 per cent. per pound. The pork raised on corn was the cheaper, while that raised on corn-cob meal was more expensive.

From January 21st to March 11th, Pen No. 1 was fed a paying ration, after which they were fed at a loss. Pen No. 2 fattened sufficiently to pay for all feed eaten. Pen No. 3 was fed profitably 63 days.

TABLE 1.—SIMPLE FEEDS TO HOGS IN THREE PENS.

(1), Corn Cob Meal.

PEN (1), CORN COB MEAL.

Dates.	Weight and Gain of Pigs.				Total Weight.	Total Gains.
	Wt. No. 1.	Gain.	Wt. No. 2.	Gain.		
Jan. 21	90	. . . . .	114	. . . .	204	. . . .
" 28	96½	6½	121	7	217½	13½
Feb. 4	102½	6	130	9	232½	15
" 11	107	4½	134½	4½	241½	9
" 18	114½	7½	147	12½	261½	20
" 25	123	8½	153½	6½	276½	15
Mar. 4	129	6	161½	8	290½	14
" 11	135	6	171	9½	306	15½
" 18	136	1	179	8	315	9
" 25	138	2	185	6	323	8
Totals.	No. 1 gained, 48.		No. 2 gained, 71.		Pen gained, 119.	

(2), Corn Meal.

PEN (2), CORN MEAL.

Dates.	Weight and Gain of Pigs.				Total Weight.	Total Gains.
	Wt. No. 1.	Gain.	Wt. No. 2.	Gain.		
Jan. 21	109	. . . . .	90	. . . . .	199	. . . .
" 28	120	11	100½	10½	220½	21½
Feb. 4	138½	18½	107	6½	245½	25
" 11	151½	13	114½	7½	266	20½
" 18	165½	14	121	6½	286½	20½
" 25	172	6½	132	11	304	17½
Mar. 4	183½	11½	137½	5½	321	17
" 11	192	8½	145	7½	337	16
" 18	201½	9½	148	3	349½	12½
" 25	214	12½	160	12	374	24½
Totals.	No. 1 gained, 105.		No. 2 gained, 70.		Pen gained, 175.	

TABLE 1.—Continued.

(3), Shelled Corn.

PEN (3), SHELLED CORN.

Dates.	Weight and Gain of Pigs.				Total Weight.	Total Gains.
	Wt. No. 1.	Gain.	Wt. No. 2.	Gain.		
Jan. 21	110	. . . . .	89	. . . . .	199	. . . .
" 28	125½	15½	100½	11½	226	27
Feb. 4	138	12½	110	9½	248	22
" 11	149	11	122	12	271	23
" 18	162	13	132½	10½	294½	23½
" 25	174½	12½	143	10½	317½	23
Mar. 4	184½	10	150	7	334½	17
" 11	190	5½	152	2	342	7½
" 18	198	8	162	10	360	18
" 25	209½	11½	171½	9½	381	21
Totals.	No. 1 gained, 99½.		No. 2 gained, 82½.		Pen gained, 182.	

Experiments with Simple Feeds.

SECOND SERIES.

After having used corn-meal and shelled corn for feeding Pen No. 2 and Pen No. 3 for 63 days, it was thought best, as a further test of the feeds, to try other hogs with them. For this purpose the pigs of Pen No. 4, which had before been fed on corn-cob meal in a compound feed test, were given shelled corn. Pen No. 5, which had previously been fed a compound ration, as noted in "Table No. 3," was given corn-meal, feeding beginning with Pen No. 4, March 25th; first weights April 1st. Pen No. 5, March 18th; first weights March 25th.

AMOUNTS OF FEED CONSUMED AND PROPORTIONAL GAINS.

Pen No. 4; Total weight March 25th, 586½ pounds.
" " April 15th, 651½ "
Total gain in 21 days, 65 "
Total amount shelled corn eaten, 357 "

Gain of 11 per cent. on the original weight of March 25th, at a cost of 3.3c per pound.

Average amount of feed consumed per week, 119 pounds.
Average gain of pigs per week, 22 pounds.

Pig No. 1 gained 1 pound for every $4\frac{1}{2}$ pounds of shelled corn eaten. Pig No. 2 gained 1 pound for every 4 pounds of same feed. Pig No. 3, 1 pound on 8.4 of corn. Average for Pen, 1 pound of flesh to 5.5 pounds shelled corn.

Pen No. 5:	Total weight March 18,	448	pounds.
	" " April 15,	561	"
	Total gain in 28 days,	113	"
	Total amount of corn-meal eaten,	286	"

Gain of 25 per cent. on the original weight of March 18th, at a cost of 2.5c per pound.

Average amount of feed consumed per week, 71.5 pounds.

Average gain of pigs per week, 28.25 pounds.

Pig No. 1 gained 1 pound for every 2.1 pounds of corn-meal eaten. Pig No. 2 gained 1 pound for every 1.5 pounds. Pig No. 3 gained 1 pound for every 3.9 pounds of same feed. Average for Pen, 1 pound of flesh to 2.5 pounds corn-meal.

DESCRIPTION.—The three pigs in No. 4 were Thin Rinds. No. 1, large black and white sow of good length, a little leggy, with large hanging ear. No. 2, large black and white list, about same as No. 1. No. 3, small black and white list, fair length, leggy.

Pen No. 5 was occupied by two Thin Rinds and a Red Berkshire. No. 1, large black and white, medium-eared barrow, with short, compact body. No. 2, long, leggy, lean barrow, with large ear, slightly red. No. 3, red barrow of fair length and small ear.

RESULTS.—Here shelled corn only produced a gain of 11 per cent. on the original weight, while that of corn meal was 25 per cent. However, the corn was fed one week less than the meal, and the pen to which the meal was given had not fattened before in the same ratio as that to which the corn was fed, gaining only 12 per cent. in 70 days, while the other pen made a rapid gain of 41 per cent. on original weight; see Table 3. Had not one of the pigs fed on meal been in such poor condition, the gain would have been much greater than 25 per cent., thus showing how radical was the change when the feed was changed on March 18th from a narrow to a much wider ration. Pen No. 5 made pork during this test much cheaper than did No. 4; but taking the entire series into consideration from January 21st to April 15th, No. 4 was fed the most economical feed.

TABLE 2.

Simple Feeds to Hogs in Two Pens; Second Series: (4) Shelled Corn; (5) Corn Meal.

PEN (4), SHELLED CORN.

Dates.	Weight and Gain of Pigs.						Total weight.	Total gains.
	Weight No. 1.		Weight No. 2.		Weight No. 3.			
March 18 . . .	217	gain	192	gain	166	gain	575	. . .
*March 25 . . .	219	2	196½	4½	171	5	586½	11½
April 1 . . .	230½	11½	210	13½	175	4	615½	29
April 8 . . .	234	3½	223	13	178	3	635	19½
April 15 . . .	245	11	226	3	180½	2½	651½	16½
Total gains. .	No. 1 gained	28	No. 2 gained	34	No 3. gained	14½	Pen gained	76½

PEN (5), CORN MEAL.

Dates.	Weight No. 1.		Weight No. 2.		Weight No. 3.		Total weight.	Total gains.
March 18 . . .	120	gain	161	gain	167	gain	448	. . .
*March 25 . . .	139	19	186	25	180½	13½	505½	57½
April 1 . . .	148	9	203	17	172	†8½	523	17½
April 8 . . .	163	15	218	15	170	†2	551	28
April 15 . . .	164	1	221	3	176	6	561	10
Total gains. .	No. 1 gained	44	No. 2 gained	60	No. 3 gained	9	Pen gained	113

* For seven days fed corn-cob meal; gain of entire pen, 11½ pounds.
† Loss.

Experiments with Compound Feeds.

FIRST SERIES.

Feeding was begun Jan. 21st, with the five Thin Rinds and one Red Berkshire in Pens Nos. 4 and 5, which were afterward fed simple rations, as shown in Table 2. The object was to find a feed that would tend to produce more of lean meat and growth than fat. For this purpose Pen No. 4 was fed corn-cob meal (considered a simple ration), and Pen No. 5 was given corn-cob meal and cotton seed in the proportion of 2 to 1. At the end of one week the feed was changed by adding wheat bran to the ration, since there was a total gain of 7½ pounds, and a loss in the case of pig No. 2. The ration 1 of cotton seed meal, 1 of wheat bran and 2 of corn-cob meal was given for 28 days, when shipstuff was substituted for cotton seed meal, because little of the meal was eaten at any time, it being pushed out of the trough and trod on—whether fed wet or dry. The bran was not relished, but the shipstuff was fairly well eaten at all times. As near as possible the cracked grains of corn were picked from the cob by the pigs and all other parts refused.

AMOUNTS OF FEED CONSUMED AND PROPORTIONAL GAINS OR LOSSES.

Pen No. 1:	Total weight January 21st	405½ pounds.
	" " March 18th	575 pounds.
	Total gain in 56 days	169½ pounds.
	Total amount corn-cob meal eaten	1,041 pounds.

Gain of 41.8 per cent. on original weight of January 21st, at a cost of 4.2c per pound.

Average amount of feed consumed per week, 130 pounds; actual weight of feed eaten in one week, 134 pounds.

Average gain of pigs per week, 21 pounds.

Pig No. 1 gained 1 pound for every 5.1 pounds of corn-cob meal eaten. Pig No. 2 gained 1 pound for every 6 pounds eaten. Pig No. 3 gained 1 pound for every 7.7 pounds of same food. Average for pen, 1 pound of flesh to every 6.1 pounds of corn-cob meal.

Pen No. 5:	Total weight January 21st	$398\frac{1}{2}$	pounds.
A	" " January 28th	406	pounds.
	Total gain in 7 days	$7\frac{1}{2}$	pounds.
	Total amount corn-cob meal eaten	55	pounds.
	Total amount cotton seed meal eaten	98	pounds.

Gain of 1.8 per cent. in 7 days, at a cost of 19.4c per pound.

B	Total weight January 28th	406	pounds.
	" " February 25th	$452\frac{1}{2}$	pounds.
	Total gain in 28 days	$46\frac{1}{2}$	pounds.
	Total amount corn-cob meal eaten	225	pounds.
	Total amount cotton seed meal eaten	113	pounds.
	Total amount wheat bran eaten	113	pounds.

Gain of 11.4 per cent. on original weight of January 28th, in 28 days, at a cost of 13.7c per pound.

Average gain of pigs per week, 11.5 pounds.

C	Total weight February 25th	$452\frac{1}{2}$	pounds.
	" " March 18th	448	pounds.
	Total loss in 21 days	$4\frac{1}{2}$	pounds.

Loss of 1.0 per ceut. on all original weights of February 25th, in 21 days. Cost of food for 21 days, $2.60.

For description, see that of pigs in Table No. 2, Pens 4 and 5, which were afterward fed simple feeds.

Results.—It was determined that with us, cotton seed meal could not be fed profitably to hogs, either for growth or fat, and that corn-cob meal was largely wasted in feeding. It was also evident that the pigs fed on a narrow ration were much the hardier, developing bone and muscle instead of fat. So much was this the case, that those fed on the mixed ration in Pen No. 5, when turned out, seriously injured those of pens No. 1 and 3 (fed corn-cob meal and corn), so that they were killed to use the flesh. Though the pigs in Pen 4 were not in such good condition at any time as those in other pens, yet they were so strong and vigorous when taken from the feed that they fattened rapidly, except No. 3. No accidents occurred to the hogs in Pen 5, while those in Pen 2, fed corn-meal, broke themselves down in the loins while being weighed, so that it was necessary to kill them. Pens Nos. 1 and 3 were afterward injured to a similar extent, the flesh about the loins and hams being bruised and bloodshot.

TABLE 3.

Compound Feeds to Hogs in two Pens; First Series: No. 4, Corn-cob Meal; No. 5, Corn-cob Meal and Cotton Seed Meal—Wheat Bran—Shipstuff.

PEN (4) CORN-COB MEAL.

Dates.	Weight and Gain of Pigs.						Total weight.	Total gains.
	Weight No. 1.		Weight No. 2.		Weight No. 3.			
Jan. 21 . . .	149½	gain	135	gain	121	gain	405½	. . .
Jan. 28 . . .	157	7½	142½	7½	121	. . .	420½	15
Feb. 4 . . .	165½	8½	147½	5	130	9	443	22½
Feb. 11 . . .	174	8½	154	6½	137½	7½	465½	22½
Feb. 18 . . .	184½	10½	162½	8½	142½	5	489½	24
Feb. 25 . . .	193	8½	172	9½	150½	8	515½	26
March 4 . . .	201½	8½	178	6	158	7½	537½	22
March 11 . . .	209	7½	185	7	165	7	559	21½
March 18 . . .	217	8	192	7	171	6	580	21
Total gains . .	No. 1 gained	67½	No. 2 gained	57	No. 3 gained.	50	Pen gained	174½

PEN (5)—CORN-COB MEAL AND COTTON SEED MEAL—WHEAT BRAN—SHIPSTUFF.

Jan. 21 . .	110½	gain	149	gain	139	gain	398½	. . .
Jan. 28 . . .	*118	7½	148½	—½	139½	½	406	7½
Feb. 4 . . .	†120	2	158	9½	148½	9	426½	20½
Feb. 11 . . .	†125	5	154	—4	160½	12	439½	13
Feb. 18 . . .	†124	—1	154	. . .	161	½	439	—½
Feb. 25 . . .	†126½	2½	161½	7½	164½	3½	452½	13½
March 4 . . .	§125½	—1	161½	. . .	156½	—8	443½	—9
March 11 . . .	§124	—1½	164½	3	170½	14	459	15½
March 18 . . .	§120	—4	161	—3½	167	—3½	448	—11
Total gains. .	No. 1 gained	9½	No. 2 gained	12	No. 3 gained	28	Pen gained	49½

* For 7 days—fed 90 pounds cotton seed meal and 55 pounds corn-cob meal. Gain 7½ pounds, 12 per cent.

† For 28 days—fed 113 pounds cotton seed meal, 22 pounds corn-cob meal, and 113 pounds wheat bran. Gain 26 pounds.

§ For 21 days—fed 78 pounds cotton seed meal, 156 pounds corn-cob meal, and 78 pounds shipstuff; loss 45 pounds.

Experiments With Compound Feeds.

SECOND SERIES.

As a further test of a compound feed, forming a narrow ration, it was thought best to try two other lots of hogs than those before used for experiment, and to continue to feed the corn-cob meal to one lot, and to add a second feed to increase the albuminoids for the ration of the second lot fed. To Pen No. 1 (which had been fed on corn-cob meal alone, gaining 13.2 pounds per week), was fed corn-cob meal and shipstuff in equal parts. Pen No. 3 (which had before been fed on corn meal, gaining 19.5 pounds per week), was fed corn-cob meal. Feeding began April 1st, after the close of the trial with simple feeds.

Pen No. 1: Total weight April 1st .... 335 pounds.
" " April 15th .... 352½ pounds.
Total gain in 15 days .... 17½ pounds.
Total amount corn-cob meal eaten.... 80 pounds.
Total amount shipstuff eaten.......... 80 pounds.

Gain of 5.2 per cent. on original weight of April 1st, at a cost of 6.5c per pound.

Average gain of pigs per week, 9 pounds.

Pen No. 3: Total weight April 1st .... 387 pounds.
" " April 15th .... 409 pounds.
Total gain in 15 days .... 22 pounds.
Total amount corn-cob meal eaten..... 281 pounds.

Gain of 5.7 per cent. on original weight of April 1st, at a cost of 8.9c per pound.

Average amount of feed consumed per week, 140 pounds.

Average gain of pigs per week, 11 pounds.

Pig No. 1 gained 1 pound on every 12 pounds of corn-cob meal eaten; Pig No. 2, 1 pound on every 13 pounds of same food. Average for Pen, 1 pound of flesh to 12.7 pounds corn-cob meal.

For description, see Pens Nos. 1 and 3 of Table 1, Chester Whites.

RESULTS.—In Pen No. 1, when the mixed ration was given (the pigs which had been fed corn-cob meal for 63 days), we find that the live weight increases steadily after the fat-forming food has ceased to be fed, thus suggesting an addition of lean meat to the fat carcass. The first week's feed made a gain of 12 pounds; the second only 5½. This may be owing, solely, to the change of feed. In Pen No. 3, we see that corn-cob meal still continues to fatten more readily than the mixed food, although fed to the fattest of the two lots, showing 11 to 9 pounds per week in favor of the meal.

TABLE 4.

Compound Feed to Hogs in Two Pens; Second Series: (1) Corn-cob Meal and Shipstuff; (2) *Blank; (3) Corn-cob Meal.

PEN 1—CORN-COB MEAL AND SHIPSTUFF.

Dates.	Weight and Gain of Pigs.				Total Weight.	Total Gains.
	Weight No. 1.		Weight No. 2.			
April 1.	144	gain	191	gain	335	....
April 8.	147	3	200	9	347	12
April 15	151	4	201½	1½	352½	5½
Totals.	No. 1 gained 7.		No. 2 gained 10½.		Pen gained 17½.	

PEN 3.—CORN-COB MEAL.

Dates.	Weight No. 1.		Weight No. 2.		Total Weight.	Total Gains.
April 1.	213	gain	174	gain	387	....
April 8.	221	8	181	7	402	15
April 15.	224½	3½	184½	3½	409	7
Totals.	No. 1 gained 11½.		No. 2 gained 10½.		Pen gained 22.	

*Pen No. 2 has no record after April 1, owing to being disabled in weighing, and out of condition.

What the Experiments Show.

In general results, our work shows many of the facts which have been proven from time to time by the various Experiment

Stations in different States, and with but one exception we find the different values of feeds relatively the same. Corn meal did not fatten so well, in the trial here given, as shelled corn. The nitrogenous food produced less flesh but more hardy development than did the non-nitrogenous feeds, as was the case in similar experiments at other stations.

Although our work did not enter into the minute scientific details, followed by other experiments, we may notice the following practical facts from the experiments concerning the feeds used:

1. Shelled corn produces fat more rapidly than other feeds tested.
2. Corn produces fat at a cheaper rate than other feeds tested.
3. Shelled corn produced pork at a profit for 63 days.
   Corn meal produced pork at a profit for 63 days.
   Corn-cob meal produced pork at a profit for 54 days.
4. Indications show that the Chester Whites in Pen No. 1, of Table 1, fattened more rapidly than the Thin Rinds in Pen No. 4, of Table 3, on the same quality of food.
5. The nitrogenous foods produced so little gain in live weight, that it may be attributed to growth and not fattening.
6. We could not feed cotton-seed meal profitably.
7. Much corn-cob meal was wasted in feeding, because picked over and refused.
8. The pigs fed on nitrogenous foods were so much stronger than others that they caused them serious injury when turned out to run together.
9. Of the nitrogenous foods tested, that of corn-cob meal and shipstuff in equal parts was the cheapest. See Table 4.

TABLE 5. Showing Formation of Nutritive Ratios of Feeds Used, and of Others that May be Fed to Swine.

Food Stuffs.	Per Cent. Water.	Per Cent. Ash.	Organic Substances. Per Cent. Albuminoids.	Organic Substances. Per Cent. Fibre.	Organic Substances. Per Cent. Other Carbohydrates.	Organic Substances. Per Cent. Fat.	Digestible Nutrients. Per Cent. Albuminoids.	Digestible Nutrients. Per Cent. Carbohydrates.	Digestible Nutrients. Per Cent. Fats.	Digestible Nutrients. Nutritive Ratio, as 1 to —.
Corn	10.10	1.55	10.34	2.29	70.59	5.13	8.16	65.64	4 36	9.3
Corn meal	15.19	1.48	9.20	1.89	68.39	3.85	7.27	63.40	3.29	9.8
Corn-cob meal	....	...	....	....	....	....	6.8	56.5	3.9	9.7
Cotton seed meal	8.33	7.25	42.06	5.69	23.43	13.24	35.75	22.25	11.65	1.4
Wheat bran	12.42	5.68	15.03	8.96	54.17	3.74	11.72	44.66	2.58	4.4
Shipstuff	12.74	4.25	13.83	7.45	57.59	4.14	10.79	44.80	2.85	4.7
Turnips	92 0	0.7	1.1	0.8	5.3	0.1	1.1	6.1	0.1	5.8
Apples	83.1	0.4	0.4	4.3	11.8	....	0.3	12.9	....	43.0
Pumpkins	89.1	1.0	0.6	2.7	6.5	0.1	0.4	7.1	0.1	18.4
Skim milk	90.0	0.8	3.5	....	5.0	0.7	3 5	5.0	0.7	1.9
Buttermilk	90.1	0.5	3.0	....	5.4	1.0	3 0	5.4	1.0	2.6
Red clover	80.4	1.3	3.0	5.8	8.9	0.6	1.7	8.7	0.4	5.7
Cow peas	15.0	3 2	20.77	4.06	55.75	1 43	18 4	54 53	1.07	3.1
Oatmeal	.7 81	2.0	14.66	0.86	67.67	7.06	11.29	50 15	5.79	5.6
Oats	11.0	2.97	11.38	9.85	60.05	4.81	8.46	46.11	3.94	6.5

The nutritive ratio of the last column is the proportion existing between the Albuminoids and the Carbohydrates, plus fats of "Digestible Nutrients;" fats being multiplied by 2.5 before being added to Carbohydrates. A ration is considered "wide" (fat-producing) when the Carbohydrates are in excess of Albuminoids in proportion of four and one-half to one.

BULLETIN No. 20.

Artificial or Commercial Fertilizers.

In order that a farmer may use commercial fertilizers intelligently, he should know, first, what his soil lacks to produce given crops, and second, the composition of the fertilizers at his disposal, that he may know whether he can supply these wants or not by the use of such fertilizers. Repeated trials on his own land is the best way to determine the first question. The way to make these trials has been presented in Bulletins Nos. 15, 16, 17 and 18, which give the results of experiments with fertilizers made at this Station on wheat, corn, potatoes and hemp. The present Bulletin treats of the second question, that is, the composition of commercial fertilizers generally, and the analysis of the various brands legally on sale in this State.

Generally speaking, a worn soil needs a fertilizer to supply a lack of potash, nitrogen or phosphoric acid, or any two, or all three of these combined. For this reason, commercial fertilizers contain one or more of these substances; in fact, their value depends upon the quantity and form in which these substances are contained in them.

Nitrogen.

If the free nitrogen which is found in nature in immense quantities could be appropriated by plants as food, there would be no need of seeking this element in commercial fertilizers; but all careful experiments indicate that none of the free nitrogen of the atmosphere can be directly used by the plant. Before it is available it must be combined with other elements, as oxygen, with which it forms nitric acid, or hydrogen to form ammonia.

Nitric acid is formed in small quantities by the direct union of the nitrogen and oxygen in the air during electrical storms, and is carried by the rain into the soil, where it combines with mineral matter, forming nitrates; but by far the larger quantity of nitrates is formed in the soil by the oxidation of ammonia compounds and of organic matter in the soil. This nitrification, as it is called, is brought about by the action of a very small organism which lives in the soil, but how it does it is as yet unknown. It is favored by warmth and moisture. In new soils, where vegetation is allowed to decay in place, the loss of nitrogen only takes place by drainage, and a little set free by oxidation. In cultivated fields the great loss is by the removal of crops. Tillage also increases the loss by drainage.

Under the conditions of cultivation the losses exceed the supply, and after a time the available nitrogen is so reduced that crops cannot be grown without the use of nitrogenous manures derived from some other source than the soils themselves. In artificial fertilizers the forms in which nitrogen is usually supplied are:

Nitrate of soda.

Sulphate of ammonia.

The crganic nitrogen of dried blood, waste from slaughter-houses, bones, fish scrap, cotton seed meal, castor pomace and other vegetable products rich in nitrogen.

Guanos.

Nitrogen in the form that can be taken up as food by plants is the most valuable element of plant life. It is also the element usually soonest exhausted in the soil.

Phosphates.

Next in importance to nitrogen as a plant food comes phosphoric acid. This acid usually combines in the soil with lime, magnesia and iron. In these forms it is insoluble in water, so that practically there is no loss by drainage. The source of loss is that carried off by the crops. The loss can be supplied only by the use of fertilizers. Phosphate of lime is the general source of phosphoric acid in fertilizers. There are many sources from which the phosphoric acid is obtained for commercial fertilizers, such as—

Bone meal.

Bone ash.

Bone black.

Superphosphate of lime, or acid phosphate.

Phosphate rock.

Thomas slag and guano.

Bone Meal.—Bone meal is valuable not only for the phosphoric acid which it contains, but also for its nitrogen. "Bones are composed of two distinct substances which interpenetrate one another." There is, as it were, a skeleton of earthy matter, which is called phosphate of lime or bone phosphate, and a flesh of organic matter, which is called ossien. Ossien is a highly nitrogenized substance.

The fineness to which bones are ground is an important consideration as to their value. The finer the meal, so much the more readily will it putrefy and dissolve in the soil, and so much sooner will the crops be fed. There is some difficulty in grinding fresh raw bones. To obviate this difficulty they are generally steamed, or carried through some process whereby the fat is extracted. Steamed or desiccated bones, if not very strongly steamed, are better for fertilizers than raw bones. This is contrary to the general belief, but raw bones contain the fat, which is not only useless to the plant, but adds weight and clogs the meal, and hinders decomposition of the bone in the soil. Of course the steaming process must not be carried on to such an extent as to extract the nitrogenous portion of the bone. It is true that some of the nitrogen is lost, nevertheless the meal from steamed bones has proved itself to be better than from ordinary raw bone.

Bone ash is sometimes used as a fertilizer. It is shipped from South America. It is generally used to make other forms of phosphates, as superphosphates.

Bone Black.—The spent black from sugar refineries is sold to manufacturers of fertilizers. When bones are heated in iron cylinders, into which air is not allowed to enter, gas, water, oily matters, and other products are driven off, while bone charcoal is left in the cylinders. This product is used to take the coloring matter out of raw sugars. After a time it becomes worthless for this purpose, when it is sold for fertilizing purposes, as all the lime phosphate still remains. The decomposition of bone black in the soil goes on slowly, and, therefore, it is not generally applied as such, but after treatment with sulphuric acid.

South Carolina Rock, Apatite, Etc.—These mineral sources of phosphates are with great difficulty decomposed in the soil, and so slowly that in general it does not pay to put these ground rocks on the soil before putting them through a process which will make the most of the phosphoric acid readily available to the plant. This leads us to the consideration of

Superphosphates.—In order to make these various phosphates more rapid in their action, they are treated with sulphuric acid, commonly called oil of vitriol. This treatment converts the insoluble phosphate into a soluble phosphate of lime, called *superphosphate of lime*, sulphate of lime or gypsum being formed at the same time. For the purpose of making these superphosphates, very impure and cheap sulphuric acid may be used. Some manufacturers make their superphosphates with acid that has already been used for purifying petroleum or coal oil. In purifying the oil the acid takes down with it tar-like matters, and settles below the oil in a mass-like substance. If water is added to this mixture after the oil is taken off, the tarry compounds are decomposed and the sulphuric acid liberated, greatly diluted, and having strongly the odor of petroleum. The use of this acid in making superphosphates imparts to them a strong odor of petroleum products. Such an odor is probably a benefit to the fertilizer, as it will undoubtedly keep insects away.

When bone, bone ash, bone black, or mineral phosphates are treated with sulphuric acid in sufficient quantity, the superphosphate formed contains the phosphoric acid in a form soluble in water. After standing, or when superphosphate is applied to the soil, the phosphoric acid is in the reverted form, as it has gone back to a form insoluble in water. This reverting of the phosphoric acid does not materially change its value as a fertilizer, for experiments have shown that plants can take up the phosphoric acid in this state as readily as in the soluble form. When the sulphuric acid is added in sufficient quantities to dissolve all the phosphates, some of the phosphoric acid remains in the insoluble form. This insoluble phosphoric acid is not as available to the plant, and it is much cheaper in the markets. In making an analysis of a ferterlizer, therefore, we separate the phosphoric acid into three divisions of *soluble*, *reverted*, and *insoluble phosphoric* acid, giving to each its value.

The "soluble" and "reverted" forms of phosphoric acid are both readily assimilable by plants, and hence are sometimes included under the common name, "available phosphoric acid." The "available phosphoric acid" in an analysis is equal to the sum of the "soluble" and "reverted" phosphoric acid.

Potassium.

Potassium ranks next to phosphorus as a valuable food for plants. Plants consume this element in comparatively large quantities, and some soils are unable to supply the demand; especially is this the case with light, sandy soils.

Primarily the plants obtain potash from the decomposition of minerals or rocks containing potash. Thus, feldspar contains from 10 to 16 per cent. of potash. It is potash combined with silica and alumina. As such, it is insoluble, and not available to the plant. In the decomposition of this rock clay is formed, and a soluble potash salt, which then becomes available. This decomposition goes on gradually, and thus in most clay soils available potash salts are being continually liberated for the use of the plant. Stirring the soil accelerates this decomposition, and the presence of lime or gypsum increases decomposition. In such soils, therefore, the application of lime has another use besides that of plant food.

Plants vary largely as to the amount of potash they require. For example, an acre of wheat yielding 20 bushels requires about 28 pounds of potash; while an average crop of potatoes requires 100 pounds of potash per acre, and an acre of tobacco yielding 3,800 pounds of leaves and stalks assimilates over 200 pounds of potash. It is evident, therefore, that the continual cropping of soils with potatoes or tobacco will, in time, exhaust the potash supply. Light and sandy soils require this element from almost the start.

The sources of potash, as generally found in fertilizers, are:

Sulphate of potash.

Muriate of potash.

Kainit.

Cotton seed hull ashes.

Wood ashes.

More rarely the nitrate of potash.

The sulphate and muriate of potash and the kainit are imported from Germany.

Different Forms of Fertilizers.

Usually commercial fertilizers contain two or all of the *essential ingredients*, viz: Nitrogen, phosphoric acid and potash, but sometimes only one. Plain superphosphates contain only *phosphoric acid.* Ammoniated superphosphates contain nitrogen and phosphoric acid. Bone contains, and is valuable for its nitrogen and phosphoric acid. Potash salts, of course, are valuable for their potash only. A complete fertilizer is one containing *nitrogen*, *phosphoric acid* and *potash.*

Explanations in Regard to the Tables.

The farmers should study carefully the tables of analyses in this Bulletin before purchasing commercial fertilizers.

It will be noticed that besides moisture, which is noted simply to compare the different analyses of the same brand, there is given in the tables the amount of phosphoric acid in its soluble, reverted and insoluble form, nitrogen and its equivalent in ammonia, and potash for each brand. Now, the selling value of a commercial fertilizer should depend upon the amount of the various forms of phosphoric acid, the nitrogen, and the potash it contains—for, as has been said, it is to supply the plants with *phosphoric acid, nitrogen and potash* that the fertilizer is mainly applied to the soil. As regards phosphoric acid, the *soluble and reverted* forms should be particularly noted. They are the forms capable of being readily taken up as food for the plant, while the *insoluble phosphoric acid* does not, in all probability, serve as food to the plant at once, and probably not for a year or more. For this reason, this form of phosphoric acid is not as valuable to the farmer as the other forms. It is also the cheapest form of phosphoric acid in the market. Nitrogen is another element of great importance and value in a fertilizer, and is needed in most every soil where fertilizers are applied with benefit. Potash is the cheapest essential ingredient of a commercial fertilizer; but in some crops, and especially tobacco and potatoes, it is a very important element.

The Estimated Value.—In the last column of each table is given the value in dollars and cents of the different fertilizers. These values are estimated from the essential ingredients contained in the fertilizers, and the forms in which they exist. In other words, they express the *commercial value*, or about the price the ingredients could be bought for on the open market, mixed and put upon the market as fertilizers. These values are not intended to express the *agricultural value* of the fertilizers, or the profit they will give the farmer by their use. They are intended rather to notify him, if he intends to purchase fertilizers, that from quotations this year of the essential ingredients of these fertilizers, he should be able to purchase them for about the estimated price given in the table. Another, and perhaps the most important use of these estimated values, is to assist the farmer in determining which is the cheapest fertilizer for him to purchase. In choosing between several fertilizers of the same kind, that is, containing the same essential ingredients in about the same proportion, the one that has the highest "estimated value per ton" in the table of analyses would be preferable at the same cost. Or, if the "estimated value per ton" is about the same in all, the one that costs the least is to be preferred. Take, for example, a supposable case. A farmer desires to purchase ten tons of some commercial fertilizer for his tobacco crop. His land is poor, and he concludes to purchase a fertilizer containing all three of the essential ingredients, namely, phosphoric acid, potash and nitrogen. He goes to his merchant and finds that he has two brands for sale. No. 1 is priced at $40 per ton, and No. 2 at $30. The farmer refers to the tables in this Bulletin, and finds the two brands relatively alike as to the essential ingredients. No. 1 is estimated at $40, and No. 2 at $25. It is evident from the estimated values that he should purchase the higher priced fertilizer, for if he paid $40 for this brand, he should pay but $25 instead of $30 for the cheaper one.

The Analyses.—But the analyses given on the tags signed by the Director, attached to each sack or package of fertilizer, or in the tables of this Bulletin, should be carefully considered, as well as the estimated value, *for the estimated value is not a sufficient guide to determine which of two or more fertilizers to purchase*, except in those cases where the proportions of phosphoric acid, potash and nitrogen are relatively the same. To illustrate the importance of considering the analyses as well as the estimated value, let us take an example. Suppose a farmer desires to purchase a fertilizer for his tobacco crop. He goes to his merchant and is offered either of two brands at the same price. The price, fortunately, does not help him to decide in this case. He next looks at the tags attached to the sacks, and finds that the Director has estimated each fertilizer at $30 per ton. He next looks at the analyses and finds fertilizer No. 1 to contain:

Soluble Phosphoric Acid	8 per cent.
Reverted " "	7 per cent.
Potash	None.
Nitrogen	None.

And fertilizer No. 2 to contain:

Soluble Phosphoric Acid } Reverted " " }	7.5 per cent.
Nitrogen	3.0 per cent.
Potash	4.2 per cent.

He is able now to judge quickly which of the two fertilizers to purchase. If his soil needs phosphoric acid, he will quickly decide on No. 1, for he will get twice as much for the same money; while, did he purchase No. 2, he would have paid $15 for the phosphoric acid which he needed, and $15 for the nitrogen and potash which he did not need. But should he be in doubt whether his land *needed* one or all the elements of a fertilizer, he would be wise in purchasing No. 2. For should his soil need potash or nitrogen, or all three of the essential elements, to produce a large tobacco crop, and should he have purchased No. 1, it is doubtful whether he would have received any benefit from it.

On account of the differences in soils, no rule can be given by which to tell what fertilizer is the best for any particular crop, and this question must be decided by actual trial, systematically and carefully made. Some such trials are made at the Station each year, and the Director will be glad to furnish a plan for similar experiments to any one who desires to test the effect of fertilizers on his land.

How to Apply Fertilizers.

In regard to the manner of applying fertilizers, it is generally best to sow broadcast or drill, and work well into the soil before planting. When a small quantity of fertilizer is applied to each hill or row at planting time, it acts mainly as a stimulant to produce an early and vigorous start, which is considered necessary for the tobacco crop, but often renders the crop more sensitive to drouth. In any case care should be taken to mix the fertilizer with the soil, so that it will not come in contact with the seeds or plants. Most fertilizers, and especially those containing much nitrogen, soluble phosphoric acid or potash, will injure or destroy young plants if brought directly in contact with them.

Fertilizers Analyzed.

The following tables give the names of all the manufacturers who have complied with the law for 1889, and the names of the brands legally on sale; also the analysis and valuation of each brand.

The following are the values used for the essential ingredients: Phosphoric acid soluble in water, 8½ cents; "reverted" phosphoric acid, 8½ cents; insoluble phosphoric acid, 3 cents; phosphoric acid in fine bone, 4½ cents; in medium bone, 4 cents per lb.; potash muriate, 5½ cents; sulphate, 7 cents; and nitrogen 20 cents per lb.

Fine bone is all that passes through a sieve with meshes 1-25 inch square. Medium bone passes through a sieve with meshes ⅙ inch square, but does not include fine bone.

TABLE I. Raw Bone Manures—Analysis and Valuation.

Station Number	Name and Address of Manufacturer.	Name of Brand.	Pounds in the Hundred.							Estimated Value per ton
			Moisture	Phosphoric Acid.			Equivalent to Bone Phosphate	Nitrogen	Equivalent to Ammonia	
				In Fine Bone	In Medium Bone	Total				
418	P. B. Mathiason & Co., St. Louis, Mo	Increscent Brand Pure Bone Meal	5.65	28.16	....	28.16	61.50	2.49	3.02	$35 30
431	The Currie Fertilizer Co., Louisville, Ky	Currie's Raw Bone Meal	8.21	11.04	10.27	21.31	46.55	3 82	4.64	33.44
436	The Globe Fertilizer Co., Louisville, Ky	Globe Bone Meal	8 34	12 88	6 35	19.23	42.99	4.53	5.50	34.79
445	North-Western Fertilizing Co, Chicago, Ill	Fine Raw Bone	9.85	21 96	....	21.96	47.96	3 72	4.52	34.55
453	North-Western Fertilizing Co., Chicago, Ill	Pure Ground Bone	11.63	22.78	3 89	26 67	58.25	1.75	2.12	30 61
455	J. B. Jones, Louisville, Ky	Pure Raw Bone Meal	7.54	11.76	8.30	20.06	43.81	3.79	4.59	32.38
458	Miller Fertilizer Works, Louisvile, Ky	Strictly Pure Raw Bone Meal	6 32	14.96	6.81	21 77	47.55	4.05	4.92	35.01
459	Thompson & Edwards Fertilizer Co., Chicago, Ill .*	Pure Fine Ground Bone	4 25	27.75	....	27.75	60.60	2.61	3.17	35.42
466	Crocker Fertilizer and Chemical Co., Buffalo, N. Y	Crocker's Pure Ground Bone	6.56	17.69	5.29	22.98	50.18	4.66	5 66	38.79
474	William Skene & Co., Louisville, Ky	Skene's Pure Raw Bone Dust or Meal	6.72	9.84	13.05	22.89	49.98	4.09	4.97	35.66
492	The Cincinnati Desiccating Co., Cincinnati, O	Pure Bone Meal	6.02	18.08	5.01	23.09	50.43	4.41	5.35	37.92
516	J. B. Jones, Louisville, Ky	Pure Ammoniated Bone Meal	6 76	10.84	4.64	15.48	33.81	3.76	4.56	28 51
..	V. M. Metcalfe, Hopkinsville, Ky	Metcalfe's Bone and Potash	7.19	10 76	7.99	18.75	40.96	3.11	3 78	*33.38
..	V. M. Metcalfe, Hopkinsville, Ky	Metcalfe's Bone Meal	7.46	10.69	9.98	20.67	45.15	3.31	4 02	30.84

516	J. B. Jones, Louisville, Ky	[illegible] Meal	6 76	10.84	4.64	15.48	[illegible]	[illegible]	[illegible]	[illegible]
. .	V. M. Metcalfe, Hopkinsville, Ky	Metcalfe's Bone and Potash	7.19	10 76	7.99	18.75	40.96	3.11	3 78	*33.38
. .	V. M. Metcalfe, Hopkinsville, Ky	Metcalfe's Bone Meal	7.46	10.69	9.98	20.67	45.15	3.31	4 02	30.84
. .	Thompson & Edwards Fertilizer Co., Chicago, Ill	Pigs' Foot Brand, Chicago Bone Meal	6.76	17 60	. . .	17.60	38.45	3.60	4.37	†35.18
. .	C & F. Singer, Nashville, Tenn	Pure Raw Bone Meal	7.27	12.15	4.84	16.99	37.10	3.75	4.55	‡32.60
. .	Michigan Carbon Works, Detroit, Mich	Homestead Raw Bone Meal, with Potash	9 56	13 28	. . . .	13.28	29.00	2.50	3.04	§25.16

* Potash from sulphate, 3 48 per cent.

† Potash from sulphate, 3.53 per cent.

‡ Potash from muriate, 2.54 per cent.

§ Potash from muriate, 2.92 per cent.

TABLE 2. Complete Fertilizers, Superphosphates, Etc.—Analyses and Valuations.

Station Number.	Name and Address of Manufacturer.	Name of Brand.	Pounds in the Hundred.								Estimated Value per ton.
			Moisture.	Phosphoric Acid.			Nitrogen.	Equivalent to Ammonia.	Potash.		
				Soluble.	Reverted.	Insoluble.			From Sulphate.	From Muriate.	
413	Thompson & Edwards Fertilizer Co., Chicago, Ill	World-of-Good Potato Grower	4.67	2.14	3.46	3.02	2.74	3.33	8 00	. . .	$33.49
419	P. B. Mathiason & Co., St. Louis, Mo	Increscent Brand dissolved Bone	9.99	6.31	3.55	3.29	2.91	3.53	. .	1.76	32.32
423	V. M. Metcalfe, Hopkinsville, Ky	Metcalfe's Tobacco Grower	9.85	2.57	4.12	2.21	2 81	3.41	5.25	. . .	31.29
432	Globe Fertilizer Co., Louisville, Ky	Eagle Fertilizer	7.00	5.46	2.89	2.68	2.50	3.04	1.50	. . .	27.91
433	. . . . Same	Standard Bone Meal	3.37	2.09	4.86	9 21	1.91	2.32	. . .	. . .	24.99
434	Jarecki Chemical Works, Sandusky, Ohio	Lake Erie Fish Guano	10.78	7.02	0.50	2.56	3.54	4.30	. . .	1.61	30.25
435	Globe Fertilizer Co., Louisville, Ky	Kentucky Standard Tobacco Grower . .	7.00	5.31	2.10	3.43	2.88	3.50	3.44	. . .	31.02
437	V. M. Metcalfe, Hopkinsville, Ky	Metcalfe's Standard Fertilizer	14.24	5.69	1 61	2.37	3.30	4.01	2.90	. .	31.09
438	. . . . Same	Metcalfe's Corn and Wheat Grower . .	9.86	3.51	3 50	2.61	2.86	3.47	3.12	. . .	29.30
439	. . . . Same	Metcalfe's Tobacco Grower	12.35	3.65	3.68	2.16	2.55	3.10	3.32	. . .	28.61
443	North-Western Fertilizing Co., Chicago, Ill	Kentucky Corn Grower	15.74	4.86	2.07	5.04	1.70	2.06	. . .	. . .	21.60

| Chicago, Ill . . . . | Grower . . . . . . | 15.74 | 4.86 | 2.07 | 5.04 | 1.70 | 2.06 | . . . | . . . | 21.60

444	North-Western Fertilizing Co., Chicago, Ill.	Kentucky Tobacco Grower	15.90	4.95	2.01	5.03	1.73	2 10	. . .	. . .	21.77
446	. . . . Same	Prairie Phosphate. .	15.17	5.18	1.70	5.22	1.99	2.42	. . .	. . .	22.79
447	. . . . Same	Ralston's Bone Meal.	14.61	1.48	3.42	10.13	2.48	3.01	. . .	. . .	24.33
448	. . . . Same	Horse Shoe Brand, Challenge Corn Grower	17.62	5.36	2.44	3.45	2.30	2.79	. . .	0.86	25.48
449	. . . . Same	Twenty-six Dollar Phosphate	15.15	5.23	2 18	4.26	2.00	2.43	. . .	. . .	23.16
451	. . . . Same	Horse Shoe Brand, Tobacco Grower. . .	18.00	3.85	4.08	3.83	2.68	3.25	0.42	1.02	28.21
452	. . . . Same	Horse Shoe Brand, Potato Grower. . . .	15.34	5.09	3.37	3.94	3.24	3.93	0.85	1.27	32.29
456	J. B. Jones, Louisville, Ky. . . .	Superphosphate of Lime	5.37	2.81	6.79	6.65	3.44	4.18	. . .	. . .	34.07
457	Miller Fertilizer Works, Louisville, Ky.	Bone Phosphate. . .	4.29	3.61	5.99	4.38	3.94	4 78	0.94	. . .	36.03
467	Crocker Fertilizer and Chemical Co., Buffalo, N. Y.	Crocker's Potato, Hop and Tobacco Phosphate	13.76	8.01	1 46	1.15	1 96	2.38	. . .	4.02	29 05
468	. . . . Same	Crocker's Southern Tobacco Phosphate	10.56	4.81	4.45	1.79	3.74	4.54	2.45	1.57	36.93
469	. . . . Same	Crocker's Ammoniated Bone Superphosphate	14.57	7.70	1.69	1.25	3.19	3.87		1 43	31.04
470	. . . . Same	Crocker's Wheat and Corn Phosphate . .	15.91	8.52	1.19	1.33	2.43	2 95	. . .	2 29	29.55
471	Thompson & Edwards Fertilizer Co., Chicago, Ill.	Sure Growth Phosphate	5.77	7 37	5.70	2.10	1.32	1.60	0.74	. . .	29.80
475	Lister's Agricultural Chemical Works, Newark, N. J.	Lister's U. S. Phosphate	9.23	6.06	1.41	2.12	1.86	2.26	2.53	. . .	25 01
476	Michigan Carbon Works, Detroit, Mich.	Homestead Tobacco Grower	13.52	8.11	1.73	0.77	3 20	3.88	. . .	3.48	33.82

TABLE 2.—Continued. Complete Fertilizers, Superphosphates, Etc.—Analyses and Valuations.

Station Number.	Name and Address of Manufacturer.	Name of Brand.	Pounds in the Hundred. Moisture.	Phosphoric Acid. Soluble.	Phosphoric Acid. Reverted.	Phosphoric Acid. Insoluble.	Nitrogen.	Equivalent to Ammonia.	Potash. From Sulphate.	Potash. From Muriate.	Estimated Value per ton.
477	Michigan Carbon Works, Detroit, Mich	Jarves' Drill Phosphate	9.39	6.84	1.44	2.61	1.19	1.44	...	...	$20.41
478	Same	Homestead Corn and Wheat Grower	12.78	7.16	0.87	2.00	2.11	2.56	...	1.34	24.76
479	Same	Jarves' Tobacco Fertilizer	9.33	4.77	1.01	1.09	1.89	2.29	...	2.03	20.27
480	Zell Guano Co., Baltimore, Md.	Zell's Dissolved Bone Phosphate	7.48	11.55	1.07	4.66	....	...	...	...	24.25
485	The Currie Fertilizer Co., Louisville, Ky	Currie's Tobacco Grower	6.38	5.28	2.29	2.19	2.41	2.93	...	3.16	27.30
486	Same	Currie's Raw Bone Superphosphate of Lime	6 26	3.66	2.63	3.43	3.79	4.60	...	1.69	29.77
487	Same	Currie's Guano	6.27	6 05	2.30	2.19	1.25	1.52	0.93	2.00	24.01
488	Same	Currie's Ammoniated Dissolved Bone	6.14	5.90	2.37	2.12	1.21	1.47	1.07	1.81	23.34
489	Same	Currie's Corn Grower	11.27	6.31	3.27	3.06	1 32	1.60	...	1.23	24.76
490	Same	Currie's Falls City Phosphate	11.30	6.26	2.69	3.48	1.47	1.78	..	1.21	24 52
491	Same	Currie's Falls City Raw Bone Meal.	6 95	5.81	4.53	6.09	0.74	0.90	...	1 44	25.77
493	Cincinnati Desiccating Co, Cincinnati, O	Gilead Phosphate	7 89	3.04	4.77	5.01	2.34	2.84	..	2.59	28.50
494	Same	Pure Acidulated Bone	6.17	3.68	8.26	8.70	3.29	3.99	...	...	38.68
495	Same	Ohio Vall'y Phosphate	12.98	0.84	4.88	3.89	1.48	1.80	...	2.06	20.24

493	Cincinnati Desiccating Co, Cincinnati, O.	Gilead Phosphate . .	7 89	3.04	4.77	5.01	2.34	2.84	. .	2.59	28.50
494	. . . . . . Same	Pure Acidulated Bone	6.17	3.68	8.26	8.70	3.29	3.99	. . .	. . .	38.68
495	. . . . . . Same	Ohio Vall'y Phosphate	12.98	0.84	4.88	3.89	1.48	1.80	. . .	2.06	20.24
496	Same	Tobacco Fertilizer . .	3.96	5.21	4.48	2.83	4.27	5.18	5.72	. . .	43.26
497	National Fertilizer Co, Nashville, Tenn	National Corn Grower	12.55	8 29	1.66	2.29	1.35	1 64	. . .	1.68	25.54
498	. . . . . . Same	Rock City Guano . .	11.29	7.30	1.19	2.17	2.00	2 43	. . .	1.83	25.74
499	. . . . . . Same	Tobacco Grower . . .	11.63	7.42	1.52	1.68	2.11	2 56	. . .	1.88	26.76
500	. . . . . . Same	National Dis'v'd Bone	12 71	8.21	1.68	2.34	1.35	1.64	. . .	1.49	25.25
501	. . . . . . Same	Tennessee Guano . .	11.98	7.33	1.33	1.68	2.01	2.44	. . .	1 96	25.93
502	. . . . . . Same	National Tobacco Fertilizer	14.02	7.78	0.81	0.86	2.49	3.02	. . .	4.17	29.67
505	Cleveland Dryer Co., Cleveland, O.	XXX Acid Phosphate	12.89	11 04	1.99	3.13	. . .	. . .	. . .	. . .	24.03
506	. . . . . . Same	Ohio Seed Maker .	10.79	8.23	2.04	4.29	1.77	2.15	. . .	. . .	27.11
507	Same	Connecticut Valley Tobacco Fertilizer.	8.04	11.31	0.55	3.25	3 39	4.12	. . .	3 58	39.61
508	. . . . . . Same	Ammoniated Dissolved Bone . . .	7.36	7.04	2.61	3.81	3.09	3.75	. . .	. . .	31.06
509	. . . . . . Same	Square Bone	6.79	5.73	3.28	7.57	2.95	3.58	. .	. . .	31.66
510	. . . . . . Same	White Burley Tobacco Fertilizer	7.37	10 91	0.66	3.58	3.23	3.92	. . .	3.14	38.19
511	. . . . . . Same	Buckeye Ammoniated Bone Superph'sp'ate	9.11	8.41	2.05	3.68	2.40	2.91	. . .	0.25	29 87
513	Furman Farm Improvement Co., Atlanta, Ga.	Adair's Tobacco Grower	11 08	7.46	1.61	1.32	3.85	4.67	. . .	4.53	36.59
514	. . . . . . Same	Golden Grain F'tilizer	11.69	8.51	1.44	2.00	3.59	4.36	. . .	3.56	36.40
515	. . . . . . Same	Furman's Soluble Bone with Ammonia and Potash	8.08	7.89	2.09	2.94	1.53	1.86	. . .	1.96	27.01
. .	The Currie Fertilizer Co., Louisville, Ky	Currie's Wheat Grower	8 45	6 15	2.69	3.85	1.58	1.92	. . .	1 39	25.19
. .	Globe Fertilizer Co., Louisville, Ky.	Globe Wheat Grower	9.10	2.67	3.32	4.50	2.66	3.23	2.24	. . .	26.66
. .	Star Slaughtering and Phosphate Co., Washington C. H., Ohio . .	Red Star Ferric Fertilizer	6.76	. . . .	. . . .	6.86	. . . .	. . . .	. . .	. . .	4.12
. .	The Zell Guano Co., Baltimore, Md	Zell's Calvert Guano.	13.19	8.67	1.17	1.80	0.81	0.98	. . .	1.63	22.84
. .	D. Blocker & Co., Baltimore, Md	High Grade Superphosphate of Bone.	11.68	5.14	2.90	3.63	1.03	1.25	. . .	2.33	22.53
. .	. . . . . . Same	Dissolved Bone and Potash	12.48	7.57	3.65	2.07	0.73	0.89	. . .	1.43	24.80

LEXINGTON, KY., July 30, 1889

M. A. SCOVELL, Director.

APPENDIX

RULES AND REGULATIONS.

By authority of section 7 of the fertilizer law, the Director makes the following Rules and Regulations concerning the sale of fertilizers in this State:

1. The SELLER is responsible for affixing the *official* label to the fertilizer packages, unless the manufacturer has provided and attached them.

2. All labels, to be official, must emanate from the Director of the Kentucky Agricultural Experiment Station. Persons attaching other than official labels, for official labels, are evading the law, and are subject to the penalties thereof.

3. Official labels are issued only to persons guaranteeing by affidavit that the fertilizer to which they are to be attached is true to the sample on which the results of the analysis and commercial value are determined. Persons attaching labels to goods misrepresenting the fertilizers, or the sample for which they are issued, are subject to the penalties of the law for each offense.

TO PURCHASERS OF FERTILIZERS.

It is estimated that from four hundred to five hundred thousand dollars are expended annually in this State for fertilizers. It becomes, therefore, of vast importance to the State that the fertilizers sold should be of the quality represented. To this end the Director would advise farmers purchasing fertilizers:

1. To purchase with a guarantee that the fertilizer is as represented by the official tag attached.

2. To take a sample, especially if purchasing in large quantities, and send it to the Director for analysis, to see whether the fertilizer is as represented by the seller.

3. To have nothing to do with fertilizers which are not labeled with a tag bearing an analysis, and certified to and signed by the Director. Manufacturers of genuine goods are always willing to comply with a law which protects them as well as the purchaser, and their goods will be found labeled as required by law. It is generally those who offer adulterated or inferior goods that do not desire the quality of their goods to be known.

In order to obtain a fair sample for this purpose, the following directions should be observed:

HOW TO TAKE SAMPLES.

* a. Select at least two average packages of the fertilizer, preserving the labels to send with sample. Open these packages and mix well together the contents of each, down to one-half of its depth, emptying out upon a clean floor, if necessary, and crushing any soft, moist lumps, in order to facilitate mixture, but leaving hard, dry lumps unbroken, so that the sample shall exhibit the texture and mechanical condition of the fertilizer.

* Connecticut Experiment Station.

b. "Take out five equal cupfulls from different parts of the mixed portions of each package. Pour them (ten in all) one over another upon a paper; intermix again thoroughly, but quickly, to avoid loss or gain of moisture; fill a can or jar from this mixture; inclose labels taken from the packages; seal," label plainly, giving name also of sender, and send to

M. A. SCOVELL, Director, Lexington, Ky.

BULLETIN No. 21.

Experiments with Wheat.

In the wheat experiments the past season, the following lines of investigation have been undertaken:

1. Test of varieties.
2. Methods of seeding.
3. Test of fertilizers.

The experiments were mainly conducted on the Experiment Station farm, the soil of which could not be considered good wheat land, and this should be kept in view in the consideration of results.

Soil.—The soil of the Blue-grass Region is derived from the gray and blue limestones of the upper portions of the Trenton group of the Lower Silurian. These beds are fossiliferous, varying in character from thin-bedded blue limestone with rich phosphatic layers to thick-bedded, semi-crystalline gray limestone. The soil varies in its relation to the rocks by the interposition of a retentive clay, thin, or having a depth increasing to many feet. At least two different soils are known in this region; one having a red clay subsoil, porus and producing fine natural drainage; the other with a light clay subsoil, retentive, and often deficient in natural drainage. The soil of the Experiment Station farm is of the latter class, and although on a ridge, from lack of proper drainage, is quite wet in the spring, and therefore may be called a cold and backward soil. It has been in cultivation for a long time, the exact length is not definitely known. At least three crops of hemp were grown on it prior to 1860. In 1863 it was planted to corn, in '70 and '71 in wheat.

In '72 it was in meadow. In '79 a crop of potatoes was taken off of it. In '81 it seems to have been in clover, in '82 in millet, in '87 in rye.

Last year the plot was planted to potatoes.

Test of Varieties.

This experiment was begun by Prof. J. H. Connell. For making the comparative test of varieties, 43 varieties were planted. Each variety was planted in drills, 7 inches apart. Each plot contained one-fortieth of an acre. The plots were all planted October 18. The fall growth of all the varieties was good.

The selection of the plots for the varieties proved to be most unfortunate for comparative tests, as the lower portion of the field where varieties from No. 1 to 11 were planted was so wet that a large portion of the wheat was winter-killed. For this reason the yield of the first ten varieties is not given in the table:

TABLE 2. Yield of the Varieties.

Number.	Name of Variety.	Yield per Acre. Wheat (Bushels.)	Yield per Acre. Straw (Pounds.)	Weight of one Bushel of the Wheat.
1	Mediterranean Hybrid	.....	.....	48
2	Diehl Mediterranean	.....	.....	46
3	Lancaster	.....	.....	53
4	Red Sea	.....	.....	55
5	German Amber	.....	.....	55
6	Velvet Chaff	.....	.....	52
7	The Good	.....	.....	54
8	McGhee White	.....	.....	55
9	Blue Stem	.....	.....	53
10	Nigger	.....	.....	54
12	Sibley's New Golden	21¼	2825	52
13	Hicks	19⅙	2200	54
14	Hickman	24⅙	2600	56
15	Canadian Finley	26	2100	56
16	Fulcaster	23⅓	2450	56
17	German Emperor	30½	3425	53
18	Extra Early Oakley	15	1300	55
19	New Monarch	22½	2050	54
20	Poole	16	2350	52
21	Square Head	19	1550	53
23	Theiss	24	2500	54
24	Browick Red	25	2800	54
25	Hunter's White	27	3500	56
26	Dietz	20½	2375	54
27	Golden Drop	17	3100	56
28	Egyptian	30½	2575	56
30	Genoese	26¼	3925	55
32	Tasmanian Red	19½	2675	54
33	Martin's Amber	22½	2525	53
36	High Grade (Suffern)	17	2950	52
37	Buckeye	17	2475	55
38	Golden Amber	21	2600	54
39	Tasmanian Red	22	2700	55
40	New Monarch	21	2825	54
41	Mealy	16⅔	2600	52
42	No Name	13⅓	1500	54

In the following table is given a description of the varieties and field notes:

TABLE 1. Summary of Characteristics.

No. of plot.	Name of Variety.	Per cent. winter killed (estimated).	Appearance. April 15.	Appearance. April 22.	Jointing, April.	Heading, May.	Bloom, May.	Cut, June.	Height, feet.	Head. Length, Inches.	Head. B–Bearded S–Smooth.	Color of Grain.
1	Mediterranean Hybrid	30*	Fair	Weak growth	29	12	18	29	2½	3	B	Red.
2	Diehl Mediterranean	40*	Very poor	"	29	12	18	29	2½	2½	B	"
3	Lancaster	40*	Poor	Fair	29	12	18	29	3	3¼	B	"
4	Red Sea	30*	"	"	29	12	18	29	3	2¾	B	"
5	German Amber	20*	"	Good	29	12	18	29	3	3	S	Amber.
6	Velvet Chaff	30*	Very poor	"	22	6	15	28	3	3¼	B	Red.
7	The Good	50*	"	"	20	5	15	25	2¾	3	S	"
8	McGhee White	30*	"	"	22	8	15	25	2½	2½	S	White.
9	Blue Stem	30*	"	"	22	10	15	25	2½	2½	S	"
10	Nigger	50*	"	Bad	29	12	18	29	2¾	3	B	Red.
12	Sibley's New Golden	30*	Fair	Fair	25	12	18	29	3½	3	B	"
13	Hicks	15	Good	Good	28	12	18	29	2¾	2¾	S	"
14	Hickman	20	"	Fair	28	11	18	29	3	2¾	S	"
15	Canadian Finley	10	Fair	"	26	11	15	25	3	2¾	S	"
16	Fulcaster	10	"	Good	26	11	17	29	3	3	B	"
17	German Emperor	5	Good	"	28	10	16	29	2¾	3	S	"
18	Extra Early Oakley	15	Fair	"	22	8	13	25	2½	2½	S	Amber.
19	New Monarch	5	Good	"	28	9	15	29	3¼	3	S	"
20	Poole	10	"	"	25	11	18	29	2¾	2¾	S	Red.
21	Square Head	10	"	Fair	23	10	15	25	2¾	3	S	"
23	Theiss	5	Medium	Good	25	12	18	29	2¾	3	B	"
24	Browick Red	5	Fair	Fair	22	12	18	29	2¾	3	B	"
25	Hunter's White	10	Good	"	24	12	18	29	3	3	B	White.
26	Deitz	10	"	"	29	12	18	29	3	3	B	Red.
27	Golden Drop	5	"	"	29	12	18	29	3	3	S	Amber.
28	Egyptian	5	Fair	"	24	10	15	25	2½	2½	S	Red.

25	Hunter's White			Fair	22	12	18	29	2¾	3	B	"
26	Deitz	10	Good	"	24	12	18	29	3	3	B	White.
27	Golden Drop	10	"	"	29	12	18	29	3	3	B	Red.
28	Egyptian	5	"	"	29	12	18	29	3	3	S	Amber.
		5	Fair	"	24	10	15	25	2½	2½	S	Red.

30	Genoese	Slight	Good	Good	22	12	18	29	3¼	3	S	Red.
32	Tasmanian Red	5	"	Fair	20	12	18	29	3¼	3	B	"
33	Martin's Amber	5	"	"	25	15	21	29	3	3	S	Amber.
36	High Grade	30†	Poor	"	29	12	21	29	3	3	S	Red.
37	Buckeye	30†	"	"	29	13	21	29	3	3½	B	"
38	Golden Amber	25†	"	"	25	14	21	29	3	3¼	B	Amber.
40	New Monarch	15†	Fair	Very Good	25	12	21	29	3¼	3¾	S	Red.
41	Mealy	20†	Medium	"	26	12	21	29	3½	3-5	S	"
42	No Name	40†	"	Good	24	8	15	26	2¾	3¼	S	"

* Plots 1 to 12 were in a low, moist situation, rendering them more liable to winter-killing than the rest. Hence the large percentages.

† Plots 36-42 were similarly situated to Nos. 1-12, though on slightly higher ground.

Conclusions as to Varieties.

The grain of all the varieties this year was inferior in quality, possibly as a result of the attack of the wheat aphis, and for this reason it is difficult to form any judgment as to relative quality. The Canadian Finley and Hunter's White, however, are worthy of mention as among the best in appearance of the grain.

The best yields were produced by the German Emperor and the Egyptian, each producing at the rate of 30 bushels per acre.

The Diehl Mediterranean, Hicks and Extra Early Oakley, which have proved such good yielders heretofore, did not turn out well in this experiment, probably because of unfavorable conditions. The Oakley is capable of giving better results, as may be seen from Table 3.

Different Methods of Seeding.

A series of experiments was begun to test different methods of seeding for wheat. The variety planted was Extra Early Oakley. This series will be continued from year to year, in order to obtain more conclusive results. The results this year are given in the following table, and seem to be most favorable in the case of plots 3 and 4, where a moderate amount of seed was used and planted at a moderate depth. In regard to plots 1 and 9, it must be noted that the yields are much lower than they should be, on account of the inroads made upon them by the English Sparrow. These were the outside plots, and were most exposed.

TABLE 3.—Different Methods of Seeding for Wheat.

No. of Plot.	Method of Seeding.	Size of Plot.	Bushels Seed Per Acre.	Yield per Acre.	
				Wheat (Bushels.)	Straw (Pounds.)
1	Subsoiled, Drilled as usual	1-10 A	$1\frac{3}{4}$	15	2660
2	Drilled 3 inches deep	1-10 "	$1\frac{3}{4}$	$21\frac{2}{3}$	2730
3	Drilled 1 inch deep	1-10 '	$1\frac{3}{4}$	$25\frac{2}{3}$	3300
4	Drilled 2 inches deep	1-20 "	1	$33\frac{1}{3}$	1700
5	Drilled 2 inches deep	1-20 "	3	$24\frac{2}{3}$	2700
6	Drills 14 inches apart	1-40 "	$1\frac{3}{4}$	$20\frac{2}{3}$	2160
7	With Shoe Drill	1-40 "	$1\frac{3}{4}$	24	2520
8	With Hoe Drill	1-40 "	$1\frac{3}{4}$	22	3360
9	Broadcast, harrowed in	1-40 "	$1\frac{3}{4}$	$15\frac{1}{3}$	3040

Test of Fertilizers.

The field on which these experiments were made is quite level. The soil is of the general character before described. The plats were each one-tenth acre in size, and were separated each from each by a path 3 feet wide. The field had been planted to potatoes in the spring. After the potatoes were dug the field was ploughed and harrowed. The wheat was drilled in on October 8th, drilling at the rate of $1\frac{3}{4}$ bushels per acre. The drill used was the Buckeye drill, with fertilizer attachment. The fertilizers were drilled in at the time the wheat was planted. The variety planted was Penquites Velvet Chaff.

The following plan shows the arrangement of the plots and the kind and amount of fertilizer used :

Plot	Fertilizer
1	No Fertilizer.
2	Acid Phosphate, 30 lbs.
3	No Fertilizer.
4	Muriate of Potash, 10 lbs.
5	Dried Blood, 15 lbs.
6	No Fertilizer.
7	Acid Phosphate, 30 lbs. Sulphate of Potash, 10 lbs.
8	Acid Phosphate, 30 lbs. Dried Blood, 15 lbs.
9	Potash Sulphate, 10 lbs. Dried Blood, 15 lbs.
10	Acid Phosphate, 30 lbs. Dried Blood, 15 lbs. Potash Sulphate, 10 lbs.

These experiments were planned for the purpose of ascertaining whether fertilizers would be beneficial to wheat on this particular field, and if so, to learn what essential ingredient or ingredients of the fertilizers were needed for the wheat crop. If potash only was needed, plot 4 would show it. If phosphoric acid was the ingredient wanted, then plot 2 would show it. If nitrogen, plot No. 5 would demonstrate it. If the soil needed a combination of any two of these ingredients, then plots Nos. 7, 8 or 9 would show which combination was needed, or if all the ingredients were needed, No. 10 would show it. Plots 1 and 6 were left blank for comparison. Plot No. 3 had no fertilizer put on it at the time the wheat was planted, but it had received 20 pounds of sulphate of potash in the spring previous when the potatoes were planted. The purpose of this plot was to see whether the potash was all used by the potato crop, or if not, to find out what benefit the potash still remaining would be to the wheat.

As soon as the wheat was fairly up, quite a difference could be seen in the growth of the wheat on the various plots. Plots Nos. 3, 4, 7, 9 and 10 had much the best appearance, while plots 5 and 8 were decidedly inferior in appearance.

Throughout the fall growth this marked contrast among the various plots was observed, and the appearance was always in favor of those plots containing potash. In the spring the growth of wheat on those plots containing potash was very even and thrifty, while the growth on the other plots was uneven, the growth on those plots containing nitrogen having a dark green appearance.

After heading, the potash plots did not appear to such advantage. At time of blooming the plots all appeared about alike, the potash plots having the thickest stand.

The following field notes are here given :

TABLE 4. Notes on the Fertilized Plots.

No. of plot.	Appearance March 18.	Appearance April 15.	Appearance April 22.	Average height..	Length of head...	Character of Straw.
1	Slightly winter-killed, but looks well	Very Fair. . . .	Fair, but uneven, jointed.	3½ feet.	3 inches.	Very pale yellow, but clear.
2	Slightly winter-killed	Medium, or good.	Fair; a little uneven, jointed	3 "	3 "	Almost white, very clear.
3	Not damaged; looks well	Very Good	Good and even	3 "	3 "	Very deep yellow.
4	Not damaged; looks very well . .	Fine	Fine; very even	3 "	3 "	Pale yellow.
5	About 15 per cent. winter-killed .	Good	Fair, uneven, dark green, jointed	3½ "	3½ "	Deep golden yellow.
6	Slightly winter-killed; fair . . .	Fair	Fair, uneven, jointed . .	3½ "	3 "	Medium yellow.
7	Not damaged; looks very well . .	Good	Good and even	3⅔ "	3 "	Dull yellow.
8	About 20 per cent. winter-killed .	Fair; not good stand	Dark green, uneven, growing well	3¼ "	3 "	Pale yellow.
9	Slightly winter-killed; looks extra well	Good	Fine; even	3 "	2¾ "	Pale yellow.
10	Slightly winter-killed; looks extra well	Good	Good; fairly even	3 1 6"	2¾ "	Golden yellow.

The following table gives the fertilizers used, the amount applied per acre, and the yield of wheat and straw calculated per acre :

TABLE 5. Effect of Fertilizers.

No. of Plot.	Fertilizers Applied, and Amount per Acre.	Yield per Acre. Wheat (Bushels.)	Yield per Acre. Straw (Pounds.)
1	None	$33\frac{1}{3}$	3510
2	Acid Phosphate, 300 lbs	$32\frac{1}{2}$	3510
3	*None	32	3600
4	Muriate of Potash, 100 lbs	$34\frac{1}{6}$	3960
5	Dried Blood, 150 lbs	29	3600
6	None	$31\frac{2}{3}$	3460
7	Acid Phosphate, 300 lbs.; Sulphate of Potash, 100 lbs.	35	3440
8	Acid Phosphate, 300 lbs.; Dried Blood, 150 lbs.	35	3470
9	Sulphate of Potash, 100 lbs.; Dried Blood, 150 lbs.	35	3390
10	Acid Phosphate, 300 lbs.; Sulphate of Potash, 100 lbs.; Dried Blood, 150 lbs.	$33\frac{1}{3}$	2960

* 200 lbs. Sulphate of Potash on potato crop which preceded the wheat.

These results are surprising, in that those plots having no fertilizers produced nearly the same yield as those fertilized. The appearance of the early growth was all in favor of the potash plots. It would appear from these results that this soil did not need fertilizers for wheat. Conclusions, however, should not be made from one year's trial, as the season may have a marked effect. These experiments will be continued from year to year on the same plots.

The series of experiments with fertilizers on Extra Early Oakley Wheat, described in previous Bulletins, was not continued this year, but this wheat was planted on the same plots as formerly, to show the effect of fertilizers remaining in the soil. These plots are situated near the College building, and as the soil differs from that of the College farm proper, the following description is quoted from Bulletin No. 15, of this Station :

"As in former years, these experiments were conducted on a piece of land used formerly as a fair ground, and now a part of the College inclosure.

"The soil is a typical blue-grass soil, a medium loam, two to three feet in depth, resting on a porous, reddish subsoil of the same nature as the surface soil. This subsoil rests on blue limestone, quite cavernous, producing a fine natural drainage. The subsoil varies in depth from three to ten feet. The field has been in cultivation five years—two in tobacco, one in potatoes and the last two in wheat. The field inclined slightly from No. 1 to 10. Each plot was separated from those adjacent by a path of three feet."

The plots were one tenth acre each.

While the effect of the fertilizers is not well marked, it is still evident that there is a slight advantage in favor of the fertilized plots, and the yields of the last season show perceptibly the effects of the fertilizers applied in former years.

The following table shows the yield of grain and straw calculated to the acre, for the past three seasons, and the average of the three seasons, for each plot:

TABLE 6. Fertilizer Experiments with Wheat for Three Years on the Same Plots.

No. of Plot.	Fertilizers Applied in 1886–7 and 1887–8, and Amount per acre.	Yield of Wheat, bu. per Acre.				Yield of Straw in lbs. per Acre.			
		1886–7.	1887–8.	1888–9*	Average.	1886–7.	1887–8.	1888–9*	Average.
1	None	16.7	19.9	20	18.9	2195	1940	2500	2212
2	Acid phosphate, 600 lbs.; Sulphate of potash, 200 lbs.; Sulphate of ammonia, 300 lbs.	17.2	30.1	22	23.1	2240	2970	3120	2777
3	Acid phosphate, 600 lbs.; Sulphate of potash, 200 lbs.	16.2	26.9	25½	22.9	1928	2605	3200	2578
4	Acid phosphate, 600 lbs.; Sulphate of ammonia, 300 lbs.	18.1	27.4	25	23.5	1996	2635	2740	2457
5	Sulphate of potash, 200 lbs.; Sulphate of ammonia, 300 lbs.	16.3	26.7	24½	21.8	2230	2775	2960	2655
6	None	17.0	26.3	24	22.4	2407	2480	3000	2629
7	Homestead corn and wheat grower, 600 lbs.	16.0	25.7	24½	22.1	2135	2400	2940	2492
8	Bone meal, 400 lbs.	18 0	29.7	24⅝	24.2	2230	2930	3500	2233
9	None	15.9	23.3	18⅔	19.3	2240	2390	1540	2057
10	Muriate of potash, 200 lbs	19.2	20.9	....	20.1	2445	2380	...	2413

* No fertilizers were applied this year.

THE GRAIN LOUSE.

(*Siphonophora avenæ.*)

BY H. GARMAN, ENTOMOLOGIST AND BOTANIST.

It seems appropriate, at the present time, to notice an insect which has this year diminished the value of the wheat crop of this State to the extent of thousands of dollars, and, including several others of the middle States, has probably occasioned a loss to the country of not less than a million. By correspondence and in conversation, we get almost invariable testimony to the effect that the injury of the grain louse was the cause of a light yield of the late-planted grain. The season was, on the whole, a favorable one for small grain, and the promise, as I observed in June during a flying trip through North-eastern Kentucky, seemed unusually good. The surprisingly light weight of wheat threshed out from the product of some fields which were infested with the grain louse, can therefore be fairly attributed to the injury which the plants sustained from the millions of aphides which sucked up the sap day and night during the month of June. It is a good illustration of the fact that a minute insect, without the power of taking a mouthful of solid tissue from a plant, may still cause as serious injuries as the Colorado potato beetle, or the Kansas grasshopper. The following letter, received by Prof. Scovell from Mr. Allen Prewitt, of Mt. Sterling, Ky., is illustrative of testimony received from other sources:

"In reply to yours of the 23d, inquiring what damage the wheat louse did in my vicinity, I would say that the wheat that was a few days early in ripening, was not so greatly damaged. But of later-planted wheat, two-thirds of the crop was destroyed. My own experience was this: I had 38 acres that wintered well, stood well on the ground, and bore large, fine heads. It would have yielded 30 or 40 bushels per acre, but only yielded 10."

Its Proper Name, and the Character of Its Injury.

This plant louse belongs to a group (Hemiptera) of insects, nearly all of which take food in a liquid form, some deriving it from other animals and the remainder from plants. The plant lice live exclusively on living vegetation, which they injure chiefly by appropriating to their own uses the sap containing nutriment, which would otherwise be used by the plants for growth, and for the production of leaves, flowers, seeds, etc. By withdrawing the sap of wheat and oats this plant louse, though it may not leave a mark on the plant, prevents the proper growth and nutrition which would result in sound kernels of grain. It is only one of a great number of species which occur on a variety of plants, such as cherry, vine, corn, maple, cabbage, etc., and has received a good many common names, among which are "green fly," "green midge," "wheat louse," "wheat plant louse," and "grain louse." Perhaps the most convenient and appropriate name is "grain louse," but it is to be remembered that it does not occur on all grains, and that some are infested with other plant lice. The grain louse has been found in corn, rye, barley, various grasses, and wheat.

Its History.

It is believed that this species was originally brought from Europe, where it has been known as an enemy of small grains and grasses for many years. The first notable injury to grain in this country occurred in 1861. Since then it has become destructively abundant only at intervals of several years.

The Influence of the Weather on Its Development.

Dry seasons are favorable to this plant louse, and we have had a succession of dry summers and a dry early spring to account for the abundance of the pest this year. During seasons unfavorable to its welfare, only a few colonies of lice can be found in grain fields, and these little groups perpetuate the species until a period of favorable weather gives them an opportunity to take possession of the fields. Doubtless a close search at any time during the last five years would have discovered this plant louse in small numbers, and it is to these that we must look as the source of the multitude of last June.

Its Manner of Producing Young.

Most insects reproduce at all times by means of eggs. Plant lice reproduce by eggs only at yearly intervals. During the summer months the young are brought forth alive, all the adult individuals at this time being females, and it is not till fall, generally, that a generation of egg-laying lice is produced. The eggs laid by this generation carry the insect through the winter, and the following spring hatch as females, which produce living young when adult. It is a method which permits a very rapid increase of numbers whenever a favorable opportunity comes. The grain louse agrees in its life history with this account, but is sometimes found in winter under circumstances which have led to the belief that it produces its young alive at all times.

Its Summer History.

With a view to finding where the grain louse passes the summer months, I have carefully examined the volunteer wheat, oats, and the grasses and weeds of stubble fields during the months of July and August just past, but have not found lice on any of them. I have little doubt, however, that some of the plants support scattered colonies. Occasional colonies, several of large size, were found on early corn. The lice persisted here as long as the corn remained green, when winged females were produced, which scattered to other plants. Some of these lice have been kept on young wheat and oats at the Station building up to the present time, and have produced numerous generations of viviparous females. This discovery completes, in a measure, our knowledge of the summer history of this pest.

Its Winter and Spring History.

In the fall of the year the lice desert the scattered plants on which they have lived during the summer, and resort to winter wheat, and as cold weather comes on descend to the underground part of the plants and to the roots. Here they remain till late in the season—some writers say all winter. But it is safe to say, from what we know of related plant lice, that at some time a brood of egg-laying females and of males is produced, the species probably passing some part of the winter in the egg-state. In spring the lice pass up the plants again, and ultimately we find them on the heads of the infested grain.

Its Dissemination.

Its singular manner of reproduction permits the grain louse to multiply at an enormus rate, and, with such unusual fecundity, the accidental transportation of lice by winds and birds would probably be sufficient to distribute it rapidly and widely. But it is not dependent on such means as these. Though commonly sluggish of habit, and remaining with its beak inserted in the plant, it is capable of moving about quite freely, and can easily pass from plant to plant by means of the ordinary three pairs of legs, with which it in common with other true insects is provided. Moreover, the winged lice, to which we have referred, are evidently meant for the dissemination of the species, and to this end possess a pair of ample wings, which they are prompt to use when necessary. The winged lice are produced at any time during the summer, their development being influenced by the ripening or drying out of the plants. Thus when the wheat ripens, they leave the hard and dry plants to found new colonies on growing vegetation, a fact which last spring led to the belief that they had been destroyed by the rains, or by parasites.

Its Enemies.

The helplessness of plant lice makes them the prey of numerous predaceous and parasitic insects. A visit to infested wheat fields in June showed great numbers of these present among the lice. Undoubtedly the injury to grain was very much lessened by the work of these friends of ours, yet, as we have shown, lice still exist in the fields, and they are liable again to assume destructive numbers.

Chief among the enemies of the grain louse are certain small, dark-colored, four-winged flies, which belong to the same order as the common honey bee. These little flies deposit their eggs in the bodies of the plant lice, placing a single egg in each louse, and from the eggs come small grubs, which live in the interior of their hosts, finally emerging as egg-laying flies. Grain lice infested with these grubs become swollen, assume a brown color, and by some means are fastened to the plants, where they remain as empty skins after the parasite emerges.

Small two-winged flies about $\frac{5}{16}$ inch long, with brassy brown thorax, and with the abdomen striped crosswise with black and yellow, also do good service in destroying the lice. They scatter their eggs among the colonies, and from these hatch greenish larvæ, which destroy the lice by seizing them and sucking their juices.

The lady bugs in both larval and adult stages devour the lice bodily. Several species of these beetles were common in the fields, but the most conspicuous from size and abundance was the 9-spotted lady bug (*Cocinella 9-notata*). It may be recognized by the arrangement of the nine black spots on the brown wing covers—four on each side, the ninth just behind the thorax and overlying the middle line. It is very nearly a half sphere in shape. The other species are like it in general shape, but differ in details of color and markings. A small list of other insects which do more or less good in destroying the aphides could be given, but this will suffice to give an idea of the more abundant and useful of our insect friends.

Birds have been thought to destroy the lice, but I have seen no evidence of their doing so. Most birds depend on larger insects, and it is only occasionally that the small species, such as warblers, eat plant lice of any kind. Excepting the Maryland yellow-throat, birds of this family rarely occur in our grain fields, so that we can hope nothing from their help. The English sparrow, with its clumsy beak and grain-eating propensity, certainly does no good in this direction.

Artificial Remedies.

There can be little doubt but that an application of kerosene, in emulsion, or of some one of the arsenites, such as London purple,* would destroy the lice, and it is largely a question as to whether the cost of making the application to grain would exceed the resulting gain in the value of the crop. This can only be determined by experiments, which we have had no opportunity to make. I believe, at present, that experimental plots and small fields, when badly infested, can be profitably treated in this way. The best time to apply insecticides would probably

*The fact that arsenic will kill many insects, when applied to the skin, is not as well known as it deserves to be. By experiment, I find London purple more destructive to grain lice than pyrethrum.

be in the spring, after the lice have left their winter retreats, and before the development of the heads of the grain. An application just before harvest would very likely mar the quality of the grain. In the fall an application of insecticides would hardly prove of value, because many of the lice are then concealed in the earth.

Where fall wheat is found to be very badly infested it may, in some cases, be well to destroy the wheat in order to prevent the spread of the pest. For this purpose a plentiful supply of fresh gas lime may be employed. This material has proved very useful for destroying certain insects in Europe, and, in addition to its insecticidal properties, is a fertilizer of some value.

The Probable Injury in the Future.

From what we know of insects of this kind we cannot expect unfavorable weather or insect enemies to prevent future outbreaks of this pest. At intervals during the past, outbreaks similar to that of last spring have occurred, and from the scattered lice now in the fields we may expect still others. But the history of the grain louse shows that destructive outbreaks occur only at long intervals, and unless the weather between now and next harvest is very dry, the probability is that the attack will not be repeated on an extended scale next year. However, it is well to go armed, and to this end it is needful that growers of small grain should familiarize themselves with the grain louse and its habits, so that next time it may be recognized soon enough to make preventive measures availing.

Description of the Grain Louse.

The fully-grown plant lice are rather less than a tenth of an inch long, with the body a little flattened from above downward (depressed), and widest behind. Each bears a pair of slender feelers (antennæ), a jointed beak which it holds close against the underside of the body when not in use, three pairs of jointed legs, and towards the hind end of the abdomen are two short tubes (cornicles) with open extremities. The general color is pale green, varying sometimes to pale brown. A series of small spots along each side of the abdomen, most of the antennæ, the tips of the thighs, the feet, and in winged examples the greater part of the thorax, are black. About the bases of the cornicles a rust-brown color is generally apparent. This brief description will enable any one to distinguish the lice from other insects which occur on small grain. Where the grain louse occurs on corn it may be distinguished from the corn louse by the brighter green color and by a characteristic black spot about the base of each cornicle of the latter.

BULLETIN No. 22.

Potato Experiments.—1889.

Our potato experiments were continued this year, and may be conveniently considered under the following heads:

1. Test of Varieties.
2. Methods of Planting.
3. Preparation of Seed.
4. Testing the Effect of Fertilizers.

The conclusions reached from the year's trials are briefly summarized below.

1. Many new varieties produced a larger yield than either the Early Rose or Burbank. Notably among the large yielders may be named the Irish Wonder, producing 389, Gen. Logan 296, Lombard 281, American Magnum Bonum 280 bushels per acre, while the Burbank and Early Rose produced, respectively, 209 and 184 bushels per acre.

2. The trench system of planting produced no marked effect as to the yield over the usual method of planting. The yield was greater in forty-eight out of fifty-five trials where potatoes were planted fourteen inches apart in the row than where planted twenty inches. On the contrary, the proportion of large to small potatoes was in favor of the twenty-inch planting.

3. Planting large whole potatoes largely increased the yield over planting potatoes cut to two eyes, or cut in two, or small whole potatoes. The yield was in proportion to the weight of seed potatoes planted.

4. The yield was largely increased by the use of fertilizers.

containing potash. Where fertilizers containing no potash were used no increased yield was obtained.

5. A profit was obtained by applying potash fertilizers, or fertilizers in which potash was one of the ingredients.

In general, the conclusions reached this year as to the "Methods of Seeding" and "Testing the Effects of Fertilizers," agree with those obtained last year, although the seasons were unlike.

A detailed report of the experiments, explanations and discussions of conclusions are given in the following pages:

Test of Varieties.

The soil of the Experiment Station farm, on which all of our experiments are made, is what is called a "Blue-grass" soil. It is derived from the limestones of the Trenton group of the Lower Silurian. These limestones in general are rich in phosphoric acid. The subsoil of the farm is a light-colored clay, not easily permeable by water, and therefore the ground is generally wet and cold in the early spring. The farm has been in cultivation many years.

The field on which the varieties were grown is quite level, and well adapted to the experiments, as the various plots have proven quite even in fertility heretofore. The soil is well worn by continued cultivation.

Cotton seed hull ashes containing 32.66 per cent. of potash, at the rate of 400 lbs. per acre, were applied to each plot in the row, and well mixed by the use of a hoe before the potatoes were planted. For seed, medium-sized to large potatoes were cut in pieces as nearly of equal size as possible, and containing from two to three eyes each. These were planted cut side down, one-half of each plot 14 inches apart, and the other half 20 inches, in rows 3 feet wide.

All the varieties were planted April 6, and covered to a depth of about 4 inches. In the cultivation all plots were treated alike. At the third cultivation the soil was thrown to the rows.

Each variety was planted in a row 180 feet long, making one-eightieth of an acre in each plot.

The stand in almost every case was nearly perfect. The number of missing hills in each plot was noted, and in calculating the yield per acre the calculations were made to perfect stand.

The field notes as to the appearance of the vines from time to time have been summarized and put into the following table:

TABLE 1. Giving Summary of Field Notes as to Growth.

Name of Variety.	When up.	Appearance. May 15.	June 1.	In bloom June.	July 1.	Vines Dying.
Irish Wonder	May 12	fair.	good		fine.	July 15
Weld's No. 40	" 11	"	fr. to good	12	"	" 10
Early Ohio	" 7	"	"	12	.....	" 1
Gen. Logan	" 11	"	good	...	"	" 15
Fearnaught	" 12	weak.	"	25	good	" 11
Weld's No. 22	" 12	fair.	only fair	12	fair.	" 11
Pearl of Savoy	" 1	"	fair.	12	only fair	" 11
Early Durham	" 1	"	good	10	fine.	" 10
Brownell's No. 31	" 6	"	"	12	"	" 20
Yellow Elephant	" 6	"	"	10	looks well	" 18
Thorburn	" 6	weak.	"	12	good.	" 5
Cayuga	" 12	"	medium.	15	fair.	" 15
Rubicund	" 12	fair.	fair.	25	good	" 18
Early Sunrise	" 6	weak.	"	15	fair.	" 10
Salt Lake Queen	" 12	fair.	medium.	15	good	" 18
American Giant	" 12	"	"	15	fair.	" 20
White Beauty of Hebron	" 12	"	fair.	12	good	" 20
Electric	" 9	"	good	12	fine.	" 10
Early Dawn	" 8	"	"	10	good	" 5
Charter Oak	" 12	"	"	...	fine.	" 15
Lee's Favorite	" 6	"	fine.	15	"	" 5
Lombard	" 9	weak.	good	10	good	" 20
New Champion	" 12	fair.	fair.	10	"	" 15
White Elephant	" 6	"	good	16	fine.	" 18
Weld's Jumbo	" 9	"	"	15	good	" 18
Early Harvest	" 8	"	"	12	"	" 15
Farina	" 12	"	only fair	15	fair.	" 18
American Mag. Bonum	" 8	"	very fine	15	choice.	" 18
Boston Market	" 8	"	good	15	good	" 15
Early Modena	" 12	"	fair.	10	only fair	" 10
Silver Skin	" 12	weak.	weak.	20	fair.	" 15
Gov. Foraker	" 12	"	fair.	10	"	" 15
Alexander's Prolific	" 12	fair.	good	12	good	" 20
McFadden's Earliest	" 8	"	fair.	10	only fair	" 15
Manitoba	" 12	weak.	only fair	24	good	" 18
Chas. Downing	" 12	fair.	good	15	fine	" 10
Crane's Keeper	" 12	"	fair	5	medium.	" 10
Dakota Seedling	" 12	"	medium.	18	"	" 15
Lake Erie	" 12	"	fair.	25	fair.	" 15
Burpee's Superior	" 12	"	"	15	only fair	" 20
Summit	" 7	"	good	10	fine	" 15
James G. Blaine	" 9	"	"	15	good	" 10
Home Comfort	" 12	"	"	15	"	" 15
Alpha	" 9	"	"	15	"	" 10
Nevada White	" 10	"	"	5	fine	" 15
Sunlit Star	" 6	"	fair.	15	good	" 5
Dakota Red	" 12	weak.	"	15	only fair	" 15
Grenada	" 12	fair.	"	15	good	" 20
Hale of Dakota	" 8	"	"	12	fair.	" 8
Triumph	" 8	"	"	10	"	" 15
Iron Clad	" 8	"	"	10	good	" 15
Gov. Cleveland	" 12	fair.	good	10	medium.	" 20
Burbank	" 12	"	fair.	15	only fair	" 22
Unknown	" 9	"	good	15	good	" 18
Alexander's No. 1	" 9	"	fair.	15	fair.	" 15
Early Rose	" 9	medium	"	12	good	" 15

Yield of the Varieties.

The following table shows the yield of the different varieties. They are named in the order of their yield. The potatoes were planted 14 inches apart in the row:

TABLE 2. Giving Yield of the Varieties.

Number.	Name of Variety.	Yield in Bushels Per Acre.		
		Marketable	Small.	Total.
1	Irish Wonder	211	178	389
2	Gen. Logan	245	51	296
3	Lombard	193	88	281
4	American Magnum Bonum	237	43	280
5	Dakota Red	211	64	275
6	Nevada White	206	64	270
7	Yellow Elephant	193	71	264
8	Alexander's Prolific	179	64	243
9	Burpee's Superior	202	40	242
10	Weld's Jumbo	208	32	240
11	Gov. Cleveland	192	48	240
12	Summit	160	67	227
13	Salt Lake Queen	184	40	224
14	Cayuga	188	31	219
15	Silver Skin	171	48	219
16	Charter Oak	174	44	218
17	Brownell's No. 31	171	45	216
18	White Beauty of Hebron	168	46	214
19	Burbank	157	52	209
20	American Giant	176	32	208
21	McFadden's Earliest	160	45	205
22	White Elephant	149	53	202
23	Thorburn	157	40	197
24	Lake Erie	160	36	196
25	Alexander's No. 1	139	56	195
26	Jas. G. Blaine	136	59	195
27	New Champion	157	37	194
28	Pearl of Savoy	125	64	189
29	Fearnaught	165	23	188
30	Gov. Foraker	147	40	187
31	Early Dawn	139	48	187
32	Weld's No. 40	167	17	184
33	Early Rose	133	51	184
34	Lee's Favorite	119	65	184
35	Chas. Downing	142	40	182
36	Snow Queen	152	29	181
37	Early Durham	131	43	174
38	Early Sunrise	120	54	174
39	Manitoba	125	48	173
40	Alpha	120	53	173
41	Rubicund	116	55	171
42	Early Harvest	112	53	165
43	Boston Market	109	53	162
44	Sunlit Star	103	57	160
45	Home Comfort	. . . . . .	. . . . . .	155
46	Unknown	. . . . . .	. . . . . .	155

TABLE 2.—Continued.

Number.	Name of Variety.	Yield in Bushels per Acre.		
		Marketable.	Small.	Total.
47	Early Modena	99	51	150
48	Electric	120	29	149
49	Farina	100	49	149
50	Early Ohio	120	21	141
51	Weld's No. 22	125	3	128
52	Dakota Seedling	89	31	120
53	Grenada	......	......	104
54	Iron Clad	......	......	91
55	Crane's Keeper	73	17	90
56	Hale of Dakota	......	......	53
57	Triumph	......	......	27

The results show that the Irish Wonder exceeds all others as to total yield, but two others exceed it in yield as to marketable potatoes.

The Early Rose and the Burbank, the varieties usually grown in this vicinity, fall short of the best yielders.

In studying these results, the fact should not be overlooked that a variety showing a greater or less yield than some other in any one year is not conclusive proof that it will do so year after year. The indications are in favor of the very large yielders. Those producing from large to fair yields will be tried again.

Quality of the Different Varieties.

While the yield should have its influence, the quality should have due consideration in the selection of potatoes. A good yielder may be worthless on account of its poor quality. The quality of a potato is supposed to depend on the amount of starch it contains, or, as the dry matter is mostly starch, it is often taken as a standard by which to judge the quality. The size of a potato also has its influence.

The following table shows the relative quality of the varieties as indicated by the amount of dry substance found in each, and the size by the weight of one potato. A good potato should contain from 23 to 25 per cent. of dry substance, or, in other words, should not contain over 77 per cent. of water:

TABLE 3. Showing Quality and Size of the Different Varieties.

Name of Variety.	Dry substance in 100 parts.	Water in 100 parts.	Average weight of one Potato.	Specific Gravity.
1. Home Comfort	27 6	72.4	3¼ oz	1.1051
2. Chas. Downing	26.4	73.6	2½	1.0999
3. Farina	26.1	73.9	3¼	1.0987
4. Alexander's Prolific	26.0	74	3¾	1.0984
5. Brownell's No. 31	25.6	74.4	4¼	1.0966
6. Gov. Foraker	24.9	75.1	3	1.0941
7. Early Modena	24 8	75.2	2¾	1 0937
8. Yellow Elephant	24.8	75.2	3¾	1.0936
9. Early Dawn	24.6	75.4	3¾	1 0925
10. Rubicund	24.6	75.4	3¾	1.0924
11. Burpee's Superior	24.6	75.4	5½	1.0925
12. Pearl of Savoy	24.5	75.5	3½	1.0922
13. Electric	24.5	75.5	3½	1.0922
14. Dakota Seedling	24.5	75.5	3¼	1.0921
15. Alpha	24.4	75.6	3	1.0916
16. James G. Blaine	24.3	75.7	3¾	1.0915
17. White Elephant	24.2	75.8	2½	1.0909
18. Early Ohio	24.1	75.9	3¼	1.0906
19. Early Durham	24.0	76	3¼	1.0903
20. Manitoba	24.0	76	4¼	1.0904
21. McFadden's Earliest	23.9	76.1	4¼	1 0898
22. Summit	23 9	76.1	4	1.0896
23. Lee's Favorite	23.8	76.2	3¼	1.0894
24. Sunlit Star	23.8	76.2	3¼	1.0893
25. American Magnum Bonum	23.7	76.3	3¼	1.0891
26. Early Sunrise	23.7	76.3	3	1.0892
27. Alexander's No. 1	23.7	76.3	3¼	1.0888
28. Boston Market	23.7	76.3	3½	1.0891
29. Thorburn	23.7	76.3	3¼	1.0891
30. Gov. Cleveland (Brownell's 55)	23.6	76.4	3¾	1.0885
31. Early Rose	23 6	76.4	5½	1.0885
32. Snow Queen	23.5	76.5	4¼	1.0878
33. Lake Erie	23.5	76.5	4½	1.0881
34. Lombard	23.4	76.6	4½	1.0877
35. Nevada White	23.4	76.6	4¼	1.0875
36. Early Harvest	23.3	76.7	3½	1.0871
37. Fearnaught	23.1	76.9	6½	1.0864
38. Crane's Keeper	23	77	2¾	1.0860
39. Salt Lake Queen	23	77	4	1.0859
40. White Beauty of Hebron	22.7	77.3	5¾	1.0846
41. General Logan	22.7	77.3	5¾	1.0846
42. Charter Oak	22.7	77.3	4¾	1.0848
43. American Giant	22.5	77.5	6	1.0841
44. Weld's No. 40	22.4	77.6	4½	1 0834
45. Silver Skin	21.9	78.1	4½	1 0812
46. New Champion	21.5	78 5	4½	1.0794
47. Weld's No. 22	21.4	78.6	5¼	1.0791
48. Irish Wonder	21.3	78.7	4¾	1.0786
49. Weld's Jumbo	21.1	78.9	5½	1.0779
50. Dakota Red	21.0	79	5¾	1.0774
51. Cayuga	20.8	79.2	5½	1.0768

Different Ways of Planting.

1. *The trench system vs. the usual method.* A few experiments were made to compare the trench system of planting with the usual method. The trials were made both with Early Rose and the Burbank, and in each case the comparison was made first with well-rotted stable manure, and second by fertilizing with cotton seed hull ashes, using at the rate of 500 pounds per acre. The furrows for the trench were made eight inches deep, and the manure or cotton seed hull ashes put in the bottom of the furrows and mixed with dirt, then potatoes planted and furrow filled until it was level with the surface. In the "plain furrow" the method of fertilizing was the same, but the furrow was made shallow, and the potatoes were not covered over four inches deep.

The subjoined table gives the yield calculated per acre in each of the experiments:

TABLE 4. On Methods of Planting.

Method of Planting.	Yield in Bushels per Acre.					
	Early Rose.			Burbank.		
	Marketable.	Small.	Total.	Marketable.	Small.	Total.
Eight inch trench with compost . .	215	40	255	297	152	449
Plain furrow with compost	320	84	404	423	113	536
Eight inch trench Cotton Seed Hull Ashes	332	71	403	372	135	507
Plain furrow Cotton Seed Hull Ashes	274	68	342	409	90	499

2. *A comparison of yield resulting from planting potatoes 14 and 20 inches apart in the row.*

As stated under the head of Test of Varieties, one-half of each plot of each of the various varieties was planted 14 inches apart, and the remainder 20 inches apart in the row. The table which follows gives the yields of the varieties by the two methods:

TABLE 5. Giving Yield of Potatoes when Planted 14 Inches and 20 Inches in the Row.

Name of Variety.	Yield in Bushels per Acre.					
	Marketable.		Small.		Total.	
	Pl'nt'd 14 in. in row.	Pl'nt'd 20 in. in row.	Pl'nt'd 14 in. in row.	Pl'nt'd 20 in. in row.	Pl'nt'd 14 in. in row.	Pl'nt'd 20 in. in row.
Irish Wonder	211	182	178	180	389	362
Gen. Logan	245	232	51	43	296	275
Lombard	193	184	88	153	281	237
American Magnum Bonum	237	213	43	31	280	244
Dakota Red	211	147	64	48	275	195
Nevada White	206	167	64	55	270	222
Yellow Elephant	193	199	71	53	264	252
Alexander's Prolific	179	160	64	32	243	192
Burpee's Superior	202	168	40	25	242	193
Weld's Jumbo	208	182	32	33	240	215
Gov. Cleveland	192	167	48	41	240	208
Summit	160	143	67	57	227	200
Salt Lake Queen	184	131	40	36	224	167
Cayuga	188	175	31	36	219	211
Silver Skin	171	142	48	29	219	171
Charter Oak	174	139	44	44	218	183
Brownell's No 31	171	179	45	43	216	222
White Beauty of Hebron	168	112	46	55	214	167
Burbank	157	147	52	27	209	174
American Giant	176	138	32	27	208	165
McFadden's Earliest	160	139	45	38	205	177
White Elephant	149	146	53	43	202	189
Thorburn	157	136	40	37	197	173
Lake Erie	160	99	36	29	196	128
Alexander's No. 1	139	119	56	52	195	171
Jas. G. Blaine	136	123	59	51	195	174
New Champion	157	102	37	32	194	134
Pearl of Savoy	125	120	64	47	189	167
Fearnaught	165	142	23	24	188	166
Gov. Foraker	147	102	40	36	187	138
Early Dawn	139	139	48	19	187	158
Weld's No. 40	167	171	17	21	184	192
Early Rose	133	88	51	45	184	133
Lee's Favorite	119	87	65	25	184	112
Chas Downing	142	89	40	39	182	128
Snow Queen	152	85	29	35	181	120
Early Durham	131	107	43	19	174	126
Early Sunrise	120	99	54	32	174	131
Manitoba	125	142	48	34	173	176
Alpha	120	76	53	32	173	108
Rubicund	116	109	55	35	171	144
Early Harvest	112	99	53	35	165	134
Boston Market	109	89	53	31	162	120
Sunlit Star	103	59	57	61	160	120
Home Comfort	...	...	...	...	155	171
Unknown	...	...	...	...	155	155
Early Modena	99	107	51	16	150	123
Electric	120	75	29	27	149	102

TABLE 5.—Continued.

Name of Variety.	Yield in Bushels per Acre.					
	Marketable.		Small.		Total.	
	Pl'nt'd 14 in. in row.	Pl'nt'd 20 in. in row.	Pl'nt'd 14 in. in row.	Pl'nt'd 20 in. in row.	Pl'nt'd 14 in. in row.	Pl'nt'd 20 in. in row.
Farina	100	65	49	50	149	115
Early Ohio	120	72	21	14	141	86
Weld's No. 22	125	99	3	16	128	115
Dakota Seedling	89	96	31	24	120	120
Grenada	...	...	...	...	104	...
Iron Clad	...	...	...	...	91	...
Crane's Keeper	73	49	17	26	90	75

From this table it will be seen that in almost every case the total yield is in favor of the plot where the seeds were planted 14 inches apart, but that the relative yield between marketable and small potatoes is generally in favor of potatoes planted 20 inches in the row.

Preparation of Seed.

Five plats were used in these experiments. They were each one-eightieth of an acre in size, and in the same field adjacent to the plots on which the varieties grew. They received the same treatment as to fertilizer and cultivation as the varieties. Northern grown Early Rose was the variety used. In all the plots the potatoes were planted 14 inches apart, and in rows three feet wide.

On plot No. 1 were planted selected large potatoes, cut to two eyes; No. 2, same, cut in two; No. 3, selected large potatoes, planted whole; No. 4, small potatoes, planted whole; No. 5, medium potatoes, cut to two eyes.

The following table shows the yield calculated per acre:

TABLE 6. Methods of Seeding.

No. Plot.	Form Planted.	Yield of Bushels per Acre.			Amount Planted in Bushels.
		Marketable.	Small.	Total.	
1	Large, cut to two eyes . . .	133	51	184	8
2	Large, cut in two	. . . . . .	. . . .	278	24
3	Whole (large).	213	131	344	48
4	Small, whole	173	99	272	17
5	Medium, two eyes.	128	59	187	6

These results show that by planting large whole potatoes there was an increased yield over the usual method of planting of nearly one hundred bushels per acre of merchantable potatoes. This has been our third trial, and each time the result has been the same, that is, by planting large whole potatoes, instead of cut potatoes, there follows an increased yield in the crop.

This is substantiated by comparing results obtained by many similar experiments throughout the country. It seems, therefore, that the yield is in direct ratio to the weight of seed planted. Whether it will pay to plant large whole potatoes rather than small or cut potatoes depends largely upon the season and the price of seed potatoes, as well as the price of the harvested crop.

Test of Fertilizers.

Taking into consideration the subsequent use that was to be made of the plots, two fields varying from each other in fertility were selected for these experiments. The field in which plots 1, 2, 3 and 4 were situated is supposed never to have been fertilized before, whereas the other field is thought to have received barnyard manure some four or five years ago. The field on which these experiments were made is quite level; soil of the general character before described; plots each one-twentieth of an acre in size, and separated from each other by paths three feet wide.

The variety of potato planted was Northern grown Early Rose of large size, each potato being cut in two and planted cut side down, 14 inches apart in the row, rows three feet wide. After the ground was well prepared by plowing and harrowing, the rows were marked out with a small plow. Fertilizers were scattered in the rows by hand, and afterwards slightly mixed with dirt with hoes. Fertilizers were applied and potatoes planted April 5th, 1889.

The following table gives the amount of fertilizer applied per acre, and the yield of potatoes on plots 1 to 4:

TABLE 7. Effect of Fertilizers on Potatoes.

No.	Fertilizer Used.	Amount Per Acre.	Yield in Bushels Per Acre.		
		Pounds.	Marketable.	Small.	Total.
1	None		28	59	87
2	Nitrate of Soda	160	43	61	104
3	Acid Phosphate	400	34	53	87
4	Sulphate Potash	160	137	21	158

In studying these results, it should be remembered that commercial fertilizers are applied to the soil for the purpose of furnishing the crops with nitrogen, phosporic acid and potash.

From the above table it will be seen that plot No. 1 received no fertilizer. This plot was left for the purpose of comparison. On plot No. 2 nitrate of soda was applied for the purpose of furnishing nitrogen. This substance contains about 16 per cent. of nitrogen. It is not the only substance that could have been used to furnish nitrogen. Ammonia sulphate, containing about 20 per cent. of nitrogen, or dried blood with about 26 per cent., or tankage, or cotton seed meal, or even bone, could have been used to furnish nitrogen. We used nitrate of soda because it was the cheapest form of nitrogen in the market at the time, and because if we had used tankage, cotton seed meal or bone, we would have had phosphoric acid also, and, therefore, would have been unable to tell, if there had been an increased yield, whether it was the nitrogen or phosphoric acid that produced it.

Acid phosphate was used on plot No. 3 to furnish phosphoric acid. This was ground South Carolina rock, and contained 13 per cent. of phosphoric acid available for plant food. Other phosphates could have been used in place of this to furnish phosphoric acid, as dissolved bone black, containing 18 per cent., or bone, containing 20 to 25 per cent. phosphoric acid; but bone also contains nitrogen, and bone black generally some nitrogen, and, therefore, acid phosphate was selected to test the result as to phosphoric acid.

Sulphate of potash was used on plot No. 4 to furnish potash. The sulphate contained 53.16 per cent. of potash. Muriate of potash, kainite, cotton seed hull ashes, or even wood ashes, are also put in fertilizers to furnish potash.

By referring to the table, it is seen that potash greatly increased the yield, while phosphoric acid alone did not cause any increased yield, and nitrogen but a slight increase. It might seem at first glance that the above experiments were sufficient to tell what fertilizer to use; but such is not the case, for a mixture of any two or of all three of these essential ingredients might be needed, and, therefore, produce better results. For the purpose of testing these various mixtures, the experiments on plots 5 to 10 were undertaken.

For comparison, No. 5 received no fertilizer ; No. 6, nitrogen and phosphoric acid in the form of nitrate of soda and acid phosphate respectively ; No. 7, nitrogen and potash, as nitrate of soda and sulphate of potash respectively ; No. 8, phosphoric acid and potash, as acid phosphate and sulphate of potash respectively ; No. 9, a mixture of acid phosphate, sulphate of potash, and nitrate of soda, in order to have all three of the essential fertilizer ingredients present, viz: phosphoric acid, potash and nitrogen.

As will be seen by reference to the tables, in the experiment where acid phosphate was used, the same amount was applied in each case. The same is true of nitrate of soda and sulphate potash. This was done in order to make the results comparable.

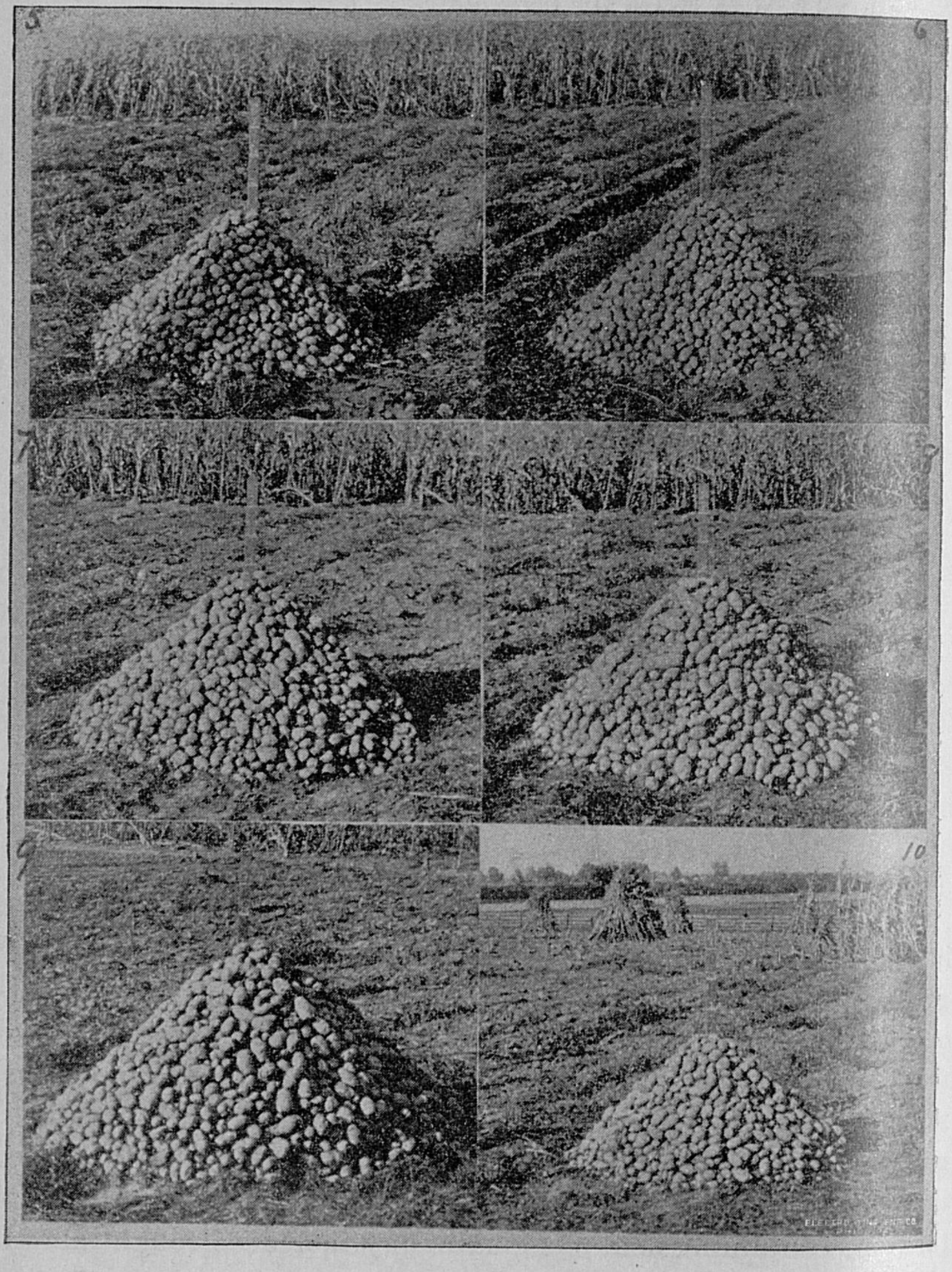
The following table gives the amount of different fertilizers used on plots 6 to 10, and the yield of potatoes:

TABLE 8. Effects of Fertilizers on Potatoes.

No. of Plot	Fertilizer Used Per Acre. Kind.	Amount per acre, pounds.	Yield in Bushels Per Acre. Marketable	Small	Total
5	None	.....	89	54	143
6	Nitrate of Soda Acid Phosphate	160 400	99	62	161
7	Nitrate of Soda Sulphate of Potash	160 160	227	41	268
8	Acid Phosphate Sulphate of Potash	400 160	243	44	287
9	Acid Phosphate Sulphate of Potash Nitrate of Soda	400 160 160	272	47	319
10	Land Plaster	160	84	52	136

Plot No. 10 received land plaster or gypsum. This was put in our trial for the purpose of checking any beneficial effect the gypsum in the acid phosphate might have. In the preparation of acid phosphate there is always some gypsum formed. When these experiments were undertaken it was fair to presume that the acid phosphate might be of benefit, and if so, how much might be due to gypsum in the acid phosphate? With about the same amount of gypsum on plot No. 10 as was contained in the plots containing acid phosphate, any increase brought about by gypsum could easily have been found out.

As the potatoes was dug they were piled up on the plots from which they were gathered. The difference in size of both the potatoes and the piles was very marked. Photographs of the various piles were taken before the potatoes were removed. From the photographs of the piles on plots 5, 6, 7, 8, 9 and 10 a photo-engraving was obtained, and the prints are represented below to show the difference in size of the various piles:



5. No Fertilizer.

6. Acid Phosphate.
Nitrate of Soda.

7. Sulphate of Potash.
Nitrate of Soda.

8. Acid Phosphate.
Sulphate of Potash.

9. Acid Phosphate.
Sulphate of Potash.
Nitrate of Soda.

10. Land Plaster.

The results show:

1. That the yield of potatoes was largely increased by the use of sulphate of potash, either when used alone or in combination with nitrate of soda or acid phosphate or both.

2. It appears that neither acid phosphate nor nitrate of soda, when used separately or in combination with each other, were of much or no benefit, but that when either was used with sulphate of potash the results were beneficial as to yield, the greatest yield being produced when both were applied together with sulphate of potash.

Our results last year indicated that potash was needed on our soil for potatoes. This year adds to the evidence, and especially as the seasons were so different, last year being very unfavorable and this year a very favorable one for this crop. The results of two years' trials, therefore, would lead us to believe that it is potash which is most needed to enrich the soil of the Experiment Station farm for the production of potatoes. They indicate, but do not prove, that worn soils of the same class in the Blue-grass Region would also be improved by the application of potash compounds. This can be determined positively, however, only by similar experiments on the various farms.

These results do not prove that potash is needed for the potato crop on the other geological formations of the State.

The effect of potash in the fertilizers was shown upon the growth of the vines, as well as the yield of potatoes. The vines on the plot containing potash were more thrifty, and were comparatively free from the blight which was more or less destructive to the vines on the other plots. This was very noticeable. The potatoes on the plots containing potash were smoother, larger and more even in size.

Whether the blight had any influence in reducing the size and yield of the potatoes on those plots which received no potash or not is not taken into consideration in the conclusions reached.

The Financial Outcome.

It is evident that if the cost of the fertilizer applied, in any case, is greater than the increase in value of the crop by its use, there will result a financial loss, unless the recuperative powers of the fertilizers extend through more than one year. Leaving out this last consideration, a compilation has been made to show the profit or loss we obtained by the use of the various fertilizers in this instance.

TABLE 9. Showing Profit or Loss by Use of Fertilizers on Potatoes.

No. of plot	Fertilizer.		Value.				
	Name.	Cost	Large	Small	Total	Increased Yield	Profit or loss
1	None	....	$8 40	$5 90	$14 30	....	....
2	Nitrate Soda	$4 80	12 90	6 10	19 00	$4 70	*$ 10
3	Acid Phosphate	4 25	10 20	5 30	15 50	1 20	*3 05
4	Sulphate of Potash	5 00	41 10	2 10	43 20	28 90	23 90
5	None	....	26 70	5 40	32 10	....	....
6	Nitrate Soda Acid Phosphate	9 05	29 70	6 20	35 90	3 80	*5 25
7	Nitrate Soda Sulphate Potash	9 80	68 10	4 10	72 20	40 10	30 20
8	Acid Phosphate Sulphate of Potash	9 25	72 90	4 40	77 30	45 20	35 95
9	Acid Phosphate Sulphate Potash Nitrate Soda	14 05	81 60	4 70	86 30	54 20	40 15
10	Land Plaster	80	25 20	5 20	30 40	....	*80

* Loss.

By referring to the profit and loss column of above table, it will be seen that wherever potash was left out of the fertilizers there followed a loss by using the fertilizers, but where potash was used, either alone or in combination with phosphoric acid or nitrogen or both, a fine profit was realized, the greatest profit resulting where the potash was combined with both phosphoric acid and nitrogen.

The Effect of Fertilizers on the Quality of the Potato.

The following table is compiled to show the effect of the different fertilizers on the quality of the potatoes. Those having the largest amount of dry substance being considered the best. The average weight of a potato also being given for a comparison of size :

TABLE 10. Showing the Effect of Fertilizers on Quality of Po

No. of plot.	FERTILIZER USED.	Per cent. dry substance.	Per cent. water.	Average size of Potatoes.	Specific Gravity.
1	None	22.8	77.2	3½ oz.	1.0850
2	Nitrate Soda	21.8	78.2	3¼	1 0810
3	Acid Phosphate	23.	77.	4¼	1.0856
4	Potash Sulphate	24 5	75.5	5	1.0918
5	None	22.3	77.7	4¼	1 0830
6	Nitrate Soda . . . . Acid Phosphate . . .	22.1	77.9	4¾	1.0817
7	Nitrate Soda . . . . Potash Sulphate . . .	23.2	76.8	5¾	1.0867
8	Acid Phosphate . . . Sulphate Potash . . .	23.2	76 8	7	1.0867
9	Acid Phosphate . . . Potash Sulphate. . . Nitrate Soda	22.7	77.3	6¼	1.0845
10	Land Plaster	23.6	76.4	4	1.0886

INDEX.