

THIRD ANNUAL REPORT
OF THE
KENTUCKY
AGRICULTURAL EXPERIMENT STATION

OF THE
STATE COLLEGE OF KENTUCKY.

FOR THE YEAR 1890.

LEXINGTON, KENTUCKY.

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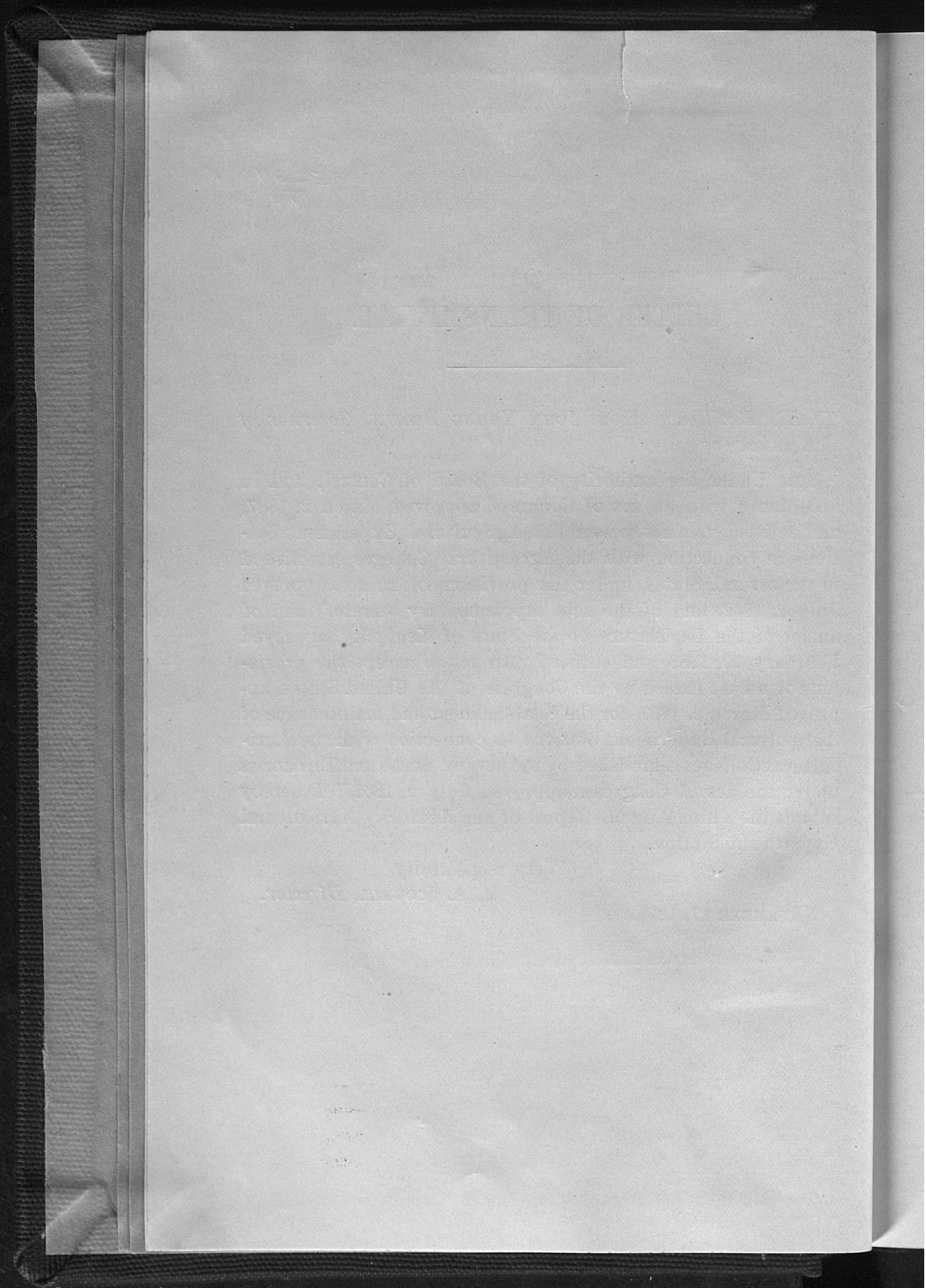
LETTER OF TRANSMITTAL.

To His Excellency, HON. JOHN YOUNG BROWN, Governor of Kentucky :

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 Third Annual Report of the Kentucky Agricultural Experiment Station.

Very respectfully,
M. A. SCOVELL, *Director.*

NOVEMBER 17, 1891.



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Address of the Station, LEXINGTON, KY.

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

1890.

To receipts from the Treasurer of the United States under appropriation for fiscal year ending June 30th, 1890, under act of Congress, approved March 2d, 1887 \$15,000 00

By salaries	\$7,830 00
By labor	2,239 79
By supplies	573 31
By freight and express	165 25
By postage and stationery	161 41
By printing	1,507 65
By library	410 45
By tools, implements and machinery	276 49
By chemical apparatus and supplies	294 94
By furniture	284 10
By live stock	21 20
By incidentals	239 12
By building	512 35
By entomological apparatus and supplies	292 50
By traveling expenses	128 10
By seeds	63 84
	<u>\$15,000 00</u>

We, the undersigned, duly authorized auditors for the institution, hereby certify that we have examined the books and the accounts of the Experiment Station of the Agricultural College of Kentucky for the year ending June 30th, 1890, that we have found them well kept, and correctly classified as above, and that the receipts for the time named are shown to have been \$15,000, and that the corresponding disbursements, \$15,000, for all of which proper vouchers are on file, and have been examined and found correct.

[Signed]

W. B. KINKAD,

HART GIBSON,

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.

W. D. NICHOLAS, *Treasurer.*

Attest: HART GIBSON,

Sec'y of the Board of Trustees.

ANNUAL REPORT

— OF THE —

Kentucky Agricultural Experiment Station

FOR 1890.

REPORT OF THE DIRECTOR.

Our investigations which have been carried far enough along to show results, have been published in the Bulletins of the year which are incorporated in this report. The lines of investigation have almost wholly been confined to field experiments and chemical work, and investigations and the study of entomological and botanical subjects.

In the Chemical Laboratory, practically, the same lines of work were continued this year as heretofore planned out. The study of the composition of the corn plant was continued in connection with the experiments described in Bulletin number 28, and partial results were published in that Bulletin.

In addition to this, some analytical work was done in connection with feeding experiments, to determine the digestibility of English Blue-grass. Six sheep were fed in this experiment, and the work is now practically ended except further chemical investigations.

Fertilizer control work occupied rather more time than usual this year, and numerous analyses were made of samples sent in by the farmers. The analyses of samples sent in by manufacturers as required by our law are published in Bulletin number 29, to which have been added several analyses completed after the publication of that Bulletin.

FIELD EXPERIMENTS.

We have under way 760 field experiments. In Bulletin 23 may be found experiments with oats under the following heads: Test of varieties, depth of sowing, mode of sowing, time of sowing, and amount of seed sown per acre. In the same Bulletin is described a preliminary test with fertilizers on meadow, the results of which indicate that potash fertilizers have a beneficial effect on timothy meadow, but on the English Blue-grass no effect was apparent.

The corn experiments are given in Bulletin 26, strawberries in Bulletin 25, tobacco experiments in Bulletin 28, wheat experiments in Bulletin 30, and experiments with commercial fertilizers on hemp in Bulletin 27.

Professor Garman has issued Bulletins on the broom rape of hemp and tobacco, a new wheat insect in Bulletin No. 30, some strawberry pests in Bulletin 31, and, in Circular No. 3, means of lessening injuries from insects and fungi. Professor Garman publishes in this report further investigations.

PUBLICATIONS.

The publications issued during the year consist of nine Bulletins and one Circular—Bulletins Nos. 23 to 31, inclusive, and Circular No. 3 following. About ten thousand copies of each of these Bulletins have been distributed in the State.

Respectfully submitted.

M. A. SCOVELL, *Director.*

OBSERVATIONS ON FARM PESTS.

BY H. GARMAN, ENTOMOLOGIST AND BOTANIST.

THE CORN ROOT WORM OF KENTUCKY

(*Diabrotica 12-punctata*, Oliv.).

This insect is deserving of special attention just now because it appears to be undergoing a change of habit similar to those undergone in the past by several other native American insects, and probably due to the destruction by the cultivation of land, and by grazing, of the wild plants upon which it has hitherto subsisted. This explanation of its sudden appearance recently over a wide extent of territory as a corn-infesting insect, seems to me the only one warranted by the published facts of its history.

Until 1888, *Diabrotica 12-punctata* did not appear in the literature of economic Entomology as an important enemy of any of our staple crops. Mr. B. P. Walsh, writing in 1866 (*Pract. Ent.*, I, 110) and referring to the beetle, states that "it is very injurious to flowers especially to Dahlias," and infers that it is in part responsible for an injury to the leaves of melons, cucumbers and other plants, of which one of his correspondents complains.

In 1868, Walsh and Riley (*Am. Ent.* Vol. I, 227), in reply to a correspondent in Bushberg, Missouri, wrote of the same beetle: "The yellow beetle with twelve black spots which we herewith illustrate (Fig. 168, twice natural size), and which has been so destructive to your watermelons and Hubbard squashes, is the 12-spotted *Diabrotica*." In the same place, in reply to R. D. Parker of Manhattan, Kansas, these authors state that insects sent to them for determination are also *D. 12-punctata*.

In 1870, Prof. C. V. Riley (2d Missouri Report, 66) wrote

that the beetle "may often be found embedded in the rind of both melons, cucumbers and squashes," a statement which is repeated in 1872 by Mr. E. B. Reed (Ent. Soc. Ont. Report for 1871, 91).

Prof. S. A. Forbes somewhat extends the knowledge of the food habits of the beetle by recording in his report as State Entomologist of Illinois (p. 104) that it was observed August 1, 1882, feeding on the pollen of corn and on the blossoms of clover.

One of the most notable cases of injury by the beetle is that reported in 1888 by the editors of *Insect Life* (Vol. 1, 58). In an orchard at Herndon, Virginia, planted chiefly in 1887, young apricot and plum trees are stated to have been badly injured in late April and early May by the beetles, which devoured the leaves as they unfolded. The land on which the trees were planted was mostly in corn in 1887, but a half acre had been in melons. In concluding their notice the authors use the following words:

"It is safe to say, however, that this occurrence is exceptional, and that it depended almost entirely upon the peculiar circumstances of a young orchard having been planted close to a last year's melon patch, which was not replanted this year. The beetles undoubtedly bred upon the melons last season, and hibernated in large numbers. The present spring, finding no more appropriate food at hand, they took to the young plums and apricots merely as a substitute. We have little fear, therefore, that a new habit has been formed."

What basis the authors had for the positive statement that the beetles bred upon the melons I am unable to say, but it is more than probable, from what is now known of the life history of the insect, that many of the beetles had developed instead on the roots of the corn. These references and quotations will serve my purpose of presenting the insect as it was known to entomologists during the time which they cover. It is to be noticed that no reference is made by the editors of *Insect Life* to the effect that the beetles breed upon melons. If these authors had known at the time their notice was written that larval *Diabrotica 12-punctata* feed on the roots of corn, we may assume that they would have mentioned it in reporting a case in

which the relation between the injury to the trees and the corn-infesting habit is so evident.

During the years 1882 and 1883 Prof. S. A. Forbes made a thorough study of the related *D. longicornis*, which affects the roots of corn in Illinois and other Middle States. In this region *D. 12-punctata* is a very common species, occurring everywhere in gardens and fields on flowers. With the thorough examination of insects from the roots of corn, which, to my knowledge, was made by him, it is altogether unlikely that it would have escaped notice if its larvæ had then been present in any numbers in corn-fields.

In the report for 1887 (published in 1888) of the Entomologist of the National Department of Agriculture, Mr. F. M. Webster states, in a brief notice, that while in Louisiana in 1886, "we frequently heard of fields of young corn being seriously injured during some seasons by a small white worm which attacked the roots, usually during April. From the description given us of the pest, and its manner of attacking the plants, we first thought it might be the larva of *D. longicornis*, as the habitat of that species is known to extend southward to Central America. On April 12 of the present year (1887) we were enabled to solve the problem by finding considerable numbers of these larvæ in a field of corn in Tensas Parish, La., where they were working considerable mischief by killing the young plants. As observed by us, their mode of attack differed from that of their northern congener, in that they did not appear to attack the fibrous roots or bury themselves in longitudinal channels excavated in the larger roots. On the contrary, they burrowed directly into the plants at or near the upper whorl of roots, which almost invariably resulted in the death of the plant. Both of these fields had produced cotton the preceding year. The adult beetles were frequently seen before we observed the larvæ, but they were not abundant about the plants in the corn-fields, being usually on the yellow blossoms of a species of aster which springs up in cultivated grounds early in the spring in great abundance. No pupæ were found, although careful search was made for them."

The above is the earliest notice *D. 12-punctata* as a corn insect of importance which I have seen. Unfortunately the

writer does not state whether his conclusion as to the author of the injury was the result of inference, or was arrived at by carrying the larvæ through their transformations. From the fact that he had not found pupæ up to the time of writing, it is proper to assume that the transformations were not observed. As a possible clue to one of the original food-plants of the larva, attention is directed to the fact that he found the beetles abundant on an aster (from its yellow color it would appear to belong to some other genus) growing on cultivated ground. If, as is not unlikely from an observation made by Prof. Lugger, and reported further on, the plants observed by Mr. Webster are attacked by the larvæ, the fact may have an important economic bearing.

During the years 1889 and 1890, the injury from larvæ to corn attracted attention over a wide area of country. To my knowledge it has been witnessed in Virginia, Alabama, Mississippi, Louisiana, Arkansas, Kentucky, Illinois, Indiana and Ohio.

My own observations began July 15, 1889, and have continued, as other work permitted, to the present time. A brief notice of the insect, its habits and stages, was printed in the Louisville Home and Farm, September 1, 1889, and in November of the same year was followed by a more elaborate account of the transformations and descriptions of the stages, presented before a meeting of the Association of Official Economic Entomologists at Washington. (See Insect Life, Vol. 2, 179.)

The latter paper is embodied in what follows, with the addition of observations made during the winter of 1889-90 and the spring of 1890.

THE INJURY TO CORN.

The larva of this insect works much like its congener, *D. longicornis*, commonly destroying the roots, but often also working on the under-ground part of the stalk. The larva of *D. longicornis* often makes a longitudinal burrow in a root, leaving little outward trace of its presence. The larval *D. 12-punctata* has not been observed to work in this manner, the roots being mined and channeled irregularly, often bored through from side to side, or completely devoured where the worms are abund-

ant. Very few fields in Kentucky are entirely free from injury, and many are affected very injuriously, the damage being perceptible to casual observation in the retarded growth, and, as the seasons advance, in the prostration of infested corn by the winds. As a rule, the injury is greatest on land that retains moisture longest. On high and well drained land it is not so prevalent. In all these respects it agrees with the related corn-root worm of the North.

I have not observed thus far that its abundance has any relation to the land having been previously in corn. The northern species, it will be remembered, is commonly most abundant on old corn land. Two of the worst infested fields examined in 1889, were one in tobacco, and the other in oats, in 1888. A third field, in corn in 1887 and 1888, was in oats in the spring of 1889, these to be followed the same season by a late planting of corn. This difference in the injuries of the two corn-root worms is to be attributed to the fact that *D. longicornis* hibernates in the egg state in the earth or corn-field, whereas *D. 12-punctata* hibernates, at least in great part, as an adult beetle which wanders actively about in fall and spring in search of food. Still, the observation reported in Insect Life concerning injury to orchard trees planted on corn land renders it probable that in some cases beetles which develop in corn land hibernate there. This would certainly be the case at any rate if the corn was very late. *D. 12-punctata* seems to be the only corn root-worm of Kentucky, and certainly is the only generally injurious one. During two seasons' collecting I have not found a single specimen of *D. longicornis* within the limits of the State.

LIFE HISTORY (FOR KENTUCKY).

Young larvæ, noted on the 15th of July, 1889, were mostly grown, and some had pupated in small cells in the earth by the 29th of the same month. Adult beetles dissected at this time contained numerous ova of relatively large size. On August 3d of that summer an examination of infested corn showed that most of the larvæ had pupated or were ready to do so. No very young worms were seen. One adult was taken from an earthen cell, where it had recently changed from a pupa. From

the abundance of females with well-developed ova about fields at this time it seemed probable there was to be a second brood. Subsequent search in the fields did not reveal young larvæ there, and towards the end of August the females disappeared, and none were observed with developed eggs during the remainder of the season. The eggs of these females were certainly not deposited freely among corn that was damaged by the early brood of larvæ. What then became of them? Several large larvæ and pupæ, perhaps from eggs laid by these females, were found among injured corn late in summer, but thorough search at different times showed them to be rare, and I was for a time led to think the species might be single-brooded like the related *D. longicornis*, but on the first of November, 1889, the discovery in a field of late-planted corn of numerous larvæ, together with pupæ and recently transformed adults, gave unquestionable proof of at least two annual broods of the insect for this locality.

The examples collected at this time were chiefly grown larvæ, contracted and ready for pupation, with occasional individuals about three-fourths grown, and a few pupæ, and recently emerged adults.

In my paper, as read at the Washington meeting of Entomologists, I stated that the above facts made it seem probable that the late brood of larvæ fed in part on plants other than corn. In the discussion following Prof. Otto Lugger, of Minnesota, showed the surmise to be well founded by stating that he had taken pupæ at the roots of one of the native Compositæ,—a species of *Rudbeckia*. At my request he has since kindly given me the following definite statement, quoted partly from his notes :

“*Diabrotica 12-punctata*.—September 3, 1889, found among roots of *Rudbeckia* sp., three pupæ of a chrysomelid, nearly ready to issue the imago. September 5, 1889, all three insects appeared above ground in breeding cage. At first white, they soon changed to the normal color, excepting that the black spots were only faintly visible. September 7, 1889, insects mature, and mounted. It is the above species.

“Many specimens occurred at this time upon the above plant and upon *Solidago* and thistles. The majority appeared quite

fresh, as if hatched quite recently. The *Rudbeckia* grew in an old field cultivated some four years ago, but grown up into a wilderness of *Solidago*, *Rudbeckia*, thistles, etc. The nearest field of corn is fully one-fourth mile from this spot."

Prof. Lugger's observation explains the whereabouts of most of the late brood. Very little corn is planted here as late as that in which the second brood occurred, so that ordinarily the beetles must resort to some other plant for oviposition. Five Kentucky species of *Rudbeckia* are known, and in all probability the beetles which emerged from the ground in this vicinity during August resorted to these. The observation also renders it almost certain that the insect is two-brooded at latitudes much higher than this.

The larvæ and pupæ in the field of late planted corn were followed until all had completed their transformations. From the excess of larvæ in November the proportion was gradually changed to an excess of pupæ in December. A short time spent digging about hills of corn on December 5 resulted in finding seven pupæ and two larvæ. Subsequently we experienced a most exceptional period of spring-like weather, and, urged apparently by its influence, all the larvæ and pupæ completed their transformations. On January 16 a close search among the infested roots did not reveal the presence of a single example. Previous to December we had some weather, during which the surface of the ground was frozen. If the winter subsequently had not been so mild, it is safe to assume that the larvæ and pupæ in the frozen ground would not have changed to beetles until the spring of 1890.

The adult beetle has been found abroad at all times when looked for from July 10, 1889, until December, 1890. During the winter it is to be found among rubbish in strawberry beds, in gardens and meadows. During mild days it is often awake, and feeds at such times on almost any green vegetation within reach. It is one of the first insects to become active in spring, and at this time is to be found on grasses, clovers and other plants, feeding on leaves, flowers or pollen. It is during this time, and before the corn is up, that the ova develop in the ovaries of the female. During the fall and winter those taken and dissected contained no developed eggs. In the latter part

of May last spring, when the corn was a few inches high, the females collected contained ova in an advanced stage of development. I was unfortunately unable to find the eggs after oviposition, but there can be no doubt but that they are placed like those *D. longicornis* in the ground at the roots of corn. A search in corn-fields June 3, 1889, resulted in no larvæ. On June 10 they began to appear, and by the close of the month were mostly well grown. On July 5 pupæ were formed in confinement from larvæ brought in June 30th. The pupæ began to appear out of doors about the same time, and the beetles came forth from them during the first two weeks of July, all apparently being out before the 21st. The first brood was thus matured earlier than in 1889, a result, doubtless, of the forwardness of the season of 1890.

REMEDIAL TREATMENT.

A complete remedy for the pest may prove hard to find. If the insect spent the winter in corn-fields in the egg state, as has been determined by Prof. S. A. Forbes to be true of *D. longicornis*, we might hope to avoid injuries by rotation of crops. Since it hibernates in part at least as an adult, and is capable of prolonged flight, rotation would not avail. The food habits too of larva and imago are such as to favor it in the struggle for existence. As a beetle it is a voracious and indiscriminate feeder, and nothing, seemingly, in the way of succulent vegetation comes amiss. Tomato leaves, clovers, potato leaves and tubers, turnips and cabbage have been used to feed beetles kept in confinement. During the latter part of August they are very common here in the ends of corn ears, eating out the silk. It is possible they may do some harm in this way, but I can not see that the affected corn fails to develop the usual number of grains. At times it is scarcely possible to find an ear of corn that does not harbor one or more beetles.

ENEMIES.

Some predaceous beetles and larvæ have been found during summer and fall in the earth with young root-worms, but not in any great numbers. Among birds I find only the brown thrush recorded as eating the beetles.

Several parasites occur in the fluids of the beetles, and can, perhaps, be expected to check any extraordinary increase in the numbers of the root-worm. The most common of these is one of the protozoans, a large Gregarina, probably the same species as that noted some years ago in the fluids of *D. longicornis*. The fluids of examples occasionally swarm also with a small nematode worm, and in one instance a large thread worm with tapering caudal appendage was noted. Occasional beetles have been found affected with an Empusa resembling *E. grylli*, a species commonly known as a parasite of grasshoppers. An interesting bacterial disease of the larva reported by Prof. S. A. Forbes at the Washington meeting of entomologists, is also to be mentioned in this connection, though I have not detected it here in Kentucky.

DESCRIPTION.

Eggs.—Matured ova from ovaries of females are much like those of *D. longicornis*. They are white, oval, with the surface reticulated and sculptured so as to produce numerous hexagonal, pitted areas. Prof. Forbes gives the dimensions of the egg of *D. longicornis* as .025 inch by .027 inch. Ova of the spotted species measure a trifle larger, being about .027 inch in length by .016 inch in greatest diameter.



Fig. 1. Larva of *D. 12-punctata*, enlarged.

Larva.—Body cylindrical, tapering a trifle towards the extremities, composed of twelve segments behind the head. Skin wrinkled, papillose along the sides, white, sometimes becoming yellowish just before pupation. Head dark brown, nearly black in some examples, with a few rather strong hairs arising from the surface; a narrow median longitudinal line of black above, and two pale lines which converge from the bases of the antennæ, following sutures to meet at the middle line on the posterior part of the head; ventral side of head pale medially; no eyes; antennæ of three segments, white; labrum dark brown; mandibles dark brown, black at tips, with four or more blunt denticles; maxillæ pale, armed with numerous strong spines within; labium

pale; cervical shield pale brown, with a narrow median longitudinal white line, broadly triangular in shape; jointed legs, pale, each with a dark brown chitinous supporting frame-work at base; each segment of legs provided with a number of strong hairs; a single brown tarsal claw, beside which arises a white, elliptical striated plate, slightly longer than the claw. Dorsal shield of posterior body segment nearly circular in outline, brown, with numerous minute black specks, slightly rimmed at posterior margin, and in young examples obscurely bituberculate; furnished with several strong marginal hairs, and with four minute striate, centrally-placed, spatulate appendages. Spiracles round, the two anterior pairs sometimes with brown rims, the rest pale. Posterior segment with a single fleshy proleg.

Length about .56 inch, diameter about .06 inch. Examples ready for pupation about .37 inch long.



Fig. 2. Pupa of *D. 12-punctata*, enlarged.

Pupa.—Translucent white, with scattered brown hairs on dorsal side of body arranged as follows: One within, and a pair posterior to, the base of each antenna; a transverse arched row near the anterior edge, a pair near the middle, one at the middle of each side, and one at each side near the posterior margin of the prothorax; four each on the meso-and meta-thorax; three at the extremity of each femur; a pair at the middle and one at each side of each abdominal segment, except the posterior three; antepenultimate and penultimate segments of abdomen each with six, the four inner being in pairs, and posterior to the others; two within, and three without each of the large spines borne on the posterior segment. Caudal spines, straight or curved, black-tipped. Wing-pads covering the posterior femora below. Antennæ curving around the femora of the two

anterior pairs of legs and then extending inwards towards the ventral middle line. Length .22-.25 inch.

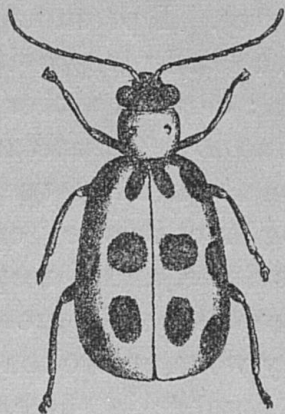


Fig. 3. Imago of *D. 12-punctata*, enlarged.

Imago.—Pale green, or greenish yellow, marked with black. Head and mouth-parts black, the former showing a brownish cast medially on ventral side. Three basal articles of each antenna pale, sometimes with dusky dots on posterior side; remainder of antennæ black. Prothorax uniformly green or yellow. Elytra green or yellow, with twelve large black spots, six on each, arranged in three cross series; the first series at the base, the second at about the middle, and the third midway between the second and the tips of the elytra. Scutellum brown or black; mesothorax beneath the coxæ, the basal third to half of femora, and the abdomen, yellow or green. Metathorax beneath the distal portion of the femora, and the whole of the tibiæ and tarsi, black.

Head with a basal pit behind antennæ. Prothorax above smooth and shining, obsoletely punctulate, with a pair of pits, one on each side of the middle line. Margin of prothorax sinuate at sides; no prominent angles. Elytra minutely, regularly punctulate, each elytron with a humeral prominence. Antennæ, metathorax beneath, abdomen and legs clothed with a fine silken pubescence. Length, .25-.28 inch; antennæ about .19 inch.

For the purpose of making this record more nearly complete, I may be allowed, in conclusion, to call attention to the most recent notice of *D. 12-punctata* known to me, printed in a recent number of *Insect Life* (Vol. 3, 150). The writer, Mr.

Webster, here gives a brief description of the larva, which agrees in the main with that given above. In several points, however, we do not agree. I presume the statement that the posterior segment of the body is provided with a pair of prolegs is a slip of the pen; certainly, there is only one of these in both *D. longicornis* and *D. 12-punctata*. The statement also that the brown plate on the hindmost segment is furnished with a ridge "bearing a long erect bristle" can not be verified on the larvæ collected in this State, and I respectfully suggest, in explanation, that in examples nearly grown some of the hairs on the plate are frequently worn or broken off. The hairs are constant in position and number in the examples I have studied, and none have been seen with a single erect hair arising from the ridge. If these differences in the descriptions are not thus to be explained away, then I submit that we have examined different larvæ, and am content to leave to others the decision as to who has described the larva of *D. 12-punctata*.

SUMMARY.

Omitting details, the above account of the root-worm may be condensed as follows: The injury, consisting of a destruction of the roots of corn, is done by the larva, a small white grub about one-half inch long. The early brood of larvæ occurs at the roots of corn during July, and most of the injury is done in this month. Larvæ of this brood change to quiescent pupæ in cells in the earth in the latter part of July and early part of August. Adult beetles are about one-fourth inch long, are pale green or yellow, with black head, and twelve large black spots arranged in three cross rows on the back. Beetles of the early brood emerge from the ground chiefly from the first to the fifteenth of August. The eggs laid by these beetles are, in some cases, placed at the roots of early corn; in others, at the roots of late-planted corn, but most probably at the roots of native plants along roadsides, edges of fields, etc. Some adults of the late brood coming from these eggs emerge from the ground in the fall during November; others probably remain during ordinary winters as larvæ and pupæ, and emerge as beetles the following spring.

A SUPPLEMENTARY NOTE.

This paper was printed substantially as here presented in the February and March (1891) numbers of *Psyche*. After the manuscript had left my hands and was nearly all in print, I received from Prof. C. V. Riley, of Washington, D. C., a copy of his unpublished notes on the same insect, with permission to use them in what I might subsequently write. In these notes Prof. Riley states that the editors of *Insect Life* meant to say that this corn-worm "fed upon the melons" at Herndon, Va., but were made to say "bred upon" by a typographical error. He further states that more recent observations on the injured orchard at Herndon make it probable that the injury from the corn-worm was overestimated, and that much of that attributed to it was really due to June bugs of the genus *Lachnosterna*. The following quotations and comments on Prof. Riley's notes are from a brief article of mine which appeared in the May number of *Psyche*, 1891:

"My knowledge of the corn-feeding habit of the larvæ of this insect dates from April 30, 1883, when Judge Lawrence Johnson forwarded to me from Allenton, Wilcox county, Ala., a number of larvæ of which he wrote as follows: 'I sent you last week from Allenton specimens of the same destructive 'bud-worm' that I once mentioned as heard of but not seen. This is about the right time, for they are going into the pupa state, and in the sand you will find one of the pupæ. The worm leaves the corn after doing its mischief, and the pupa referred to was found immediately under the stalk among the roots. I have never met with this worm except in the prairie regions of Southern Alabama, but have heard of it in Mississippi.'"

From these larvæ Prof. Riley obtained adults May 21, 1883. He obtained larvæ and beetles from Mississippi in 1884, where they are said to abound in corn-fields from March to the middle of May. In June, 1886, they were reported to him as injuring corn at Mt. Vernon, Virginia, the result being a withering and drooping of the central parts, while in some cases the plants were killed as soon as sprouted. The eggs were obtained by Prof. Riley from females confined with earth, and were placed

in the soil as in the case of *D. longicornis*. Larvæ collected June 18 from infested corn at Mt. Vernon, Virginia, changed to pupæ June 22, and beetles emerged July 6, and produced eggs on the following day. Larvæ from these eggs were first observed July 15. In this connection Prof. Riley continues:

“The above indicates that this insect is at least double-brooded, in which respect it differs in habit from the closely allied *D. longicornis*, which is single-brooded, and winters usually in the egg, though occasionally in the adult state. The second brood of *Diabrotica 12-punctata* doubtless winters over, and deposits eggs about the young corn or other plants in the spring. Eggs of the last brood are also doubtless deposited in the fall and winter over, as is usually the case with *D. longicornis*.’”

I am not at present prepared to believe that the female *D. 12-punctata* produces eggs in the fall of the year. Careful examination of examples taken whenever possible has failed to show ova in the ovaries at any time except in the early spring, just before the first brood of larvæ appear, and again when these larvæ become beetles. After these adults have deposited their eggs no gravid females occur again until the following spring. The search for them has been especially thorough in the fall and winter, and among all the examples dissected during these periods not a single one showed any signs of developed ova.

“The early stages of *D. 12-punctata* are scarcely different from those of *D. longicornis*. The egg is larger, being .03x.02 of an inch as against .025x.015 in the case of *longicornis*. In color, instead of being dirty white, it is dull yellowish. The hexagonal pits are exactly like those on the eggs of *longicornis*, but are perhaps smaller, as there are 30-35 in its entire length as against 20 only in the smaller egg of *longicornis*.’”

The larva is said to differ from that of *D. longicornis* in being larger and in the presence of the two small tubercles at the posterior edge of the caudal plate. The pupæ of the two species are said to differ only in size.

Two dipterous parasites of *D. 12-punctata* are known to Prof. Riley, one a Tachinid obtained from the larva, the other coming from the adult.

THE GRAIN-LOUSE

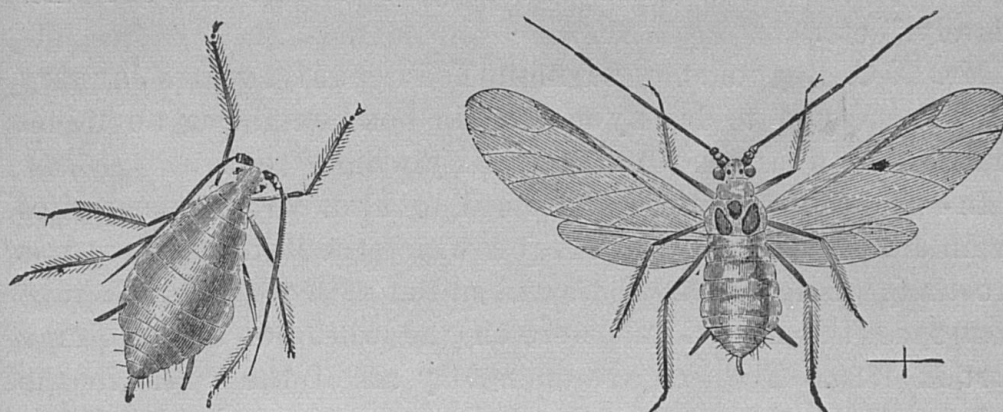
(Siphonophora avenæ).

Fig. 4. Wingless and winged forms of the grain-louse.

This insect has attracted much attention during the season of 1889, and several papers have been published by entomologists in response to the demand for information concerning it. Probably nowhere has it been more injurious to small grain than in this State. The yield of wheat was, in many localities, materially lessened by its injuries, a loss of as much as 60 per cent. of the usual crop having been experienced by some farmers. With the advent in the latter part of June of a host of predaceous insects and parasites the lice disappeared, and nothing was afterward heard of them from farmers until the winter of 1889-90, when, encouraged by the mild weather which prevailed, the lice hidden away in small numbers among barley, fall wheat and volunteer oats again increased in numbers, and appeared on the blades. This winter outbreak was especially severe in the southwestern part of the State, but the unusual activity of the lice was apparent in other parts of the State also. Our attention was first drawn to the injury they were doing, when, on December 11, at a meeting of the State Grange at Louisville, Mr. J. L. Mosely, of Christian county, exhibited a sample of injured wheat, and reported that it was from a field of fifty acres which had been almost ruined by grain-lice. As showing something of the nature of this winter outbreak, the following letters may be quoted:

Mr. J. Bibb Groom, of Sims' Store, Caldwell county, writes under date of January 6, 1890, to Prof. Scovell: "You will find

enclosed a stalk of wheat with numerous little green insects. Please name and give remedy, if there is any. They are on my wheat by the *millions*, and are *killing* it. Please answer immediately," etc.

Mr. C. C. Reynolds, of Trenton, Todd county, writes January 9: "I send you to-day by mail a tin box containing an insect that is quite abundant in all our early wheat," etc.

In response to inquiries addressed to him, Mr. Groom writes again January 13: "The land [on which the injured wheat was growing] was in oats in 1889, and millet in 1888. Chinch bugs destroyed the millet, and were on the wheat of an adjoining plot in 1889. The lice are on nearly all of the wheat in the neighborhood now, though they do not seem to be damaging any but mine seriously. I suppose they have killed about an acre outright. It is hard to estimate, as they are scattered over eight acres in spots of ten to twenty steps square. I have an adjoining piece of twenty acres that was in wheat last year that they have not begun on yet, and have another field of forty acres about one-fourth of a mile off that I have not discovered them in."

Mr. J. A. Browning, Secretary of the State Grange, writes from Church Hill, Christian county, January 13: "After my return from Louisville [in December] I noticed several pieces of wheat where oats grew last year, and in each could, by riding along the road, see the effects of the grain-louse, and have noticed each time I passed that the spots of dead wheat were larger than at the previous time."

. AFFECTED BY THE WEATHER.

At Lexington the numbers of grain lice gradually increased on young oats until about the 20th of January, when severe frosts destroyed much of the volunteer oats, and with it many of the lice which had accumulated upon it. An examination of the frost-killed blades showed a good many dead and blackened bodies there. The suddenness of the change rather than the low temperature, was probably what destroyed the lice in this instance. They endure a very low temperature when this comes gradually, and a good many escaped destruction by concealing themselves at the bases of the plants.

During almost any season a few of these insects can be found by diligent search among wheat and oats, but their numerous enemies and their sensitiveness to vicissitudes of weather serve generally to keep them within bounds. When these from some cause become less efficient, an outbreak takes place such as we have witnessed this year. A series of dry seasons, it has been observed, generally precedes these irruptions, and with an increase in rainfall the plant-lice again disappear. The fact that dry seasons permit the grain-louse to increase to destructive numbers in spite of its insect enemies, which are affected by the same conditions of weather, suggests the existence of a check more potent than these enemies, from which dry weather relieves this enemy of grain. Its power of very rapid multiplication, it may be suggested, permits it to gain for a brief time when circumstances favor, a start on its enemies, which latter reproduce much more slowly. But the power of increase in the plant-louse is something extraordinary, and is quite sufficient, it seems to me, from observations made in the fall of 1889 and the succeeding winter, to enable it to occupy the grain fields each season as it did in the spring of 1889, provided it had nothing to control it but its insect enemies.

AN EPIDEMIC DISEASE OF GRAIN LICE.

The animal parasites and enemies were not observed among the lice at all during the winter; the grain louse was active while they were hibernating. But a check upon the lice was observed in the shape of an epidemic disease caused by the attacks of a microscopic plant like that which, during damp weather, destroys flies and leaves them sticking to walls. The parasitic plant most common among the lice, and most efficient in their destruction, is known to entomologists and botanists as *Empusa planchoniana*. It was extremely common everywhere, both out of doors and on the plant lice kept in the College hot-house. Two other species of the same genus, one of which will probably prove new to science, were also observed attacking plant lice kept in doors, but did not prove common at any time.

Grain lice which were sent to the Station from Southwestern

Kentucky, were quite as badly affected with the disease as those from the vicinity of Lexington, and in one instance a lot received from the Western part of the State, and afterwards kept at the Station on growing wheat, was eventually completely destroyed by the fungus.

The affected grain lice show the presence of the parasite in their bodies by sluggish movements and a gradual change of color from the usual dull green to a uniform reddish brown. They finally die, and often remain with the now swollen body adhering to the blades only by means of the inserted beak. Under the microscope the dead bodies of plant lice collected in the winter were commonly found full of the small spherical, thick-walled spores of the *Empusa*, known as resting or winter spores, because they are produced by the parasite when cold weather sets in, and serve to convey the disease to the lice which appear the next spring.

Now these species of *Empusa* and other parasitic fungi are greatly favored in their development and spread by dampness. They are always more destructive to insects in spring and fall, when rains are most frequent, and become less abundant, or disappear entirely during the dry weather of August and late July. Exceptionally wet summers, such as that of 1889, bring them out in great numbers, and many of our insect pests which live in colonies, or in damp situations, then suffer much from their attacks. This is the reason, I conceive, why prolonged dry periods are times of irruption for the grain-louse and chinch-bug, both of which species are now known to have fungus enemies.

INSECT PARASITES AND OTHER ENEMIES.

Toward harvest time in the spring of 1889, the swollen brown bodies of many grain-lice could be seen glued to the glumes which enclose the grains of wheat. These were lice which had been killed by small four-winged flies, not so much smaller than the grain-lice, but belonging to a different order of insects. These parasitic flies deposit their eggs within the bodies of the grain-lice, and the young grubs hatching from them exist at the expense of the lice, which latter finally die without producing young. The parasites were very common in the spring, becom-

ing most abundant just before the lice disappeared from wheat. Several species have been described, some in England, and others by Dr. Fitch, of New York. Only two species have come to my notice, one, an *Aphidius* very much like *A. avenæ*, of the English entomologist Curtis, was noticed in Illinois, the other, a species of *Trioxys*, became at one time in August very abundant on grain-lice on wheat grown indoors at the Station. No doubt these small flies do much at times to lessen the injuries of grain lice. They are aided in this good work by a number of larger insects of other orders, some of which devour the lice bodily. A brown lady bug (*Coccinella 9-notata*) with large black spots on its back was especially noticeable here from its abundance and activity among the plant-lice. Lace-wing flies were also abundant and useful. The adults of the latter may be recognized by their slender bodies, greenish color, large transparent net-veined wings, and especially by a very offensive odor which they emit when handled. The larvæ of the lace-wing flies hatch from eggs placed on leaves in clusters, each egg attached by a long stalk. The larvæ have flattened bodies, and are provided with a pair of long, curved, sharp jaws which they use, not for biting and chewing, but for piercing and sucking up the juices of their prey. The syrphus flies are small two-winged insects, with the abdomen generally striped crosswise with black and yellow. The flies themselves feed on flowers. Their long white eggs are scattered among the grain-lice, and give rise to footless grubs, which creep about among the lice devouring as they go, and after a time change to pupæ attached to the blades.

Unfortunately birds can not be expected to destroy many of the lice. They do not, as a rule, feed on insects as small as these. Large flocks of the English sparrow roam about the fields when the grain is ripe, but they are undoubtedly attracted there solely by the grain. There need be no hesitation on the score of their possible usefulness in placing poisoned bait in the fields for these birds. Their character as farm pests was well known before they were introduced into this country.

LIFE-HISTORY.

At the beginning of July, 1889, the grain-lice had disappeared from wheat fields, having been destroyed, it was gen-

erally believed, by the numerous lady bugs, lace-wing flies, etc., that had appeared. Some had simply acquired wings and left the ripened grain for growing plants of other kinds. In the latter part of July several colonies, some of large size, were discovered on early corn and transferred to wheat in pots. The descendants of these have been kept ever since at the Station. (Written in the latter part of the winter of 1889-90.) When collected July 25, they were producing living young, and have continued to do so from that time to the present, yielding many generations of wingless and winged viviparous females.

From observations in the fields it has also been made evident that the grain-louse may, at least during mild winters, continue to produce young viviparously all winter. Since October 1 they have been found whenever sought on fall wheat, barley, and in especial abundance on young volunteer oats. The grain-lice found upon early corn were followed until August 15 out of doors. Previously for some time winged lice had been increasing in numbers among the colonies, and these left the corn to resort to other plants. Examples transferred at this time to younger corn also soon acquired wings and disappeared. They were not again observed in the fields until October 1, when a few were found on young volunteer oats at the edge of a corn-field. From this date forth they increased in abundance pretty steadily until the recent frosts (in the month of March) destroyed many of them, and put a stop to the activity of the rest. Some of the lice now in the fields may be expected to escape the epidemic disease, and their insect foes, to begin again their injuries in the spring. The number of these will, I believe, depend very largely on the kind of weather prevailing between now and that time. If the rains continue as frequent as they have been during the two months just past, there is good reason for the belief that the number will be small. (This prediction has since been verified. The grain-louse has done little harm since the winter of 1889-90.)

FOOD PLANTS.

The grain-louse is not confined to the small grains. It is known in Europe to live also on grasses belonging to the genera *Danthonia*, *Hordeum*, *Bromus*, *Dactylis*, *Holcus*, *Glyce-*

ria, Poa, on Sorghum, and on Lady's Thumb (*Polygonum persicaria*). Mr. Oestlund, of Minnesota, adds for this country canary grass, *Phalaris canariensis*, and *Poa annua* to the list of food plants. Indian corn and Kentucky Blue-grass (*Poa pratensis*) are also to be added. It has long been known to me as occurring on the latter grass in the fall of the year. Last fall it was quite common on Blue-grass, and it has thrived indoors upon this grass for the past three months. Its favorite plant during the fall and winter seems to be young volunteer oats, upon which it has been very abundant.

DESCRIPTION.

The grain-louse of the latter part of summer and of winter differs considerably from the form which occurs on grain in spring. The colors of the spring form are paler, and it has been described as having antennæ longer than the body; whereas, in the fall form the antennæ are always, as far as observed, shorter than the body.

According to Buckton the winged viviparous grain-louse has a brown or yellow head, red eyes, brown thorax with darker colored lobes, green abdomen with seven black spots in two rows on each side, black cornicles, yellow cauda, and ochreous legs, black at the joints, and with black feet. The wingless viviparous females are described by the same author as green or brownish green with red eyes, brownish antennæ, brown cornicles, yellow cauda, ochreous femora, and with the distal extremity of the tibiæ and the feet black. The descriptions of Lintner, Oestlund and others agree in the main with the above, and, as Buckton had not seen the winter form, his description may be taken as applying to the lice which occur before harvest time.

The winged lice which have been observed in this State from July, 1889, until March, 1890, measure about .08 inch in length of body, and have a wing expanse of about .25 inch, thus agreeing in size with the spring form. The antennæ are never longer than the body, reaching commonly, when drawn back a trifle, beyond the bases of the cornicles. As seen with the unaided eye, or with an ordinary hand lens, the head, antennæ, thorax, femora, tips of the tibiæ, the whole of the tarsi and the

cornicles, appear black, while the abdomen appears pale green, with a series of black spots at each side. When more highly magnified the eyes are seen to be dark brown, the bases of the antennæ and femora, and the basal two-thirds of the prothorax above show pale green or yellowish, a series of six minute black specks appear within the three marginal spots of the abdomen, a large blotch shows behind the base of each cornicle, and the edges of the two or three hindmost segments of the abdomen, and the edges or the whole of the cauda, are brownish black. Beneath the greater part of the head and thorax, the tip of the rostrum, the coxæ, and two transverse spots near the tips of the abdomen, are brownish black. The veins of the wings and the stigma appear a trifle smoky, becoming paler towards the base. This description applies to all the winged lice observed since last summer. The size varies greatly, depending on the vigor of the plant on which the lice live. On wheat that has been retarded by injury from unusual numbers of lice, or from having been kept from the light, the grain-lice sometimes become diminutive in size, the length in such cases not being more than half that of well grown examples.

The nymphs of the winged females are chiefly pale green, with little or no black on head, thorax and abdomen. The antennæ and femora are extensively pale at their bases; rostrum black at the tip; eyes dark brown; wing pads more or less dusky; cornicles black only at the tips; margins of cauda dusky.

Fully grown wingless females on wheat indoors last summer were pale green in color, including the head, thorax and abdomen, with a conspicuous rust-colored area between the cornicles (due to oily matter within the bodies). The antennæ in these were dusky, with pale bases. The tips of the hind pair of femora of all the tibiæ, of the rostrum, of the cornicles, and the whole of the feet were black. The length of an alcoholic example is .05 inch.

In the fall the colors of the wingless females become very much darker. Examples taken November 1 from the underground portion of the stems of young oats are mentioned in my notes as very stout and wide, with the antennæ much shorter than usual, and the color dull blackish brown, in some cases nearly black. When moistened with alcohol an arrange-

ment of the colors similar to that of examples taken in summer becomes apparent, the general duskiess being due to the body contents. The wingless lice which appeared on the blades in the winter of 1889-90 were of a very dark green color, but otherwise resembled those taken last summer. An example measures .07 inch in length of body, with antennæ not quite .06 inch in length.

REMEDIAL TREATMENT.

The lice are so sensitive to many insecticides that it would seem probable that with the spraying apparatus now in use for fruit trees some one of these could be successfully employed. In the laboratory a strong solution of tobacco made by soaking tobacco "stems" in water for twelve hours has proved very destructive to the grain-louse. Kerosene emulsion in water would certainly be effective if sprayed so as to reach the lice. The opportunity to test the matter out of doors may come next spring.

From the frequency with which farmers report that infested grain was in oats last spring, and the fact that wheat-fields which were badly infested last spring now contain few or no plant lice, it is plain that the volunteer oats which springs up after harvest has to do with conveying the lice to winter wheat. An examination of the plants which sprang up in wheat-fields last summer after the crop was removed failed to discover the grain-louse there, and an examination of wheat this winter in fields where the grain was badly injured last spring, shows the lice to be very scarce, and in some cases to be plainly working in from the edges. On the same farms, volunteer oats along paths and at the edges of fields have been found to support numbers of the lice. Since the grain-louse can subsist on blue-grass, a destruction of this volunteer oats would not prevent grain from becoming infested with lice, but it could be expected to defer the attacks until after the grain gets a good start.

A singular little insect as big as a mustard seed becomes common on young wheat in late April and early May, when it may be found creeping about on the blades and stalks as if feeding upon them. It belongs to a group of insects known to entomologists as Thysanura, a group thought by some authors to

belong pretty near the beginning of the insect series. They undergo no metamorphoses, the young coming from the eggs almost exactly the counterpart in form and structure of the larger adults.

A WHEAT SPRING TAIL

(*Sminthurus* sp.).

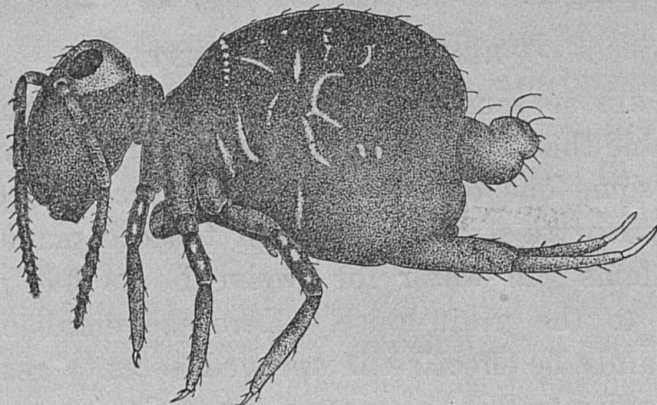


Fig. 5. The wheat spring tail, greatly magnified. Garman, del.

The body of the wheat-infesting species is somewhat globular in shape; the head relatively large, and provided with two groups of simple eyes, each group occupying a black area above the base of an antennæ. The latter organ is made up of four pieces, the terminal one being much longer than the rest, and with a number of rings which seem to separate it into shorter segments. With the usual three pairs of legs, the little creatures moves slowly about under ordinary circumstances over the surface of the plants; but, with a two-branched "spring" shown in the figure, it can take vigorous leaps when it wishes to hurry from the presence of danger. The possession of this spring has given these insects the vernacular name, "spring tail." They are also provided with a ventral sucker (shown in the figure), which projects forward beneath the body, and with which they cling securely to objects when it suits them so to do. These two organs, the sucker and spring, will distinguish insects of this kind from all others.

The little species here referred to is of a dull green or brown color, with scattered dots and tapering streaks of white on the back. The head is blackish below and orange above, with a white stripe at the inner edge of each eye spot. The antennæ are

dark, with the two first segments more or less pale. The legs are dusky in the main, but some of the basal divisions are marked with a few white spots. The length of large examples is about .05 inch.

Their abundance and behavior on the plants led me to think them injurious to the wheat, and it was not until specimens had been examined with the microscope that I was undeceived. They probably benefit the young wheat by devouring parasitic fungi, and it is evidently for these, and not to gnaw the young blades, that they creep up the plants in spring. The stomachs of those examined were filled with fragments of fungi, and with what seemed to be pollen of some kind. It is well to know both our friends and our enemies, and we may safely rank this insect as one of the former class. The species resembles closely a species which occurs on grasses in Sweden, Germany, England and other European countries.

THE TOBACCO-WORM

(*Phlegethontius carolina*, Linn.)

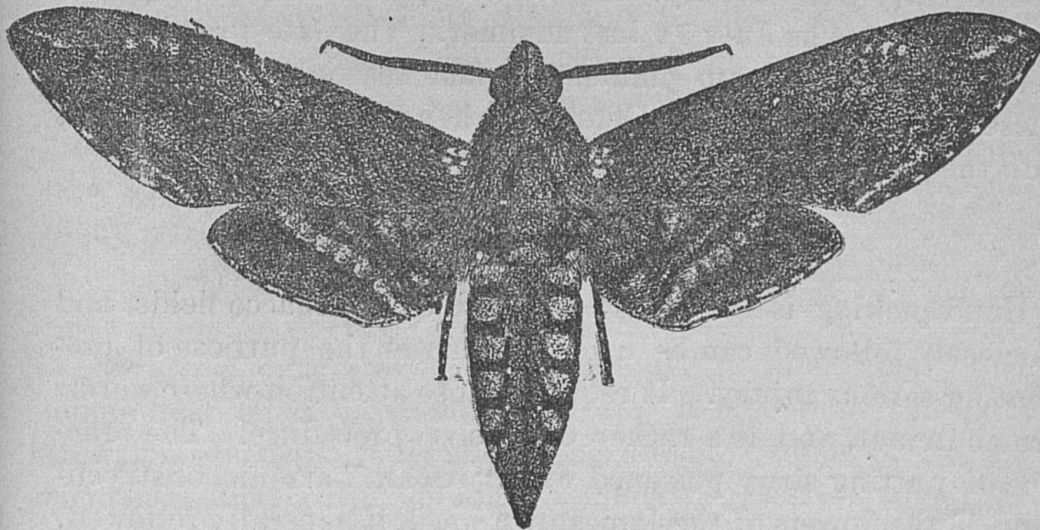


Fig. 6. The imago or moth of the tobacco-worm. Natural size. Garman, del.

This well-known pest was not often observed by me on tobacco last summer, but on late tomatoes it was extremely common and destructive. The adults are very generally known to farmers as the large gray hawk-moths, which fly about flowers, particularly those of the Jamestown weed, in the dusk of evening. Two species occur in the United States—one a north-

ern insect, the other southern in its distribution. Both feed on the same plants, and are very much alike in all their stages. The common Kentucky species is *P. carolina*, the moth of which may be known from its northern relative by its darker colors, and by the presence of a small white spot at the base of each fore wing. The inactive pupæ of the tobacco-worm are often thrown up in the spring by the spade or plow. They are long, somewhat cylindrical objects of a bright brown color, and are provided with a long tongue-case, which is bent around and applied by its expanded tip to the ventral side of the body, forming a handle like that of a pitcher.

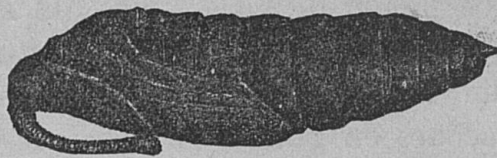


Fig. 7. The pupa of the tobacco worm. Natural size. Garman, Del.

The worms of the first of the two annual broods depend almost entirely on tobacco, and enter the ground to become pupæ in the early part of July. Some examples of this brood were noticed as late as July 11 last summer. The late brood works very largely on tomato plants, and last season was present on these up to the first of October, when the last worms went into the ground for pupation.

REMEDIAL TREATMENT.

Hand-picking is commonly resorted to in tobacco fields, and if closely followed can be made to answer the purpose of preventing serious injury. It requires close attention where worms are abundant, and is a rather expensive procedure. The practice of putting sirup poisoned with "cobalt," arsenic, or strychnine, in the flowers of the Jamestown weed, if generally followed, might be expected to greatly diminish the numbers of the pest by killing the moths. It has been practiced for many years in all parts of the South with good effect, some farmers even going so far as to plant the seeds of Jamestown weed about their tobacco fields, and when the plants are in bloom poisoning a few of the flowers on each plant and destroying the remainder.

The late brood of tobacco worms on tomatoes seems to be

given little attention. It is important that these should be destroyed if we are to expect any permanent diminution in the numbers of the worms on tobacco. The pupæ also should be destroyed whenever found.

PARASITES.

Fully seventy-five per cent. of the worms observed in tomato patches during the present season and that of 1889, were infested with the small four-winged fly, *Apanteles congregatus*. So abundant were they at times that it was not possible to get results of value from experiments on tobacco worms with insecticides. Worms under experiment would suddenly become covered with the small white cocoons of the parasites, and of a half dozen in a lot perhaps not one worm would complete its transformation.

Cocoons of the parasite which were formed on worms brought in doors were placed by themselves in a breeding cage, and as the winged flies emerged during the fall and winter they were preserved. Examination of these shows that three Hymenopterous insects of as many different families came from these cocoons. Two of these are parasites of the *Apanteles*, and are thus secondary parasites. Up to the present time 123 *Apanteles congregatus*, 97 *Ætroxys tabacum*, and 197 examples of a new species of *Mesochorus* have emerged, more than twice as many secondary parasites as of *Apanteles*.

DESCRIPTION OF PARASITES.

Apanteles congregatus, Say.—About .10 inch long. Body moderately stout. Antennæ filiform, longer than the body. Mandibles bicuspid. Maxillary palpi long, slender, of five segments. Labial palpi of three segments. Legs slender. Abdomen not petioled. Ovipositor of female not exerted. Head, antennæ and thorax black. Abdomen of male black, with some traces of yellow at the sides. Abdomen of female black, with a large yellow spot on each side near the base, and the edges of some of the anterior segments yellow. Mandibles brown. Palpi pale whitish. Legs yellow, with the coxæ, tips of femora and most of the tarsi of the posterior pair of legs, and the tips of

the distal article of the tarsi of the anterior two pairs, brown. Wings hyaline, with black veins and a large, subtriangular black stigma.

Mesochorus sp.—This is a very handsome new species which Prof. C. V. Riley has described in manuscript. It may be distinguished from the two species here described by its slender body, long legs, petioled abdomen, and the exerted ovipositor of the female. It has proved more common than either of the others at Lexington.

Ætroxys tabacum, Fitch.—Body short and stout. Male about .08 inch long, female .14 inch long. Head large, transverse, coarsely and closely punctured, excavated above the bases of the antennæ. Antennæ elbowed, with a slight terminal club, basal segment longest, cylindrical; second article short, obovate, a trifle longer than wide; third and fourth very short, ring-like; 5-10 about equal in length and much alike in size and shape; 11-13 forming a slight club, the distal article contracted toward the apex and there truncated, with a terminal sense-knob. All segments beyond the fourth with numerous longitudinal carinæ and clothed with fine appressed pubescence. Maxillary palpi with four segments, the basal shortest, the next two about equal in length, distal segment longest, somewhat fusiform in shape, widest at the beginning of the distal third, bristly. Labial palpi of three segments, first and third about equal in size and length, second about half as long. Right mandible with four large teeth; left mandible with three teeth, the basal tooth quadrate. Thorax closely and coarsely punctured, wings hyaline. Stigmal vein expanded at fore extremity. Abdomen depressed, smooth and shining, a ring of short setæ on the middle of most of the segments. Length of male (alcoholic), .08 inch; of female (alcoholic), .14 inch. Color metallic green, more or less brassy on head and thorax. Abdomen of male brownish black, with a large median yellow spot on dorsal and ventral side. Abdomen of female uniform green, without brassy reflection. Basal segment of antennæ yellow, remaining segments dull brown, appearing black to the unaided eye. Maxillary palpi brown at the base, whitish distally. Labial palpi brown. Mandibles reddish brown at base, denticles black. Wings hyaline, veins dusky.

Legs translucent, yellowish, pubescent, distal segment of tarsi dusky.

A STRAWBERRY SCALE INSECT

(*Aleurodes vaporarium*? Westwood).

Most of the scale insects live upon woody plants, but in the species named above we have an exception to the rule. It is not confined to the strawberry, but attacks the leaves of tomato plants also, and the same, or a very closely allied species, is common on the leaves of *Abutilon avicennæ*. It appears to be a hot-house pest besides, and was probably brought to us from abroad among hot-house plants. The insect is not mentioned in the published accounts of strawberry insects, and Dr. A. S. Packard (see his Guide to the Study of Insects, 9th edition, p. 712) is the only one, as far as I know, who has recorded its injury to strawberry plants.

Towards fall on the College grounds at Lexington the young scales are to be found in abundance on the under side of strawberry leaves. They adhere to the leaves very closely, at first by means of the short feet and beak, but later by a waxen secretion. The scales are at this time oval in outline, only a trifle convex, and are white, without markings of any kind. No limbs or other appendages are visible, but when highly magnified, such appendages, having the usual structure and arrangement, but of very small size, are apparent at the under side of the body. When the scales have reached a length of about .027 inch and a diameter of .015, a waxy material is secured at the margins, by which the scale is immovably fastened to the leaf. Up to this time the insect has been a larva. Within the scale thus secured the insect now takes on the quiescent pupal condition during which it remains, like the chrysalids of butterflies, without food and without power of locomotion. The scale containing pupæ may be recognized by the fact that the secretion of wax at their edges forms a sort of wall upon which the scale itself rests; at a late period they become pale yellow, the color of the nearly mature insect showing through and giving this effect. The adults emerge late in the fall, coming out as minute four-winged flies, which probably, for some time, continue to puncture the leaves and abstract the fluids of the

plant. They disappear finally, leaving eggs for another generation.

Young scales, probably from the eggs deposited by the fall brood of winged flies, are present on the few green strawberry leaves which appear in March of the next season.

The adult fly is of a uniform pale yellow color, with reddish-brown eyes, and four ample, plain, white wings. It may be described briefly as follows: Eyes four, in two pairs, the upper one of each side a trifle smaller, and with smaller facets than the lower; facets more or less round at margin; angular centrally. Antennæ of six pieces, the first short and thick, the second longest of all; three to six subequal; all but the first with numerous annuli. Proboscis arising from under side of head at hind margin, consisting of three pieces (Westwood says two), with a groove in front for the reception of three slender bristles. A sort of labrum in front, and a pair of stout, sharp-pointed processes, one at each side, support the proboscis at base. Prothorax free. Legs consisting of a coxa, trochanter, femur, tibia, and a tarsus of two pieces, the terminal piece bearing a pair of claws and a slender median appendage. Abdomen of female, with a terminal ovipositor of three sharp pieces, and with a singular organ before the tip above, consisting of a flap and short club-shaped appendage. Length about .043 inch. Wings extending a trifle beyond tip of abdomen.

MILLIPEDES AND THOUSAND-LEGS

(*Myriapoda*).

The millipedes may be known from several other pests which occur with them and do similar mischief by the great number of similar divisions of their bodies, each bearing two pairs of legs. They are sometimes called wire-worms, but true wire-worms have but three pairs of legs, and are the grubs of several kinds of click-beetles. When young, the millipedes have but few body segments and a correspondingly small number of legs. As they grow the divisions of the body and the number of limbs increases, but they never undergo transformations such as occur in the lifetime of a bee, moth or click-beetle.

They are near allies of the poisonous centipede of the South

and West, which, with numerous small harmless species constitute one section of the same class. The centipede-like forms are chiefly, perhaps wholly, carnivorous, and differ besides in having but one pair of legs to each segment of the body. We have a common example of this group in the slender gray creature (*Cermatia forceps*), with numerous very long legs, which is often seen running with great rapidity over the walls of buildings.

The millipedes are chiefly vegetable eaters, and are especially injurious at times to potato tubers, carrots, lily bulbs, strawberries, raspberries and germinating seeds. Commonly, I believe, most of the species feed on dead vegetable matter, such as fallen leaves, the roots of wheat-stubble, etc.

Two species of injurious habit have been observed in Kentucky. One (*Cambala annulata*, Say) is a widely distributed form known as a cave-dwelling species, but occurring everywhere in fields under stones and in the earth. It occasionally gnaws small pits in sound potato tubers, and may be responsible in part for what is sometimes wrongly called potato scab. When kept indoors it has gnawed such pits in the tubers furnished it, but deserted the sound tubers for decayed ones when the latter were added.

It may be recognized among all the other myriapods of this locality by its long, slender cylindrical body, rather coarsely ribbed segments, and especially by the arrangement of its eyes (ocelli) in a single transverse line on each side of the head. In the latter character it is peculiar among known American myriapods.

The second species, noted as injurious in habit, is *Parajulus impressum*, Say. It is the common millipede of green-houses, and is especially abundant in these if vegetable refuse, boards and the like are permitted to lie about. It lurks under such objects during the day and comes forth at night to feed upon the sprouts from germinating seeds, in one reported case having thus destroyed the greater part of a planting.

It is shorter than the preceding millipede, and is usually marked with a narrow brownish black line along the middle of the back, and a rather wide, obscurely defined one along each side. The segments are so faintly ribbed that the surface ap-

pears smooth to ordinary observation. The eyes are in a cluster of nearly circular outline at each side of the head.

REMEDIAL.

The first thing to be looked to in the case of green-houses infested with millipedes is neatness in the matter of surroundings. All material in the shape of old wood or vegetation not of use should be removed, and no lurking places should be left them. Bait may also be used with good effect to trap them. Pieces of carrots, potatoes, apples or bits of dough sweetened with molasses may be placed under boards on the beds and elsewhere, to be examined at intervals for the millipedes which will be attracted to them, when the latter can be destroyed with hot water.

An infusion of tobacco or a solution of naphthaline kills millipedes quickly, and can be recommended as a means of rendering the soil offensive to them.

In the field the injury is not often severe enough to call for other remedy than clean culture, and perhaps the avoidance of a too free use of stable manure, to which they seem to be attracted. In England farmers sometimes thrust sticks through potatoes and bury these here and there in fields before planting the regular crop. They are taken up occasionally, and the pests attracted to them destroyed. A similar practice could be resorted to for field crops here in case of any future injurious outbreak.

BORDEAUX MIXTURE AS AN INSECTICIDE.

I wish to call attention to this mixture because some experiments made last summer showed it to be useful for the prevention of insect injuries as well as for destroying parasitic fungi. My attention was first called to its properties in relation to damage by insects while working on some late-planted potatoes. From the time these came up they were infested and badly injured by what is commonly known in this region as the cu-

cumber flea-beetle (in this case chiefly *Crepidodera pubescens*). On the majority of plants there was not a leaf that was not riddled with small holes gnawed by the beetles.

After the injury was under way, some of the plants were sprayed with Bordeaux mixture, and this was kept up, with intervals of about a week, until the potatoes were plowed up. The injury was at once checked, and the treated plants soon showed the effects of a relief from the insects. It was noticed that as new leaves unfolded between sprayings the beetles would gather upon these, to be driven off when the plants were sprayed again.

In August the margined blister beetle appeared in the field, and in a few days took most of the leaves from untreated plants, but avoided those which had been sprayed almost entirely. Occasionally examples were observed gnawing leaves of sprayed plants where the lime and copper had been washed off by rains, or had not fallen. But it was evident before the close of the season that the mixture could have been made to save these potatoes from at least nine-tenths of the injury inflicted by the two beetles mentioned.

Subsequently, with a view to learning just how Bordeaux mixture affects insects, several species were confined in breeding cages and supplied with sprayed food plants. Some of the insects ate sparingly and were poisoned; others would not eat sprayed food plant at all, as far as could be seen. The protection it affords plants is thus partly by poisoning and in part by rendering the leaves obnoxious. With some insects its action under ordinary circumstances would probably be entirely preventive. As a poison taken in the small quantities which insects will eat, it acts very slowly. The following experiments illustrate its effect as a poison:

EXPERIMENT 147.

September 21, 1889. Three tobacco-worms were confined in a breeding cage, and supplied with tomato leaves which were sprayed with the mixture. A check lot of three was placed in another cage, and fed untreated leaves.

September 23. Two larvæ of treated lot dead. All of check lot alive.

September 26. The third larva of the treated lot proves to be infested with parasites. Check lot all alive.

September 30. One of check lot parasitized.

October 1. Remaining larvæ of check lot still alive.

EXPERIMENT 149.

September 26, 1889. Eight grasshoppers (*Pezotettix atlanis*, Riley, and *P. femur-rubrum*, De Geer) were confined in a breeding cage, and provided with clover and grass which had been sprayed with Bordeaux mixture. A second lot of eight was confined, and provided with untreated grass and clover.

September 30. Three of the treated lot dead, several others feeble. Leaves sprayed again. Check lot all alive.

October 1. Three more of treated lot dead. All of check lot alive.

October 2. Remaining two of treated lot dead. Three of check lot also dead, remainder alive and active.

EXPERIMENT 150.

September 26. Thirteen Colorado potato beetles were confined in breeding cage and furnished potato leaves sprayed with mixture. A check lot of thirteen was placed in another cage.

September 30. All alive in treated lot. One of check lot feeble.

October 1. All alive in treated lot. One of check lot dead.

October 2. One of treated lot dead. Twelve of check lot alive.

October 4. Another of treated lot dead. Twelve of check lot alive.

From this time forth no food was to be obtained, and the cages were set away with the idea that the beetles would hibernate as those out of doors were doing.

October 22. All but three of treated lot dead. Eleven of untreated lot alive.

October 26. All of treated lot dead. Eleven of check lot alive.

The mixture can not, of course, be used on such crops as tobacco or cabbage, excepting very early in the season, so that

subsequent rains may remove it before the crop is to be used. For the tobacco worm on tomatoes it will prove useful, and for the cabbage flea-beetle (*Phyllotreta vittata*) on turnips, it can also be used to advantage. There is every reason for believing that it will protect most of those plants whose foliage is injured by gnawing insects, though in some cases kerosene emulsion or London purple will perhaps answer the purpose better.

Applied to the bodies of insects it has no effect beyond rendering them uncomfortable for a time.

As a poison its efficiency can be increased by the addition of a little arsenic or Paris green.

An objection is sometimes made to its use on plants which bear fruit because the presence of the lime and copper on the fruit affects its market value. In some cases it is not necessary to continue its use after one or two sprayings, and the rains subsequently wash it off before the fruit is ripe. The mixture may be removed from fruit by suspending it for a short time in a tub of water to which has been added a couple of quarts of cider vinegar. (A suggestion which we owe to Prof. Chester, of the Delaware Station.)

The formula, which has been employed in making the mixture used in my experiments, is: Sulphate of copper, eight pounds; air-slacked lime, ten pounds; water, twenty gallons. The sulphate of copper is dissolved separately, and then added to the water containing the lime, the mixture being stirred during the process of adding. There is some danger of burning foliage with mixture of this strength, and it should consequently be applied with a nozzle which will produce a very fine spray.

A BACTERIAL DISEASE OF CABBAGE.

In July, 1889, cabbage in the vicinity of Lexington was badly affected with a rot, which bore marks of being caused by the action of bacteria in the tissue. In some gardens two-thirds of the heads were affected, and of these more than half were finally completely invaded and rendered worthless. The disease

often appeared in the outer leaves first, rendering the whole surface of the head black, while the center was still sound; but more often there was an internal decay, which, in the end, resulted in the affected heads breaking off at the stalks and falling to the ground. The invaded heads varied in size from those not larger than a man's fist to those nearly grown. The conditions most favorable to the rapid extension of the disease are moisture and heat, and it was especially destructive during some very warm weather during July. The invaded leaves became brown and watery at first; later, to become black when the decay had reached an advanced stage. The heads did not at first emit an especially offensive odor, but when thoroughly putrid towards the last, gave forth a peculiarly noxious smell, such as cabbage alone among vegetables is capable of producing. This final rotting was doubtless ordinary decomposition brought about by septic bacteria.

It was at first supposed that the disease might be caused by some one of the "higher" parasitic fungi, but nothing of the kind to which the result could be attributed was ever found in the plants. At the same time the rotting was in all its stages accompanied by bacteria, the only other organisms associated with it being examples of the well-known scavenger beetles, *Ips fasciatus* and *Nitidula bipustulata*, which, beyond question, were drawn there by the decaying plants. The bacteria found in the tissues pertain to more than one species, and doubtless some of them were ordinary bacteria everywhere concerned in putrefactive changes of dead organic matter.

On July 20 several heads of cabbage were inoculated from a head on which the disease had recently originated. The inoculation was made by thrusting a new-drawn glass pipette into the diseased head, and then making a similar puncture with it in a sound head.

On July 22 all the inoculated heads showed a slight rot about the puncture. From July 24 to July 31 there was a gradual spread of the disease in the outer leaves of the heads, and on the latter date the largest and apparently best head was found to be badly rotted at the heart.

On August 2 a second head of cabbage with the stem cut off, as is usual, was brought into my room at the Station and in-

oculated as above, in the center of the severed stalk. The rot was under way the following day, and on August 5 the stalk was decayed to the depth of one-half inch where it had been punctured, but elsewhere the head was perfectly sound. On August 7 the whole center of the head, including the bases of the leaves, was decayed.

On August 3 a young cabbage plant growing in a flower pot was inoculated at the side of the midribs of all the leaves. On August 6 two of the leaves showed a number of small rotted patches, but at some distance from the punctures. August 9 most of the punctured leaves showed decayed regions. From these regions the rot gradually spread until on August 22 two of the leaves which had been completely invaded fell off. One of the others was at this time largely brown, and still another had a large brown area at the tip.

September 30 a test tube of agar agar containing, in addition to the usual beef extract, an infusion of cabbage leaves, was infected by drawing along the surface a sterilized needle previously thrust into a decaying plant. On October 2 there was a decided growth of bacteria along the track of the needle. Until that date the room had been cool, and the growth had consequently been delayed. On October 4 the growth was greatly extended, having spread over the surface of the agar agar next the needle track, and very extensively also at the lower part of the gelatine surface. Most of the growth was then milky white, but at intervals yellow spots occurred, showing that at least two species were present. This indication was confirmed by a microscopic examination of the growth, the white growth being found to consist of innumerable non-motile bacilli. The yellow growth was made up of an actively motile bacterium.

A second tube of agar agar treated exactly like the preceding at the same date showed subsequently the same character of growth along the track of the needle. In this case the spore of some fungus was introduced on the needle, and produced at one point a growth of mycelium in and on the agar agar.

A third tube repeated the history of the two preceding. From these cultures other growths were started in fresh tubes, and the yellow and white forms were thus isolated.

BACTERIA.

The decaying cabbage showed the presence of two species of bacteria in abundance. The commonest form, in most samples studied, was a small species in couples which moved rapidly across the field of the microscope in a somewhat zig-zag course. These constituted generally from two-thirds to four-fifths of the individuals seen. They were always motile and in doubles, never in chains. The size and behavior of this species leads me to think it a form of *Bacterium termo*. With it occurred smaller numbers of a larger Bacillus, often in short chains, but generally in doubles, which measured about .0042 inch in length. In shape it is not unlike the smaller bacteria, being short and thick, rounded at the extremities, and staining solidly. It differs in its larger size in staining more deeply under the same treatment, and in being, as far as observed, non-motile.

The same two species were always obtained in the cultures. The Bacillus producing the white growth, and the Bacterium the more rapidly-growing yellow growth.

From the examinations and experiments made, it seems to me we have here a well-marked disease of cabbage, attributable perhaps, to several causes working together, and at least encouraged by the vital activities of bacteria. Whether the disease is induced primarily by the attacks of bacteria or by hot damp weather, the work thus far done will not show satisfactorily. From the facts in my possession, it appears to me probable that neither alone will cause the disease ; that it is only during periods of high temperature and excessive rainfall that the organisms are able to invade and break down the tissues of plants. The few tests which were made in the fall of the year with the two species of bacteria from cultivations, were without decisive results. Since the summer of 1889 opportunities for the completion of this record by further observations and more thoroughgoing experiments have not presented themselves.

BULLETIN No. 23.

1. EXPERIMENTS WITH OATS.

The work was done under the following heads :

1. Test of Varieties.
2. Depth of Sowing.
3. Mode of Sowing.
4. Time of Sowing.
5. Amount Seed Sown Per Acre.

Summaries.

Based upon one year's trials, and under conditions given, the following conclusions were reached :

First. The best variety tried was White Victoria, followed closely by Haggett's White Siesure, Barley Oats, Welcome, Improved American and White Schoener. Haggett's White Siesure and Improved American were sent to us by the Department of Agriculture last spring, and seem to be worthy of trial by the farmers. The Harris oats, sent out by the Department of Agriculture a few years ago, is a failure here.

Second. The earliest planting produced the largest yields, both as to grain and straw. Those planted after April 12 were failures.

Third. Plots on which the oats were sown broadcast and harrowed in produced larger yields than those drilled in, or than those sown broadcast and plowed in, as is sometimes practiced.

Fourth. Seed planted to the depth of two inches produced larger yields than when planted one or three inches deep.

Fifth. The amount of seed drilled in per acre seems to have but little effect on the yield, the rate of yield varying from 27.4 to 30.5 bushels per acre. The best yield was on plots planted with from two to three bushels per acre. The smallest resulted

from sowing one bushel. The best yield of straw resulted from sowing four bushels per acre.

The results in detail are given below.

The season was unfavorable for the oat crop, being very dry in the early part and very wet in the latter part, causing slow growth at first and light and musty oats at harvest time. The total amount of rain during the oat season was as follows: April, 1.52 inches; May, 3.53; June, 3.49.

The soil was a wet, cold, clayey, blue-grass soil. The natural drainage was imperfect, caused by a layer of hard-pan lying below the surface from 18 inches to two feet. The soil has been long in cultivation and is somewhat worn. It received an application of barn-yard manure about four years ago, said to have been at the rate of 20 loads per acre. At the time of the planting, 500 lbs. of cotton seed hull ashes per acre were applied broadcast.

1.—TEST OF VARIETIES.

Twenty contiguous plots, each 6 by $180\frac{1}{2}$ feet, were selected for these tests. The field was level and the soil was in fine condition at the time of planting. Millet was the previous crop. The ground was plowed, harrowed, and then leveled with a brush drag. The oats were drilled in with a Buckeye wheat drill on March 26, at a depth of two inches, and a distance between the drills of eight inches.

All the varieties were coming up finely on April 8. On May 15, the field notes show that the stand was good in all varieties. All varieties tillered well, except where mentioned in the table of brief field notes which follows:

TABLE 1.—Field Notes on Varieties.

NAME OF VARIETY.	Condition.				Time of cutting.	Quality of Straw.
	May 1.	May 15.	June 1.	June 15.		
Welcome	Looking well	Fine	Choice	Heading	July 12.	Medium size, soft.
Early Dakota	Looking well	Choice	Very good	Half headed	July 12.	Fine, soft.
Clydesdale	Fair	Good	Good	Few heads	July 18.	Coarse, harsh.
White Schooner	Good	Good	Good	Few heads	July 18.	Coarse, harsh.
Bohemian	Good	Good	Fine	Full headed	July 18.	Medium, soft.
Monarch	Good	Fine	Good	Some heads	July 18.	Coarse, soft.
Haggett's White Siesure	Fair	Choice	Choice	Some heads	July 12.	Fine, soft.
Hopetown	Poor	Fair	Only fair	Some heads	July 18.	Coarse, soft.
Unnamed (from Ohio)	Poor	Fair	Only fair	Some heads	July 26.	Very coarse, harsh.
White Victoria	Good	Choice	Choice	Half headed	July 12.	Medium, soft.
White Russian	Good	Good	Good	Few heads	July 26.	Coarse, harsh.
Welsh	Fine	Choice	Choice	Half headed	July 18.	Coarse, harsh.
Probesteier	Fair	Fair	Fair	Some heads	July 18.	Small, soft.
Barley Oats	Good	Choice	Choice	Half headed	July 12.	Small, soft.
Harris	Poor	Some heads	Full headed	Ripening	July 12.	Medium, harsh.
Pringle's Am. Triumph	Good	Tilling but little	Good	Good, some heads	July 18.	Medium, soft.
Black Tartarian	Fair	Fair	Good	Few heads	July 26.	Very coarse, soft.
White Canadian	Good	Choice	Choice	Half headed	July 18.	Medium, stiff.
Haggett's (U. S. D.), White Siesure	Very fine	Choice	Choice	Some heads	July 12.	Small, very soft.
Improved American	Choice	Good	Good, not tall	Not rank, some h's	July 18.	Medium, very soft.

Although there were heavy rains while the oats were ripening, all the varieties stood up well. Smut was almost entirely absent. The following table gives the names of the varieties in order of their yield, the yield of grain and straw, weight of grain per bushel, and height of straw :

TABLE 2.—Giving Yield of Grain, Straw, &c.

NAME OF VARIETY.	YIELD PER ACRE.		Weight of Measured Bushel of Grain, Pounds	Height of Straw . .
	Grain, Bus. .	Straw, Pounds		
White Victoria	46.5	2,776	36	3½ feet.
Barley Oats.	46.5	3,111	31	3 feet.
Haggett's White Siesure	45.9	2,355	35	3¼ feet.
Welcome	45.9	2,785	34	3½ feet.
White Schoener.	45.4	3,167	30	3¾ feet.
Early Dakota	43.8	3,222	30	3½ feet.
Welsh	43.0	3,022	27	3½ feet.
Monarch	43.0	2,911	27	3½ feet.
Improved American.	41.2	2,744	28	3½ feet.
Haggett's White Siesure (U. S. D.)	40.2	2,244	35	3½ feet.
Probsteier	39.2	2,851	29	3 feet.
White Canadian	37.7	2,488	30	3¼ feet.
Black Tartarian.	36.7	1,955	27	3 feet.
Hopetown	33.4	2,711	31	3½ feet.
Pringle's American Triumph.	29.1	2,222	34	3½ feet.
Unnamed (from Ohio)	27.7	2,553	29	3½ feet.
White Russian	27.7	3,222	31	3½ feet.
Clydesdale	27.4	2,789	28	3½ feet.
Bohemian	24.0	2,963	30	3¼ feet.
Harris	20.7	1,422	26	3½ feet.

DEPTH OF PLANTING.

For this purpose three plots were selected, near the plots on which the varieties were planted. The soil and management was the same as that of the varieties. The oats were drilled in at the rate of $1\frac{1}{2}$ bushels per acre: On plot No. 1, one inch deep; on plot 2, two inches; on plot 3, three inches. The variety selected was the Welsh oats.

The following table shows the yield of grain and straw per acre:

TABLE 3.—Showing Depth of Planting, and Yield of Grain and Straw.

DEPTH OF PLANTING.	Yield of Grain in Bushels Per Acre.	Yield of Straw in Pounds Per Acre.	Weight of Measured Bushels of Grain in Pounds.
One Inch	26.2	2,933	28
Two Inches	39.8	2,703	29
Three Inches	31.2	2,755	28

METHODS OF PLANTING.

It has been customary in this part of the State to sow oats broadcast, but the drill is beginning to be used now extensively both for convenience and economy. One-fortieth acre plots were used in these experiments. The time of planting was March 27. Seed were planted at the rate of $1\frac{1}{2}$ bushels per acre, on plots 28, 29 and 30. On plot 28, drilled in; plot 29, broadcast and harrowed; plot 30, broadcast and plowed in.

On the following plots, $2\frac{1}{2}$ bushels were used instead of $1\frac{1}{2}$: Plot 31, drilled; plot 32, broadcast, harrowed; plot 33, broadcast, plowed in.

The following table shows the different results :

TABLE 4.—Showing Methods of Planting and Yield Per Acre.

Plot Number . .	How PLANTED.	Amount of Seed Planted Per Acre.	Yield of Grain Per Acre. . .	Yield of Straw Per Acre . . .	Weight of Grain Per Measured Bushel.
28	Drilled	1½ Bushels. .	27	2,911	29
29	Broadcast, Harrowed in	1½ “	43.7	2,444	30
30	Broadcast, Plowed in	1½ “	25	2,622	
31	Drilled	2½ “	30.5	2,888	28
32	Broadcast, Harrowed in	2½ “	35.2	3,222	28
33	Broadcast, Plowed in	2½ “	30.5	2,333	28

TIME OF PLANTING.

A few experiments were made as to the time of sowing oats, and the plots selected for the purpose were contiguous to those on which experiments as to the depth of sowing were conducted.

The following table gives the results obtained :

TABLE 5.—Giving Time of Planting, and Yield of Grain and Straw Per Acre.

TIME OF PLANTING.	Yield of Grain in Bushels.	Yield of Straw in Pounds.
March 27	30.5	2,333
April 4	27	2,200
April 12.	16.6	1,577

AMOUNT OF SEED PLANTED.

Six plots were used for this experiment, each containing one-fortieth of an acre. The oats were drilled in March 27, at a depth of two inches.

The following table gives the yield of grain and straw calculated per acre:

Plot No...	Amount of seed planted.	Yield of Grain in Bushels.	Yield of Straw in Pounds.	Weight of grain per Measured Bushel.
21	1 Bushel.	27.7	2,530	28
22	2 Bushels.	30.5	2,377	30
31	2½ "	30.5	2,888	28
23	3 "	30.5	2,733	29
24	4 "	28.3	3,066	28

2. FERTILIZER EXPERIMENTS ON MEADOW LAND.

In the spring of 1888, four acres of the Station Farm lying to the extreme east was consigned to meadow experiments. Two acres on the north side were sown to English blue-grass, or meadow fescue—(*Festuca pratensis*)—while the two acres on the south side were sown to timothy.

The ground in question lies low, and is decidedly wet land. At the extreme northeast corner there is a small run, and the drainage of this land tends to that direction, although the slope is very gentle.

This meadow was platted off like the rest of the field, into one-tenth acre plots, each plot being 24 by 180½ feet, with paths 3 feet wide between the plots. The timothy failed to make a perfect stand in the spring, and was resowed in the fall of 1888. The English blue-grass made a fine growth from the start. The soil was well worn. It was planned to make a series of fertilizer experiments on both timothy and English blue-grass. Accordingly in the spring of 1889, seven plots of each field were selected for a preliminary study, while the other plots were left for a more extended trial as soon as the fertility of each plot could be ascertained.

The following plan will show the arrangement of the plots and the fertilizers applied to each in each of the two trials :

11	Sulphate of Potash, 16 lbs.
12	Muriate of Potash, 16 lbs.
13	Nitrate of Soda, 16 lbs.
14	Sulphate of Ammonia, 13 lbs.
15	No. Fertilizer.
16	Stable Manure, 2 loads.
17	Tobacco Stems, 400 lbs.

FIELD NOTES.

SHOWING EFFECT OF FERTILIZERS ON ENGLISH BLUE-GRASS.

(*Festuca Pratensis*.)

Plot 11.—Sulphate of potash. No marked effect.

Plot 12.—Muriate of potash. No marked effect as to growth.

Plot 13.—Nitrate of soda. Effect was apparent in about a week after application. Grass grew rapidly. Dark, rich green color. May 1st, growth continuous. June 1st, still improving. Marked effect over plot where no fertilizer was used.

Plot 14.—Sulphate of Ammonia. Effect was shown in about a week after application. Growth dark green, but not as rich as Plot 13. May 1st, fair growth. June 1st, looks much better than Plot 15.

Plot 15.—No fertilizer. Fair growth throughout season.

Plot 16.—Two loads well-rotted manure. Effect was apparent in less than a week. June 1st, effect not as marked as that where nitrate of soda was applied.

Plot 17.—Tobacco stems spread with a fork. Effect apparent in less than two weeks. Fine growth, showing above all other plots. June 1st, looked finer than any other plot. Fine rank growth.

On June 27th the grass on the various plots was cut, and, after curing, the hay on each plot was weighed separately. The following table gives the results obtained :

TABLE 7.—Showing Kind and Amount of Fertilizers Applied and Yield of Hay Per Acre.

Plot Number. . .	KIND OF FERTILIZER USED.	Amount Per Acre. Pounds	Yield of Hay Per Acre. Pounds.
11	Sulphate of Potash	160	1,900
12	Muriate of Potash	160	2,320
13	Nitrate of Soda	160	2,670
14	Sulphate of Ammonia	130	2,520
15	No Fertilizer		1,620
16	Stable Manure	20 loads	2,200
17	Tobacco Stems	4,000	3,350

FIELD NOTES.

SHOWING EFFECT OF FERTILIZERS ON TIMOTHY.

Plot 11.—Sulphate of potash. Marked effect in two weeks. May 26 observed soon after a rain, plot looking well. June 1st, still making a good show.

Plot 12.—Muriate of potash. Effect shown in two weeks.

May 20, not as fine looking plot as No. 11. June 1st, looking fairly well.

Plot 13.—Nitrate of soda. Hardly visible after ten days. May 20, looks nearly as well as 11 and 12. June 1st, growth very good, and compares favorably with 11 and 12.

Plot 14.—Sulphate of Ammonia. Effect not marked in ten days. May 20, looks fine. June 1st, fine plot.

Plot 15.—No fertilizer. Growth fairly good throughout the season.

Plot 16.—Stable manure. Effect marked in ten days. Dry weather checks growth. May 20, begins to show effect again. June 1st, effect not marked, but shows up better than 15.

Plot 17.—Tobacco stems spread with fork. Effect not marked in ten days. May 20, shows fine rank growth. Finest plot. June 1st, making a fine show. Effect is very marked.

The following table gives the results obtained :

Plot No.	FERTILIZERS USED PER ACRE.	Amount per Acre in Pounds	Yield of Hay in Pounds per Acre
11	Sulphate of Potash	160	3,000
12	Muriate Potash	160	2,950
13	Nitrate of Soda	160	3,100
14	Sulphate of Ammonia	130	3,600
15	No Fertilizer		2,850
16	Stable Manure	20 loads.	2,970
17	Tobacco Stems	4,000	4,700

By referring to the tables it will be seen that the fertilizers containing nitrogen, as in nitrate of soda, sulphate of ammonia, tobacco stems, or stable manure, acted beneficially on both timothy and English blue-grass, while the potash fertilizers gave much the better results on timothy. It is not believed that the difference in the soil caused the potash to act so differently on the timothy and blue-grass, as the two plots lie almost adjacent.

BULLETIN No. 24.

THE BROOM-RAPE OF HEMP AND TOBACCO

*(Phelipaea ramosa**, Linn.).

BY H. GARMAN, ENTOMOLOGIST AND BOTANIST.

This parasite of hemp and tobacco was brought to my notice toward the close of last summer. At that time its growing season was past, and most of the plants were dead; but a cursory examination of it in the field showed that serious injury had been done by it in several counties, and from its general distribution among hemp and tobacco in the region about Lexington, future damage to these crops was to be apprehended. The time during which the plant has been known to me will not permit statements from personal observation as to its rate of growth, time of appearance above ground, etc., during the normal growing season; but enough has been learned by observation, by experiment and by inquiry to warrant this preliminary account presented now especially because of the desirability of promptly spreading a knowledge of the pest.

In a brief general account of the broom-rape published in the report of the State Commissioner of Agriculture, I have stated that the plant has been known in Kentucky at least three years. Subsequent inquiry among farmers showed that while most of them had first observed it about three years ago, some had seen it earlier. Mr. Sandford Lyons, of Jessamine county, states that he observed the pest on his tobacco in 1880. He had previously noticed that hemp did not grow well on this land, and although he did not see the broom-rape among it, he thinks now that it was there when he bought the land in 1879. Mr. John Steele, also of Jessamine county, informs me that an old farmer of his neighborhood whom he has known many years

* *Orobanche ramosa*, according to some botanists.

declares that the pest was observed in hemp fields fifty years ago, and that old colored men long familiar with hemp growing have made similar statements to him. It is safe to say, therefore, that broom-rape has been in this region ten years at least, but there can be little doubt but that it has only recently become severely destructive. Whether this is because it has been favored by the weather the past few years or because it has only succeeded in gaining a foothold after having been imported repeatedly during a series of years with hemp seed from abroad, remains for future observation to decide. It is to be hoped that it is not acclimated, and that its recent outbreak will prove temporary.

The imported hemp seed used by growers seems to have been brought chiefly from China, and very probably the parasite has been introduced from that quarter. The species has a very wide distribution in Eastern countries, occurring, according to literature to which I have access, from the British Islands as far east as Persia, from which it is probably safe to assume that it occurs also in China. (I have been thus far unable to find any positive record of its occurrence there.)

That it is disseminated with hemp seed is well established. A number of facts brought out by inquiry of farmers point to this as the means by which most of the land here has become infested. New land on farms on which the pest had not previously been known was infested last season. In some cases, it was found that where the land was newly invaded, hemp seed had been recently obtained from places in which the pest was abundant. Indeed, there is a strong probability that it has, since its introduction, spread from one or two places by this agency.

The method of collecting hemp seed, commonly practiced, explains the manner in which the two kinds of seeds get mixed. The stalks are made into bundles which may be laid zig-zag on the ground, the heads of one bundle resting on the butts of another. From these bundles the seeds may be beaten out either in a wagon, or on the ground in the field. In either case, the collected hemp seed is liable to have broom rape seed mixed with it, if the field is infested, the chances of this being greater in case the seed is beaten out on the ground. If the hemp seed

beaten out in wagons was not laid upon the ground previously, its chances for containing broom-rape seed would be lessened, though there is always risk, with all reasonable precautions, of taking up some of the minute broom-rape seed in collecting hemp seed from a badly-infested field.

Doubtless, broom-rape may be distributed also to some extent by winds. The seeds are very light, and may be scattered by a breath of air. A strong wind blowing for several hours in one direction during the fall of the year would, consequently, be quite capable of sowing the small seeds from infested land over miles of territory.

SPECIES OF BROOM-RAPE WHICH OCCUR IN KENTUCKY.

The broom-rape belongs to a group of parasitic flowering plants, all of which derive their material for growth from the roots of other plants. The green coloring matter so important to the nutrition of most non-parasitic flowering plants is absent from their tissues, and they have no leaves. The stems are thick and fleshy, and the different species are white, or of various colors, such as yellow, brown, red or purple. The flowers also vary greatly in color, sometimes being like the stems in this respect. Some species are prized by florists for their beauty. Otherwise than as affected by their inability to take food from the air and soil, they are much like other flower-bearing plants, having the same tissues, the same mode of growth, and the same method of reproduction.

Of the fifteen species of the broom-rape family which occur in North America, three in addition to *Phelipæa ramosa* are known to occur in Kentucky. The beech-drops (*Epiphegus virginiana*) which is said to be very abundant in beech woods within the State, differs from the broom-rape of hemp and tobacco fields in having flowers of two kinds, one sterile, the other fertile, and with a very small corolla.

Another of the three species is the squaw-root (*Conopholis americana*). It has a very thick, scaly stem and the stamens protrude from the mouth of the corolla, whereas in the introduced species the stem is not very scaly and the stamens do not protrude. This plant occurs among oak trees.

The third species (*Aphyllon uniflorum*) is more closely allied

to the parasite of hemp than either of the two preceding. It occurs in woods, and differs in that its stem remains in the earth, the flower-stalks, bearing a single flower each, being the only parts that come above ground.

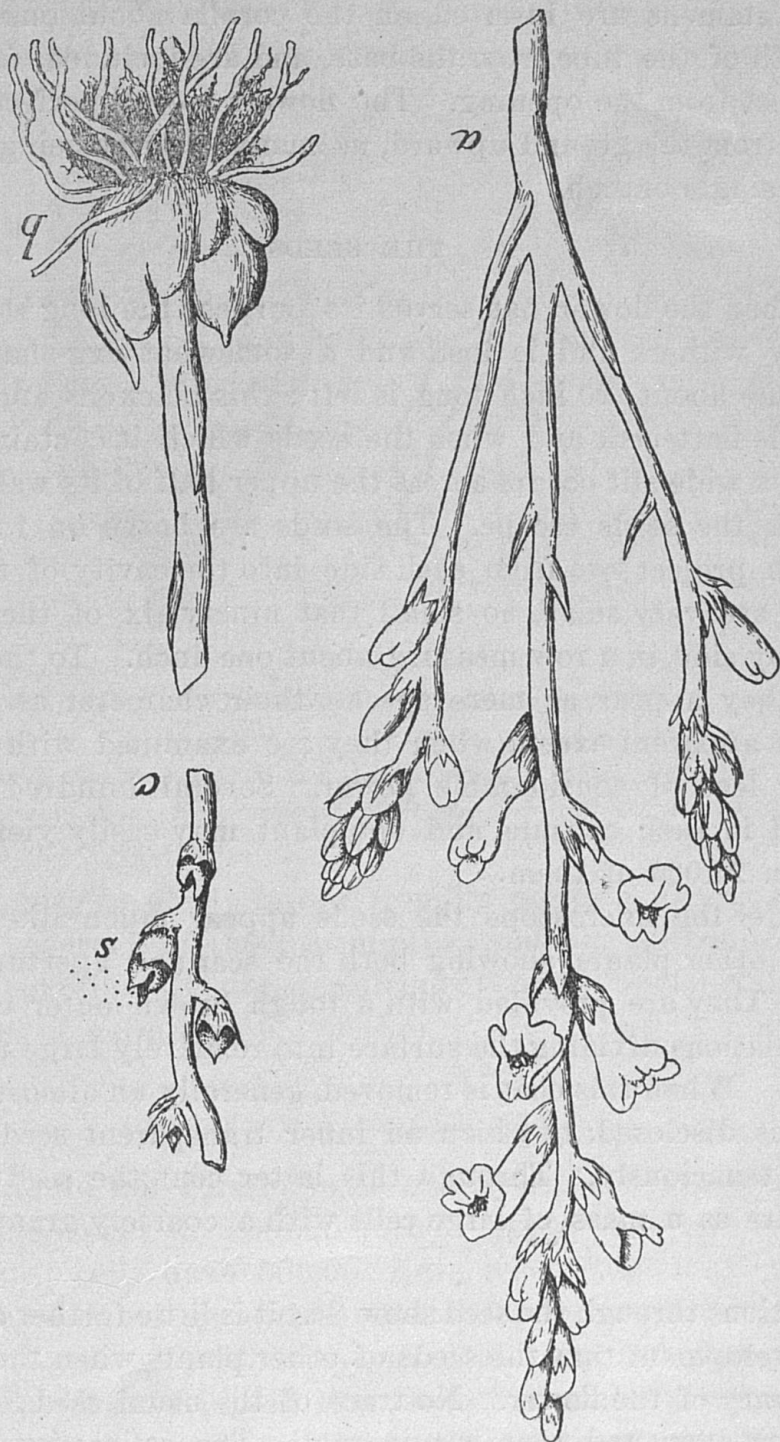
Still another species (*Orobanche minor*), parasitic on clover and some other plants, has been introduced into this country from Europe, and may be expected to occur sooner or later in this State. Gray gives its distribution as from New Jersey to Virginia. It may be distinguished from *Phelipæa ramosa* by its unbranched stem, single flower bract and divided calyx.

Aphyllon ludovicianum, a native broom-rape which occurs from "Illinois and Saskatchewan to Texas, thence west to Arizona," is perhaps the most closely related to the broom-rape of hemp and tobacco of all our native species. Its host-plant is not given in the manuals, but a specimen which I owe to the kindness of Dr. J. Schneck, of Mt. Carmel, Illinois, was taken "on the roots of *Ambrosia trifida*," the large ragweed of rich, damp soil. This native species is much coarser than the introduced parasite, and its flowers, which are at least a third longer, are crowded upon the branches, forming close spikes. The calyx alone of this plant, measured from its base to the tip of one of the lobes, is about as long as an entire flower of a broom-rape plant now before me which was grown from the seed. In essentials the two are much alike, agreeing in the number and position of placentæ, the included stamens, the lobes of the corolla, the calyx lobes, and the general arrangement of the flowers.

DESCRIPTION.

In good soil and where well shaded *Phelipæa ramosa* grows to a height of about ten inches. The stems are thick, whitish, fleshy, pubescent, generally branched, and bear small, scale-like bracts in place of leaves, which, when old, turn brown at the tips. The flowers are about one-half inch long, are white with a faint purplish tinge, or in some cases of a decided purple color, and are borne in loose spikes, each flower arising in the axil of a bract and bearing at the base of the calyx two additional slender bractlets, one at each side. The calyx is cup-shaped, entire, with four acutely-pointed, tooth-like lobes.

Fig. 1. The broom-rape of hemp and tobacco. *a*, representing a plant with flowers, flower buds and bracts; *b*, the lower part of the same plant, showing the swollen base and fibrous roots; *c*, a part of a branch with seed-pods, the seeds at *s* represented of natural size (*a* and *b* after Sowerby; *c*, original).



The tube of the corolla is about twice the length of the calyx, is two-lipped, the upper lip being two, the lower three-lobed. The stamens are inserted on the corolla about one-third the length of the tube from the base, and are included, *i. e.* do not project from the opening. The flowers are all perfect, and mature from the ground upward, as many as forty being produced on a single branch.

THE SEEDS.

When the flower has served its purpose the long style of the ovary withers and is lost, and a somewhat egg-shaped seed-capsule about .20 inch long is left; this blackens and becomes a trifle flattened, and when the seeds which it contains are mature, a wide slit occurs across the upper half of its wall through which the seeds escape. The seeds are borne on four ridges which project two from each side into the cavity of the ovary. They are very small, so small that ninety-six of them placed side by side in a row measure about one inch. To the unaided eye they appear as mere specks, their character as seeds not being apparent except when they are examined with a magnifying lens of considerable power. Several hundred are produced in each capsule, and one plant may easily yield in one season 24,000 of them.

Under the microscope the seeds appear much like those of many other plants, showing both the scar and aperture at one end. They are provided with a tough brown outer coat, with reticulations dividing the surface into relatively large polygonal areas. When this coat is removed, generally an almost spherical mass is disclosed, to which an inner transparent seed-coat adheres tenaciously. Through this latter coat the seed contents appears as a mass of large cells with a coarsely granular contents.

Sections through the seed show that it is little farther advanced in development than the seeds of other plants when these are in the ovary of the flower. No trace of the usual seed leaves and primary stem and root is apparent. The cells with granular contents which are so conspicuous from without, are seen to form an outer layer only. Within it is a central mass of cells, with angular outlines, which are without granular contents.

Near the opening through the seed-coats is a small oval mass of cells, with finely granular contents, which is embraced in part by the clear central cells, and partly by cells of the outer layer. This mass seems to have no intimate connection with the other

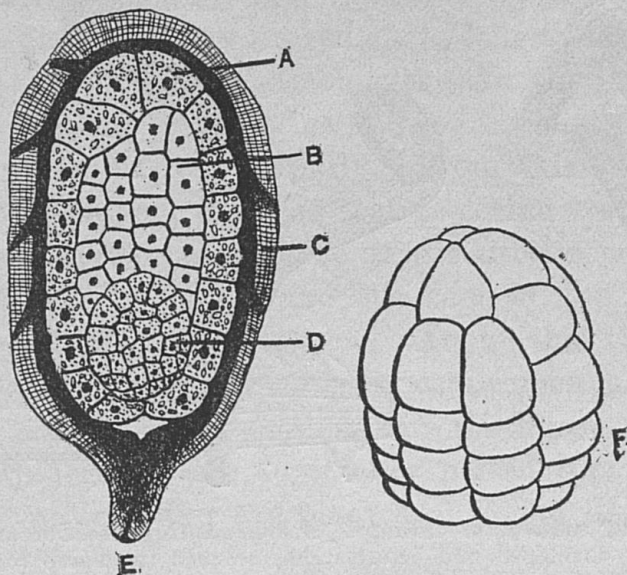


Fig. 2. A thin section of a broom-rape seed, and the germ (F), as seen under the microscope. A, the outer layer of cells; B, the central cells; C, the outer seed-coat; D, the "germ;" E, the aperture through which the radicle pushes during germination; F, a surface view of the germ when removed from the seed and highly magnified.

cells, and may be easily forced from its position among them. It is the "germ" of the broom-rape, and the inclosing cells probably contain only stored nutriment to be used up during the process of germination.

GERMINATION OF THE SEEDS.

The seeds do not germinate as readily as do most seeds, and all attempts to get them to do so by soaking in water or keeping in moist cells have failed. Even when kept with young hemp, they did not germinate until the latter was at least six inches high. I was at first surprised at this, but when I saw later the rapid growth, and the amount of material consumed by the young plants, it was plain that if they should attach themselves to very young hemp, the latter would be destroyed, and the broom-rape with it. This is not one of nature's maladjustments, and the parasite in the seed is in some way informed

(if I may use the word) when its host is ready to receive it. Previous to germination, many (perhaps all) of the seeds become fastened, with other particles, to the root hairs of the

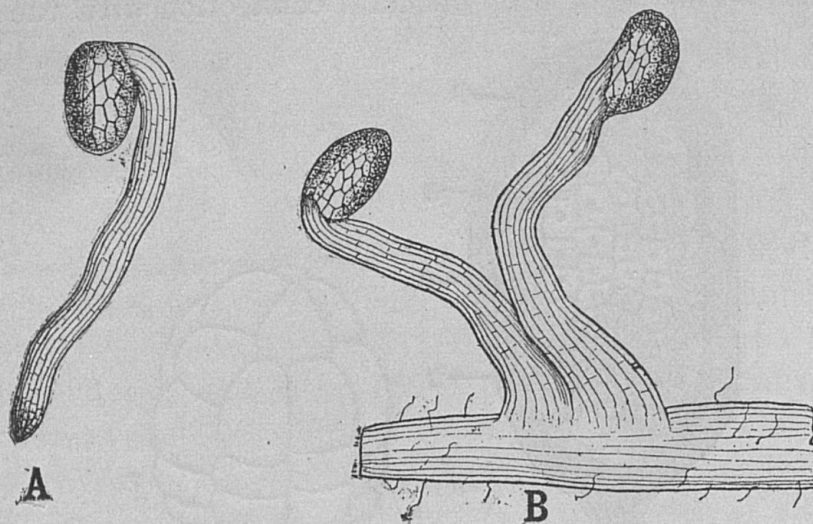


Fig. 3. Germinating seeds of broom-rape. *A*, representing a seed immediately after the radicle has developed, and before it has reached the hemp root to which it would have become attached; *B*, two broom-rape seeds as they appear immediately after the radicle becomes fixed to the root of the host-plant. (Greatly enlarged; the young parasite is, at this stage, microscopic in size.)

host-plant, and it may be that the activities of these are the message that stirs the broom-rape seeds to activity.

The radicle is cylindrical, semi-transparent, is made up largely of very long cells, and at its free extremity is rather bluntly pointed. The cells at its tip are shorter than the rest, and the walls here are thickened and embrowned.

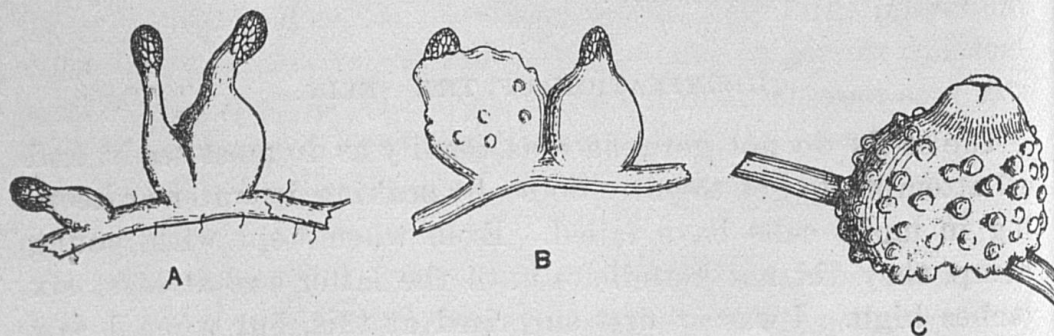


Fig. 4. Young broom-rape soon after it has become attached to the roots of hemp or tobacco. *A*, Three young plants at an early stage, that on the right being the oldest; *B*, two young plants at a little later stage of development, the figure on the left showing the first appearance of the fibrous roots of the parasite; *C*, a still older plant, with the fibrous roots forming numerous rounded prominences, and the bud from which the stalk is to grow showing at the upper side. (All greatly magnified.)

THE LIFE HISTORY.

If the seed lies in contact with one of the fibrous roots of its host, the apex of the young root at once becomes attached to the other and grows no longer than is necessary to do this. If it lies some distance away its radicle is longer, and in some observed cases was several times longer than the seed itself. As soon as attached the root begins to swell up next the hemp root and increases in size very rapidly. From this swelling it soon becomes flask-shaped, the seed-coat inclosing a small, rounded group of cells resting on the top of the swollen mass. Later it becomes discoid in shape, and the root of the hemp is now chiefly imbedded in its substance. About this time numerous small rounded eminences begin to appear over much of its surface, and pushing out rapidly develop into the fibrous roots. They grow so rapidly and are so thickly placed that they conceal the swollen radicle, and the plant soon looks like a tangle of roots.

With the appearance of the roots the seed-coats are lost, and where they last rested an eminence appears with a rounded central region, flanked by a couple of lips. This is the first appearance of the bud from which the stalk is to grow, and the lip-like structures are the first bracts.

The cell-structure of the young plant up to the time the roots begin to push out is very similar throughout, and resembles a mass of parenchyma. But there is a difference in the function of cells of different parts even then. The cells next the single outer layer (epidermis) begin to deposit starch soon after the plant becomes attached, and are soon filled with it. This is, in fact, the explanation of the swelling. And when ready to send out its bud and fibrous roots, the little radicle consists in great part of a reserve store of food laid up in this way. Certain other cells in the interior of the mass, which seem to be concerned more directly in the vital processes of growth and nutrition, never contain starchy matter.

A thin section through a young parasite, and the root to which it is attached, shows that the tissues of the two are very closely united. Certain elongated cells of the young broom-rape push into the root of the host-plant, and spreading out become ap-

plied to the axial fibro-vascular bundle. These elongated cells are the ones concerned in robbing the host of the food it elaborates from the air and soil, and they pass it up to the other tissues of the parasite.

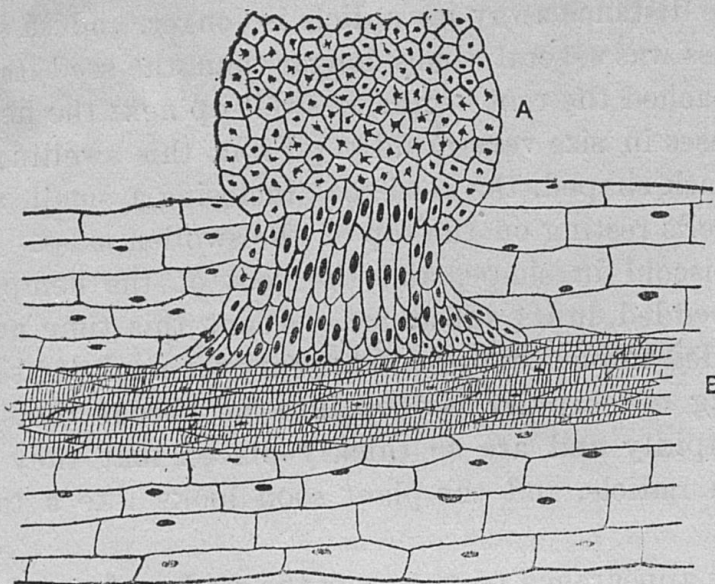


Fig. 5. Representing a thin vertical section through a young parasite (*A*) and the hemp root (*B*) to which it is attached. Only the basal portion of the broom-rape is shown; from it elongated cells will be seen to extend into the hemp root to spread out and become applied to the central fibro-vascular tissue of the latter opposite *B*.

The young bud, once started, develops rapidly, pushing toward the surface, unfolding bract after bract, and appearing above ground as a thick, whitish growth, resembling a small shoot of asparagus. Lateral buds now appear in the axils of some of the bracts and develop into branches, or, in some cases where the ground is packed, these may develop before the main shoot reaches the surface. In the meantime the roots have increased in length, and by the time the shoot reaches the surface may be an inch in length. They are blunt-pointed, commonly simple, and more or less contorted. The young broom-rape is attached by its base at first, as we have seen, to a single fibrous root of its host (I have never observed one attached to the "tap" root). But this is not sufficient for it as it increases in size, and moreover it is liable at any time to be isolated from its host by the gnawing of insects or other means.

The supply of food is made secure by its contorted fibrous

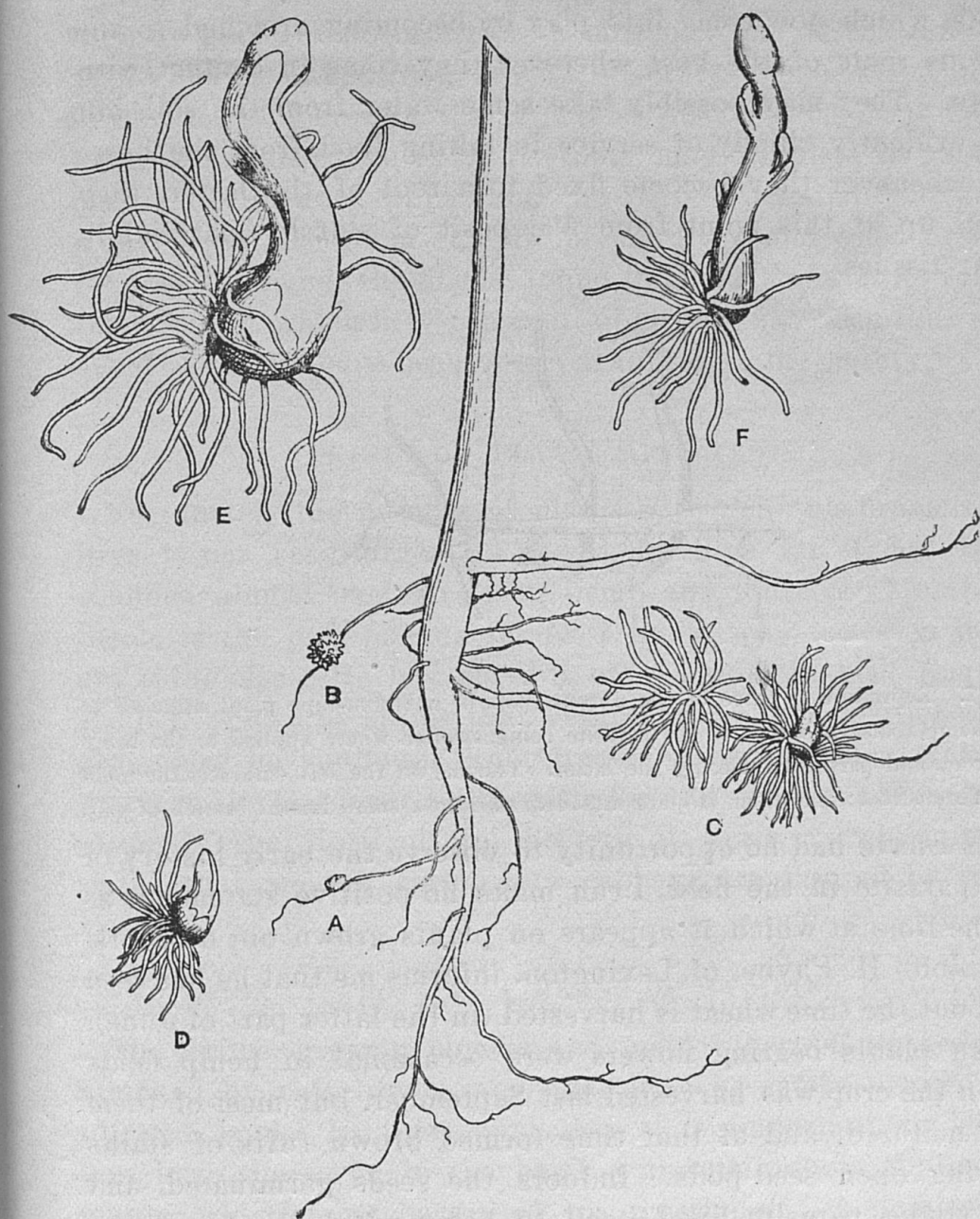


Fig. 6. Representing stages in the development of young broom-rape. *A*, a plant which is just beginning to put out the stalk bud and the fibrous roots; *B*, a later stage when the closely placed fibrous roots form conspicuous prominences which conceal most of the surface; *C*, two parasites at a still later stage, the right one turned so as to show the bud, now of considerable size; *D*, a still later stage, with a short stem and bracts; *E*, a well-grown young parasite as it pushes through the ground at the surface, its long fibrous roots not yet attached to those of the host-plant; *F*, a young plant which was grown in packed soil, with several lateral buds which would have produced branches. (All the figures of natural size.)

roots, which now come into play by becoming attached to the fibrous roots of the host wherever they come in contact with these. They may possibly take some water from the soil, but are evidently chiefly of service in taking food from the host; for whenever they become fixed to a root of the latter, they swell up at this point from a deposit of starchy material in their tissues.

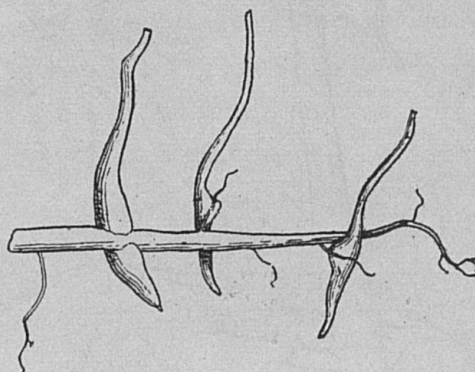


Fig. 7. Representing three of the fibrous roots of a broom-rape plant attached to hemp roots, each root of the parasite being swollen where applied to the hemp root, and partially inclosing the latter. The one on the left embraces the main fibrous root; the other two are attached, each to a small lateral branch of this.

As I have had no opportunity to observe the early history of the parasite in the field, I can make no positive statements as to the time at which it appears on plants grown out of doors. Mr. John H. Payne, of Lexington, informs me that he has seen it about the time wheat is harvested (in the latter part of June). Fresh plants bearing flowers were occasional in hemp fields when the crop was harvested last September, but most of them had matured, and at that time formed brown tufts of stalks bearing open seed-pods. Indoors the seeds germinated, and the young parasite fixed itself to hemp when the latter was about eight inches high, and injured the infested plants considerably before pushing through the earth. Taken together, these observations indicate that the injury extends over a considerable period of time, and it is probable from them that the hemp and tobacco is being injured during a couple of months.

NATURE OF THE INJURY.

The injury which the parasite does to hemp and tobacco consists in appropriating the sap which these plants elaborate for

their own use. The result is an enfeeblement of the infested plants shown in retarded growth, weakness of the stems, and, in the case of hemp, in the imperfect fiber. A vigorous hemp plant, with few parasites on its roots, may complete its growth and in all outward appearance be perfectly sound, but such plants generally die in the fall prematurely, and when broken between the hands the fiber is found to be weak and of no value. Instances in which fifty per cent. of a crop has been thus rendered worthless have been observed in Jessamine county.

KINDS OF PLANTS AFFECTED.

Fortunately the number of plants on which this broom-rape lives is not very large. In Kentucky thus far it has been confined almost exclusively to hemp and tobacco. Mr. John Steele is the only one, as far as I know, who has seen it on any thing else. He has noted it on tomato. In his "English Botany," Sowerby states that besides the plants mentioned, it grows also on sunflower, knot grass and archangelica, while a writer in the Gardener's Chronicle for 1880 notices a communication to the Horticultural Society of Paris, in which it is stated that melons, cotton and cabbage are injured by it in Persia.

ROTATION OF CROPS AS A MEANS OF AVOIDING INJURY.

The grains, grasses, clovers and many other plants are not attacked by this broom-rape, and may be safely planted on infested land. In this connection it is important to know how long the seeds in the earth will retain their vitality, a matter which must be settled by experiment. A number of cases have been reported to me of infested fields being planted one year in wheat or potatoes, and the next year again in hemp, with the result that broom-rape was still present. Mr. Steele, to whom I have already referred, gives me an instance in which the seeds appear to have remained dormant in the soil three seasons. He had thirty-four acres of land in infested hemp. This was planted two successive seasons in wheat, then one season in clover, and the fourth summer in hemp again, and broom-rape occurred in this hemp. It is to

be remembered, however, that while these cases render it probable that the seeds will live through one or more seasons in the soil, they do not amount to a demonstration that they do so. The seeds may be reintroduced with hemp seed, or a few unnoticed volunteer plants along fences may furnish the seeds for infecting the crop.



Fig. 8. A young broom-rape plant from which the terminal bud has been removed, showing two adventitious buds pushing out just above the swollen base of the plant.

REMOVING BROOM-RAPE BY HAND.

It is plainly not practicable to remove the parasites from a crop grown as is hemp. In the case of tobacco, or of hemp grown for seed, good may be done in this way by keeping the pests from seeding. They are too firmly attached to the roots of their host to be entirely removed in this way, and new shoots from adventitious buds are likely to follow the removal of the old ones. This has been the result where plants grown at the Experiment Station have been eaten off by slugs, or where the terminal bud has been removed purposely. In such cases a number of small buds at once pushed out at the sides of the swollen base of the plant.

BURNING OVER INFESTED FIELDS.

When hemp is removed in the fall, the seed capsules of the broom-rape still contain many of their seeds; even those which have been long mature and open contain some. Quantities of these would unquestionably be destroyed, if at this time the fields could be burned over. This would involve, of course, the removal at once of the harvested crop, but in many cases it would be well worth while to do this. Fire could not be ex-

pected to destroy all the seeds, as many of them have, by the time the hemp is cut, been washed into the ground beyond its reach; but it would do much, and, in connection with other precautions mentioned, could, I think, be depended on to rid land of broom-rape in the course of a few years.

CARE IN COLLECTING SEED FOR PLANTING.

The importance of care in the matter of collecting hemp seed for planting can not be too strongly insisted on. At best, some broom-rape seed may get among hemp seed collected from infested plants. In no case should plants from which seeds are to be taken be laid upon the ground, or the seeds be beaten out there, if the broom-rape has grown in the field.

APPLICATIONS TO THE SOIL.

No substance is known which will destroy growing broom-rape and not at the same time affect injuriously plants on whose roots broom-rape grows. Hosts and parasite are so much alike that it is not probable that any practicable remedy of this kind will be discovered. Applications made to the soil with the object of killing the broom-rape seeds are more likely to prove successful. Of all the substances known to me which have proved useful for purposes such as this, gas lime, a waste product in the manufacture of ordinary illuminating gas, is calculated to answer best. It has a caustic property which corrodes animal and vegetable structures with which it is brought in contact, and is known to be useful both for killing root-eating insects and for the slime fungus (*Plasmodiophora brassicae*), which causes club-root in cabbage and other garden crops. On exposure to the air for some time it loses this property, and is changed largely to lime sulphate, in which condition it is beneficial to many plants as a manure. It should be applied to the land in the fall of the year, about two tons per acre being a safe quantity to use, and later may be plowed or harrowed into the ground. Ordinarily, gas lime may be obtained of gas companies by asking for it. In England, in some places, the demand for it has, in recent years, become so great that the companies charge \$1.50 per cart load.

THE USE OF FERTILIZERS TO STIMULATE INFESTED CROPS.

A stimulating dressing applied to the land can not fail to have a good effect in counteracting the injury done by the parasite. But stable manure or compost, as commonly prepared, are not to be recommended for the purpose because of the advantage they give the broom-rape by rendering the soil loose. Crops in fields recently wooded are especially subject to severe injury, because of the favoring effect to broom-rape of dead leaves and other vegetation in the soil.

THE INFLUENCE OF THE SOIL ON BROOM-RAPE.

A rich, loose soil favors the growth of broom-rape—a fact which has been noted both in the field and in doors. Through a heavy soil, or a packed one, it does not push its way readily. Where not already infested, there is no reason why fields in which the soil is loose should not be employed for hemp or tobacco growing; such land is not more liable to invasion from outside, as far as is known, than other land. The point worth noting in this connection is, that as between two pieces of infested land, one with loose and the other with heavy soil, the danger is greater to a crop of hemp or tobacco planted in the former than in the latter. If from any cause it should seem expedient to plant in one or the other of such fields, I should recommend the one with heavy soil as likely to yield in the end the best crop. If, in special cases, it seems best to a farmer to risk injury on land with a loose soil, I would suggest that rolling such land with a heavy iron roller will, to some extent, do away with one of the conditions which favors injury from broom-rape.

CONCLUSION.

It will be observed that I have not dwelt on the use of salt and other materials which, applied to the soil, have been thought to be useful as preventives of injury. The truth is that the evidence as to the usefulness of such applications is not at all conclusive, and it seems best not to waste words on matters which are at present largely theoretical, or of uncertain value. Experiments are now under way, having for their object the determination of several of the questions briefly touched

upon above, and the result will be given in a later report. It will add greatly to the value of such report if every farmer interested in the matter will contribute by correspondence the result of his observations with reference to the value of applications to the soil, as to treatment of soil, and with regard to the influence of situation, kind of soil, moisture, etc., on the abundance and injuries of broom-rape.

BULLETIN No. 25.

STRAWBERRIES.—1890.

In the spring of 1888, soon after purchasing the Experiment Station Farm, a number of different varieties of strawberries were received and planted to make a start at testing the various new varieties that might come out from time to time.

The plot of ground selected for the purpose had previously been used for a family garden. It appeared as though it had been manured from time to time, and, therefore, might be considered fairly rich. In this particular spot the soil is underlaid with a light yellow clay, commencing at the depth of about ten inches, and at the depth of nearly two feet there is a layer of irregular-shaped gravel cemented with iron, forming hard pan. This prevents drainage. During the winter of '89 tile drain at the depth of three feet and thirty feet apart was laid in this garden. Previous to the tile draining, it was impossible to cultivate the land for a good while after a rainy spell, while now it dries very rapidly, and can be cultivated as soon as any of the land having the best natural drainage.

The plants were set in rows three feet apart and twelve inches in the row, care being taken that every third row should contain plants with perfect flowers. The growth the first year was fair. The runners were kept off until the middle of July, and then

allowed to grow until we set new plants. These were removed, and the runners kept off the rest of the year, except in the case of the Cumberland Triumph and a portion of the Bubachs. After the ground was well frozen in the fall of '88, the entire plot was covered with hemp herds from the hackling factories. This served a double purpose—to protect the plants from freezing, and to check the growth of the weeds, and afterwards keeping the berries clean. The ground was not cultivated until after the picking season was over. A slight frost on the 5th of April destroyed the early blooms. From that time on the season was good, except during the picking season the continued rains prevented the berries ripening rapidly.

At various times during the season observations were taken and notes made as to the relative merits of the different varieties. The following table gives a summary of such notes:

TABLE No. 1.—Showing Comparative Data.

VARIETIES.	Date of Bloom	Date of First Ripe Fruit	Date of First Picking	Average Diameter
Jesse	Apr 1 1.	May 12 . .	May 20 . .	1 $\frac{1}{8}$ in.
Crawford	20 . .	17 . .	25 . .	1 $\frac{1}{4}$ in.
Itasca	23 . .	19 . .	25 . .	1 in.
Cumberland	17 . .	18 . .	25 . .	1 $\frac{1}{4}$ in.
Ohio	21 . .	18 . .	24 . .	1 $\frac{1}{8}$ in.
Sanafee	10 . .	14 . .	20 . .	1 $\frac{1}{8}$ in.
Annie Forest	10 . .	15 . .	20 . .	1 $\frac{1}{4}$ in.
Ontario	15 . .	15 . .	25 . .	1 $\frac{3}{8}$ in.
Bubach No. 5	22 . .	20 . .	28 . .	1 $\frac{1}{8}$ in.
Kentucky	22 . .	25 . .	29 . .	1 $\frac{1}{8}$ in.
Warfield's No. 2	23 . .	15 . .	24 . .	1 $\frac{1}{8}$ in.
Gypsy	17 . .	17 . .	25 . .	1 in.
Haverland	12 . .	15 . .	25 . .	1 $\frac{1}{4}$ in.
May King	12 . .	12 . .	20 . .	1 $\frac{1}{8}$ in.
Henderson	23 . .	18 . .	28 . .	1 $\frac{1}{8}$ in.
Gold	28 . .	22 . .	28 . .	1 $\frac{1}{8}$ in.
Phelps	17 . .	20 . .	25 . .	1 in.
Primo	19 . .	23 . .	June 1 . .	1 in.
Parry	19 . .	23 . .	1 . .	1 in.
Gandy's Pride	May 6 . .	June 1 . .	6 . .	1 $\frac{1}{2}$ in.
Logan	April 20 . .	May 20 . .	May 25 . .	1 in.
Lida	12 . .	15 . .	23 . .	1 in.
Photo	26 . .	23 . .	June 1 . .	1 in.
Mammoth	24 . .	20 . .	May 25 . .	1 in.
Jewell	20 . .	20 . .	26 . .	1 in.

FIELD NOTES.

Jessie.—Perfect flower; a fine vigorous plant, almost free from rust; runners not very numerous; blooms early; a large, fairly solid, deep crimson, red fleshed, fine berry; a little irregular in shape; early, productive; of fine size throughout the season, a fine berry for market or family use.

Crawford.—Perfect flower; only fairly vigorous; rusts; few runners; blooms fine but not numerous; berry large sized, well shaped, crimson in color, flesh pale red, not very solid; fair flavor; not very productive with us this year; season medium early.

Itasca.—Pistillate; plant a fine rank grower, runners numerous; berry a little under sized, but almost perfect in shape; color red; not very solid; flavor good; productive; very fine; ripens evenly, medium to late.

TABLE 1.—Showing Comparative Data.

General Appearance (scale 0 to 10)	Productiveness (scale 0 to 10)	Hardness (scale 0 to 10)	Vigor (scale 0 to 10)	Value for Home use (scale 0 to 10)	Value for Market (scale 0 to 10)	Firmness (scale 0 to 10)	Quality (scale 0 to 10)
8	8	10	10	10	7	9	9
8	6	7	8	8	6	6	8
10	10	10	10	9	9	7	9
10	8	10	10	8	9	5	7
6	6	7	7	6	6	8	5
0	0	2	2	0	0	7	1
8	6	8	8	8	8	8	8
8	8	10	10	7	8	7	7
10	10	10	10	8	10	7	7
6	6	7	7	6	6	9	5
9	8	9	9	7	8	10	8
8	6	7	7	5	5	10	8
8	9	8	8	6	8	10	6
8	7	6	6	8	7	8	8
8	6	8	8	10	7	9	10
8	6	8	8	10	7	9	9
8	6	8	8	6	6	6	6
6	6	8	8	6	6	6	6
0	0	0	0	0	0	0	0
10	7	10	10	10	8	10	10
7	6	8	8	6	6	7	7
7	10	7	7	4	7	8	6
6	4	8	8	6	4	8	8
4	2	7	7	0	0	8	8
9	4	8	8	8	5	8	8

Cumberland Triumph.—Perfect flower; plant vigorous and rapid spreader; rusts badly; a heavy bloomer; ripens early; berry red and large, hollow center, soft, color pale red; flesh white; productive; a good berry for home market; sells well.

Ohio.—Pistillate; growth slow; runners numerous; was taken by rust; a fine, regular shaped, medium sized berry; slightly acid; color pale red with white flesh; not very productive; late.

Sanafée.—Perfect flower; weak plant with few runners; rusts somewhat; berry small in size; deep crimson; flesh white; very unproductive; worthless.

Annie Forrest.—Perfect flower; a fine vigorous plant with few runners; almost free from rust; ripens a few days after the earliest; a fine large berry; crimson; solid; white flesh; flavor excellent; productive; worthy of further trial here.

Ontario.—Perfect flower; plant fine and vigorous; the most showy plant of any variety we had in the early spring; rusts somewhat; ripens rather early; berry large; fair flavor; irregular in shape; not very firm; crimson; flesh pink; productive; berry keeps well, and its large size makes it sell well on the market.

Bubach No. 5.—Pistillate; plant very vigorous, with rich dark green foliage; numerous runners; rusts somewhat; medium early; berry large and very showy; irregular in shape; not very firm; color red; flesh pink; berries continued large in size throughout the season; very productive; sold best of any berry we had.

Kentucky.—Perfect flower; growth fairly vigorous; runners somewhat numerous; rusts badly; a regular shaped and medium sized berry; not very firm; color pale red; acid.

Warfield's No. 2.—Pistillate; very vigorous; runners numerous; rusts; medium early; berry well shaped; medium to large in size; color dark crimson; showy; very acid until perfectly ripe; fine flavor; firm red flesh; productive; a berry worthy of further trial.

Gypsy.—Pistillate; plant strong and vigorous; runners numerous; free from rust; ripens rather early; berry well shaped; medium sized; crimson; flesh solid; red; fine flavor; not very productive with us this year.

Logan.—Pistillate; plant a good grower; rusts badly; only

fair bloomer ; berries ripen medium early ; large ; well shaped ; bright red ; flesh pink ; flavor fair ; produced only an average crop with us this year.

Lida.—Pistillate ; fine vigorous plant ; abundant runners ; free from rust ; white plant with blooms ; berries ripen soon after the earliest ; fair-shaped but uneven in size ; color deep red ; solid ; flavor not extra ; very productive.

Photo.—Pistillate ; plant rusts badly ; scant bloomer ; berries ripen rather late ; small size ; fine flavor ; red, solid flesh ; not productive.

Mammoth.—Perfect flower ; plant small ; few runners ; rusts badly ; fine shaped ; medium in size ; dark red in color ; flesh solid, dark red ; unproductive.

Phelps.—Perfect flower ; good strong plant ; almost free from rust ; berry ripens medium early ; somewhat irregular in shape ; medium sized ; soft ; color red ; flesh red ; fair flavor ; very unproductive.

Primo.—Perfect flower ; plant not vigorous ; attacked by rust ; rather late ; medium size ; somewhat irregular in shape ; soft, pale red, white fleshed berry ; flavor not good.

Gandy's Pride.—Perfect flower ; plant made a fine vigorous growth ; runners not very numerous ; attacked by blight or rust in August ; scant bloomer ; large fine shaped berry ; color pale red ; well flavored ; solid ; not very productive ; season late ; no doubt will become very popular as a late berry.

Haverland.—Pistillate ; a strong, vigorous plant ; almost free from rust ; runners numerous ; fine bloomer ; berry very large, long cone-shaped, pale red, solid, and of only fair quality ; very productive ; berries lie in clusters on the ground, and therefore must be mulched ; medium early.

May King.—Perfect flower ; plant medium growth and vigorous ; few runners ; almost free from rust ; small bloom ; ripens early ; well shaped and fair sized berry ; light red in color, solid and of fine quality ; not very productive.

Henderson.—Perfect flower ; plant thoroughly vigorous ; runners scant ; blooms fine ; berry ripens medium early ; berry fair sized, red in color ; best flavored berry we have ; not productive ; fine for family use.

Gold.—Pistillate ; plant small ; few runners ; nearly free from

rust; medium early; berry good size and shape; color red; quality good, but not very productive.

The following varieties have not been sufficiently tested by us to be commented upon at present: Jewell, Summit, Bombay, Monmouth, Covill, Carmichael, Piper, Belmont and Scarlet Queen.

The following new varieties were sent to us in the spring of '89, and reports will be given as soon as they fruit:

Loudon's 15, Pine Apple, Durham, Pearl, Burt, sent by M. Crawford, Cuyahoga Falls, Ohio; Barton's Eclipse, claimed to be the largest berry ever grown; and from the growth and vigor of the plant, we should judge that this claim might be substantiated; Lady Rusk, sent for trial by the Nauvoo Fruit-Growers' Association, Nauvoo, Ill.; Cloud, Daisy, Eureka, Miami and Triomphe de Grande. Plants made a fine growth during the summer.

From our observations this year, the following new varieties would seem worthy of trial for market: Jessie, Bubach No. 5, Haverland, Warfield's No. 2, Itasca, and perhaps the Crawford, and for a late berry Gandy's Pride. For family use the Jessie, Warfield's No. 2, Itasca, Crawford and Henderson, and for a late berry Gandy's Pride would be a good selection.

Plants with pistillate or imperfect flowers should never be planted exclusively, but every third row should be planted with perfect flowering plants. It will be noticed that the Bubach No. 5, Haverland and Warfield's No. 2 all have imperfect flowers. In planting these varieties the Jessie would be a good variety to plant with them, as it has a perfect flower.

BULLETIN No. 26.*EXPERIMENTS WITH CORN.*

We continued our experiments with corn this year, generally following out the plans adopted last year. The experiments may be conveniently discussed under the following heads:

1. *Effect of the leading elements of plant food used in various combinations on the production of corn.*

2. *Permanency of effect of potash fertilizers.*

3. *Relation of fertilizers to shrinkage and to the proportion of kernel to cob.*

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

THE SEASON.—The season was favorable to the corn crop throughout its growth. The rain fall during the corn season was as follows:

April	1.52 inches.
May	3.53 "
June	3.49 "
July	5.82 "
August	1.15 "
September	6.79 "
October	3.06 "

During the entire growing season the temperature was above 41 degrees, Fahrenheit, except two days in April. April had one day above 68 degrees, Fahrenheit. The per cent. of sunshine to cloudiness was as follows:

April	50 per cent.
May	43 " "
June	34 " "
July	37 " "
August	50 " "
September	51 " "
October	39 " "

The Soil.—The soil of the Experiment Station Farm is what is termed a "Blue-grass" soil. It is derived from the Lower Silurian limestone, rich in phosphoric acid. The subsoil is a light colored clay, so retentive as to make the soil deficient in natural drainage. The land is worn, having been in cultivation for many years. It is believed that no stable manure or other fertilizers were applied before the farm was purchased by the Station.

1. *Experiments showing the effects of the leading elements of plant food used in various combinations, on the production of corn.*

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.

For this trial two separate experiments were made here, and many co-operative experiments in different parts of the State.

Experiment No. 1.—The land used for this experiment was the same as that used for the same purpose last year, the plot receiving no fertilizer last year received none this year. The plot receiving all three of the leading elements last year received the same this year, etc. The field was nearly level, slightly sloping lengthwise of the plots. Size of plots, one-twentieth of an acre each.

The following table shows the kind of fertilizers applied to the various plots; the amount calculated per acre; the number of pounds of the leading elements of plant food applied per acre, and the per cent. of these elements in the various fertilizers:

Number	COMPOSITION OF FERTILIZER USED.	Amount in Pounds	Number of pounds of the leading elements of plant food.			Per cent. of the leading elements of plant food in fertilizer used.		
			Phosphoric Acid .	Potash	Nitrogen	Phosphoric Acid .	Potash	Nitrogen
12	No Fertilizer	..	..	..	..	..	..	..
13	{ Acid Black 320 Muriate of Potash 160 Nitrate of Soda 160 }		57.6	80	25.6	9.00	12.5	4
14	{ Acid Black 320 Muriate of Potash 160 Dry Dirt 160 }		57.6	80	..	9.00	12.5	..
15	{ Acid Black 320 Nitrate of Soda 160 Dry Dirt 160 }		57.6	..	25.6	9.00	..	4
16	{ Muriate of Potash 160 Nitrate of Soda 160 Dry Dirt 320 }		..	80	25.6	..	12.5	4
17	No Fertilizer	..	..	..	..	..	..	..
18	{ Dry Dirt 480 Muriate of Potash 160 }		..	80	..	..	12.5	..
19	Land Plaster	160	..	..	..	..	..	..

As will be seen by reference to the above table, we used acid black containing in round numbers 18 per cent. phosphoric acid to supply this ingredient, muriate of potash containing 50 per cent. of potash for potash, and nitrate soda containing 16 per cent. nitrogen to supply nitrogen.

FIELD NOTES.

The following field notes are given to show the effects of these different fertilizers at the various stages of the growth of the corn :

Plot 12.—No fertilizer used ; corn up May 15 ; June 1, poor ; June 20, common, ten inches high ; July 20, tasseling, $4\frac{1}{2}$ feet high ; July 30, shooting ; August 4, silking.

Plot 13.—Fertilized with 8 pounds nitrate soda, 16 pounds acid black, 8 pounds muriate of potash ; corn up May 15 ; June 1, very good ; June 20, looks well, 18 inches high ; July 20, $6\frac{1}{2}$ feet high, some tassel ; July 27, shooting ; August 4, silking.

Plot 14.—Fertilized with 8 pounds muriate of potash, 16 pounds acid black ; corn up May 15 ; June 1, very fair ; June 20, good, 20 inches high ; July 20, 7 feet high, some tassel ; July 26, shooting ; August 1, silking.

Plot 15.—Fertilized with 8 pounds of nitrate of soda and 16 pounds acid black ; corn up May 15 ; June 1, very good, of good color ; June 20, good, 18 inches high ; July 20, some tassel, $5\frac{1}{2}$ feet high ; July 26, shooting ; August 1, silking.

Plot 16.—Fertilized with 8 pounds of muriate of potash and 8 pounds nitrate soda ; corn up May 15 ; June 1, good ; June 20, good, 18 inches high ; July 20, some tassel, 6 feet high ; July 26, shooting ; August 2, silking.

Plot 17.—No fertilizer used ; corn up May 15 ; June 1, hardly fair ; June 20, poor, 10 inches high ; July 20, 5 feet high ; July 29, shooting ; August 4, silking.

Plot 18.—Fertilized with 8 pounds muriate of potash ; corn up May 15 ; June 1, very fair ; June 20, good, 16 inches high ; July 20, some tassel, 6 feet high ; July 26, shooting ; August 7, silking.

Plot 19.—Fertilized with land plaster; corn up May 15; June 1, hardly fair; June 20, poor, 10 inches high; July 20, 4½ feet high; July 26, some tassel; August 1, shooting; August 5, silking.

The following table shows the yield of the field-cured ear corn and fodder, calculated per acre, as well as the fertilizers used, and the increased yield of corn and fodder resulting from the use of the fertilizers. The corn is given in bushels, containing 70 pounds per bushel. Under "yield of fodder," we include the whole amount of stalks, leaves, etc., after removing the ears, and it should be noted that the corn was cut near the ground for the sake of uniformity:

TABLE 1.—Showing Results of Fertilizers on Corn.

No. of Plot	FERTILIZERS USED.	No. lbs of Fertilizers Applied Per Acre	Yield of Ear Corn Per acre in Bushels of 70 pounds.	Yield of Fodder in lbs. Per Acre	Increased Yield of Corn per Acre in Bushels	Increased Yield of Fodder Per acre in Pounds
12	No Fertilizer		38	1,060		
13	{ Acid Black Muriate of Potash Nitrate of Soda	{ 320 160 160 }	88	3,960	56	2,210
14	{ Acid Black Muriate of Potash Soil.	{ 320 160 160 }	87	4,880	55	3,130
15	{ Acid Black Nitrate of Soda Soil.	{ 320 160 160 }	35	2,980	3	1,230
16	{ Muriate of Potash Nitrate of Soda Soil.	{ 160 160 160 }	94	4,040	62	2,290
17	No Fertilizer		25	2,440		
18	{ Muriate of Potash Soil.	{ 160 160 }	77	3,740	45	1,990
19	Land Plaster	160	33	2,020	1	270

In examining these results it will be noticed—

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

2. That in Plot 15, where a fertilizer was used without potash, there was scarcely any increase in corn, but a considerable increase in fodder.

3. That the greatest increased yield was made on Plot 16, where both nitrogen and potash were applied.

4. That muriate of potash, when applied alone, made a marked increased yield over the plots containing no fertilizer.

5. By reference to Bulletin No. 17 it will be seen that the results this year were the same as last.

EXPERIMENT No. 2.

In this experiment the conditions were all the same as in Experiment No. 1, except as regards the ingredients of fertilizers. The plots were adjoining lengthwise the plots of Experiment No. 1, No. 12 in Experiment 2, being a continuation of Plot No. 2 in Experiment No. 1, and so on. In this Experiment sulphate of potash was substituted for muriate of potash in Experiment No. 1, and acid black was substituted for land plaster. The results are given in the accompanying table:

TABLE 2.—Showing Results of Fertilizers on Corn.

Number of Plot	FERTILIZER USED.	Number of Pounds of Fertilizer Applied Per Acre.	Yield of Ear Corn Per Acre in Bushels of Seventy Pounds.	Yield of Fodder in Pounds Per Acre.	Increased Yield of Corn in Bushels Per Acre.	Increased Yield of Fodder in Pounds Per Acre.
2	No Fertilizer . . . . .	.....	25	2,320	.....	.....
3	{ Nitrate of Soda Acid Black Sulphate of Potash	{ 160 320 160 }	79	3,920	45	1,380
4	{ Sulphate of Potash Acid Black	{ 160 320 }	74	3,680	40	1,140
5	{ Nitrate of Soda Acid Black	{ 160 320 }	34	2,420	.....	.....
6	{ Sulphate of Potash Nitrate of Soda	{ 160 160 }	81	3,620	47	1,080
7	No Fertilizer . . . . .	.....	44	2,760	.....	.....
8	Sulphate of Potash	160	80	4,100	46	1,560
9	Acid Black	320	33	2,160	.....	.....
10	Nitrate of Soda.	160	41	2,420	7	.....

1. Comparing tables 1 and 2 it will be seen that the general results are the same, viz: That an increased yield followed the use of potash fertilizers.

2. It appears from comparing these two results that it makes little difference whether sulphate or muriate of potash is used to furnish potash—the difference, if any, being in favor of the muriate of potash.

THE FINANCIAL RESULTS.

In taking into consideration whether there followed a profit by the use of the fertilizers on the various plots, neither the fodder was considered—although there was generally a marked increased yield—nor the benefit which the fertilizers might have on subsequent crops. As the corn could have been sold at 35c. per bushel of 70 pounds, our calculations are based on this

price. The acid black applied cost at the rate of \$4.00 per acre; muriate of potash, \$3.60; nitrate soda \$3.60.

In considering the financial results we will only take for an example experiment No. 1. 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 the above 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 or Loss
12	None		\$13 30		
13	{ Acid Black Muriate of Potash Nitrate of Soda	{ \$11 20	30 80	\$19 80	\$8 60
14	{ Acid Black Muriate of Potash	{ 7 60	30 45	19 45	11 85
15	{ Acid Black Nitrate of Soda	{ 7 60	12 25	1 25	*6 35
16	{ Muriate of Potash Nitrate of Soda	{ 7 20	32 90	21 90	14 70
17	None		8 75		
18	Muriate of Potash	3 60	26 95	15 95	12 35
19	Land Plaster	.80	11 55	.55	*25

* Loss.

From this table it appears—

1. That there was a profit in every instance where potash fertilizers were used, the largest net profit arising from the nitrate of soda and muriate of potash on Plot 16.

2. There was a loss by using acid black and nitrate of soda without potash, as shown on Plot 15.

The results would indicate that soils of like character in the

"Blue-grass" region would be benefited by fertilizers containing large quantities of potash, but the conclusions reached should not be considered as being applicable to the soils of the other geological formations of the State. The experiments, however, should be an object lesson as to the intelligent use of commercial fertilizers. They show that every farmer should know just what his soil needs, and, knowing, apply such a fertilizer as will furnish the elements required. There were over forty different brands of fertilizer on sale in this State last year containing less than two per cent. of potash. Such fertilizers would have been of little benefit to our soil for corn—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.

EXPERIMENT NO. 3—CO-OPERATIVE EXPERIMENTS.

In order to test the soils of the other formations of the State, a series of co-operative experiments was planned, and a beginning made this last year. These experiments will have to be continued several years, in all probability, before general conclusions can be reached. The following circular was sent to each person making the experiments. The fertilizers were mixed at the Station, and sent labeled, as in the circular:

1. "The soil should be well worn and in need of manure of some kind. Select as level a piece of ground as possible, that rains may not wash the fertilizer from one plot into any adjoining plot.

2. For the experiment, mark off ten plots, each one-tenth acre in area. Separate the plots by paths at least three feet wide. If convenient, make the plots narrow and long, say eight rows wide, and long enough to have the plot contain 4,356 square feet. If the corn is planted in rows four feet apart, the plots would be eight hills wide and thirty-four hills long, or thirty-two feet wide by one hundred and thirty-four feet long. If it is more convenient, make the plots sixteen hills wide and seventeen hills long, or four hills wide and sixty-eight hills long. In all cases see that each plot contains 4,356 square feet, or so nearly that era that the results will be relative and accurate.

3. Be sure to number the plots and apply the fertilizers as follows :

1 No Fertilizer.

2	{	Ammonia sulphate.....	4 lbs.	}	
		Azotine.....	8 "		
		Sodium nitrate.....	4 "	}	For Nitrogen.
3		Acid phosphate.....	40 "		—For phosphoric acid.
4		Muriate of potash.....	16 "		—For potash.
5		No fertilizer.			
		Acid phosphate.....	40 "		—For phosphoric acid.
6	{	Ammonia sulphate.....	4 "	}	
		Azotine.....	8 "		
		Sodium nitrate.....	4 "	}	For nitrogen.
		Muriate of potash.....	16 "		—For potash.
7	{	Ammonia sulphate.....	4 "	}	
		Azotine.....	8 "		
		Sodium nitrate.....	4 "	}	For nitrogen.
8	{	Acid phosphate.....	40 "		—For phosphoric acid.
		Muriate of potash.....	16 "		—For potash.
		Acid phosphate.....	40 "		—For phosphoric acid.
		Muriate of potash.....	16 "		—For potash.
9	{	Ammonia sulphate.....	4 "	}	
		Azotine.....	8 "		
		Sodium nitrate.....	4 "	}	For nitrogen.
10		Plaster.....	16 "		

4. Sow each fertilizer on its corresponding plot broadcast, taking every precaution to have the fertilizer evenly distributed over the entire plot, and be careful not to allow the fertilizer to blow over on an adjoining plot while sowing. Do not sow while the wind is blowing. It is best in order to get an even distribution, to sow in such quantities that each plot will have to be gone over twice to use up the fertilizers.

Mix fertilizers Nos. 2, 3, 4, 6, 7, 8 and 10 with enough dry dirt to make the same bulk as fertilizer No. 9 before sowing.

After sowing, harrow the ground, and then it is ready for planting. If the corn is planted before this set of fertilizers reaches you, sow broadcast over the planted ground and leave one row between each plot without fertilizer, or one plot may be left between each fertilized plot, which in that place should be labeled "No fertilizer," but not numbered.

Plant the corn thick enough to insure a perfect stand, and at the proper time thin to the usual number of stalks to the hill.

Treat all plots alike in every respect, except as to fertilizers applied; that is, prepare the ground the same and at the same time, plant the corn on all plots the same day, and cultivate each time the same day.

NOTE THE FOLLOWING.

1. Time the corn was planted.
2. Date the corn was up on each plot.
3. When the corn is about three inches high on the plot containing no fertilizer, note the height and appearance of the other plots.
4. When thinning, record the number of missing hills and stalks in each plot.
5. The appearance of the corn at tasseling and date of tasseling.
6. Same as regards silking.
7. Same at time of harvest.
8. The height of stalk from ground when matured.
9. The comparative size of ears on the various plots when husked—that is, say small, large, largest, etc.
10. The weight of ear corn, when gathered, from each plot.
11. Please note any other observation of interest.
12. Report the results to the Station as soon after the experiments are completed as possible.

*REPORTS.***Geological Formation, Upper Subcarboniferous.**

DR. J. D. CLARDY, HOPKINSVILLE, CHRISTIAN COUNTY, KY.

Soil rich, and produces large crops without using fertilizers. Dr. Clardy makes the following report: There is no marked difference in the plots, and the average is not greater than in many parts of the field where fertilizer was used. Each lot was carefully weighed in the shack, and we estimated seventy-six pounds to the bushel. The season was very wet, and another experiment will be necessary to tell what we need. The yield in bushels was as follows:

Number Plot . . .	FERTILIZER USED.	Yield of Corn in Bushels of 70 Lbs. Per Acr.	
		Increased Yield of Corn in Bushels Per Acre. . . .	
1	None	59	. . .
2	Nitrogen	64	2
3	Phosphoric Acid	59	. . .
4	Potash	69	7
5	None	65	. . .
6	Phosphoric Acid, Nitrogen	69	7
7	Potash, Nitrogen	66	4
8	Potash, Phosphoric Acid	59	. . .
9	Phosphoric Acid, Potash, Nitrogen	73	11
10	Land Plaster	63	1

Geological Formation, Upper Subcarboniferous.

W. S. DICKINSON, TRENTON, TODD COUNTY, KY.

Mr. Dickinson reports that cattle broke into his experiment plot before the corn was gathered, and it was impossible to report results, but that the corn on Plots 6, 9 and 10 had the best color at tasseling time, and kept ahead up to maturity. No. 4 looked yellow until the corn began to tassel, and from that time until roasting-ear time it looked fine.

Geological Formation, Upper Subcarboniferous.

WM. DARBY, CAVE SPRING, LOGAN COUNTY, KY.

Land dry, having been cultivated four years in succession immediately preceding the experiment.

Corn planted three feet eight inches each way. Ten plots were laid off, each six hills wide and sixty-four hills long. One row of corn was plowed up all around the acre and one row between each plot. Fertilizer applied as per directions. On April 25th the corn was up from two to three inches high. Weather was very dry up to the 4th of June. From June 4th to the 19th the season was rainy and wet.

Observations June 19th: Plot 2 no better than No. 1. Plot 3 much better than No. 1 or 2; 4 and 5 same as No. 1. No. 6 better than any preceding. No. 7 not so good as No. 6, but better than No. 1. No. 8 looks nearly as well as No. 9. No. 9 best looking plot. No. 10 same as 1 and 5. Wet weather continued until July 24th, causing grass to grow on all the plots, but much thicker and ranker on 3, 6, 8 and 9 than the others.

Observations July 24th after continued wet weather: No. 1 good color, dried slightly at bottom, tasselling at height of 6½ feet. No. 2 dark green from ground up; tasselling at 6 feet. No. 3 paler green than No. 2; firing at bottom. No. 4 deep green. No. 5 same as No. 1. No. 6 light green; firing at bottom. No. 7 deep green from ground up. No. 8 firing at bottom; light in color. No. 9 deep green but firing slightly. No. 10 good color; firing slightly.

After the corn was husked it was weighed and the results follow:

No. Plot	FERTILIZER USED.	Yield of Corn in Bushels of 70 Lbs. Per Acre.	Increased Yield of Corn in Bushels Per Acre
1	None	31	. . .
2	Nitrogen	33	2
3	Phosphoric Acid	31	. . .
4	Potash	26	. . .
5	None	31	. . .
6	Phosphoric Acid, Nitrogen	38	7
7	Potash, Nitrogen	36	5
8	Phosphoric Acid, Potash	37	6
9	Phosphoric Acid, Nitrogen, Potash	50	19
10	Land Plaster	35	4

Mr. Darby thinks that the difference in yield would have been greater had the fertilizer been applied sooner.

Geological Formation, Upper Subcarboniferous.

DR. P. W. FOOTE, BEWLEYVILLE, BRECKINRIDGE CO., KY.

The corn was planted three weeks later than the balance of my crop, owing to the continued early drouth. It was planted by hand, all your directions being carefully followed, except in the case of No. 9. Here the man skipped two rows, which I planted after the other was up, making it ten days later, and consequently a little lighter than it otherwise would have been. On May 9th fertilizer was applied, and on the 10th corn was planted very thickly. On May 19th corn was up on all the plots, perfect stand; thinned to two stalks to the hill; plowed with a cultivator four times. When corn was about three inches high the fertilized plots were the most vigorous and best color. From twelve inches high up to time of tasseling, the fertilized plots could be distinguished for two or three hundred yards, having larger stalks and being of a much darker green, and tasseled earlier. Did not note date of tasseling and silking. We had about this time some very heavy rains, and my land being very level, I am of the opinion that some of the fertilizer was washed to the unfertilized plots, as it eared and weighed out better than it promised while growing. All the fertilized plots made better quality of corn than the unfertilized plots. But while growing Nos. 3, 6, 8 and 9 looked best of all. Am confident that this acre would have made twenty bushels more had it been planted three weeks earlier. Am at a loss to account for the large yield on No. 5, unless the fertilizer was washed to it.

I got the following results:

Number Plot. . . .	FERTILIZER USED.	Yield of Corn in Bushels of 70 Lbs. Per Acre.	
		Yield of Corn in Bushels of 70 Lbs. Per Acre.	Increased Yield of Corn in Bushels Per Acre. . . .
1	None	38	. . .
2	Nitrogen	49	4
3	Phosphoric Acid	59	14
4	Potash	52	7
5	None	53	. . .
6	Phosphoric Acid, Nitrogen	57	12
7	Potash, Nitrogen	53	8
8	Phosphoric Acid, Potash	65	20
9	Phosphoric Acid, Nitrogen, Potash.	57	12
10	Land Plaster.	41	. . .

Geological Formation, Upper and Lower Subcarboniferous.

VINCENT FREEMAN, CAMPBELLVILLE, TAYLOR COUNTY, KY.

I could see very little difference in any of the plots when the corn came up; but in a short time the corn on plots where phosphoric acid had been applied looked better than the others, and was the best-looking plot during the whole season. The corn on plots where potash and nitrogen were applied was only a trifle better than the blanks; and, where all three were applied, the result was only a little better than where phosphoric acid was applied alone.

Just before time for gathering the corn my hogs got in and ruined the crop. The conclusion at which I arrived, from the appearance of the plots, was, that phosphoric acid was what was needed, and nothing else. Had I gathered the corn before the hogs got in, I would have gotten one hundred-fold more where phosphoric acid was applied than I would have gotten on plots where it was absent.

Geological Formation, Upper Subcarboniferous.

L. A. FREEMAN, AUBURN, LOGAN COUNTY, KY.

I simply give the results in pounds of the corn on the ear (shucked) on each plot. You will notice that Plot No. 4, containing potash alone, gave the smallest yield. Plot No. 9 gave the largest yield. The plots seem to show up differently on my farm from what they did on yours.

The results were as follows:

No. of Plot . . .	FERTILIZER USED.	Yield of Corn in Bushels of 70 Lbs. Per Acre.	Increased Yield of Corn in Bushels Per Acre. . . .
1	None	7	
2	Nitrogen	17	6
3	Phosphoric Acid	12	1
4	Potash.	6	
5	None	16	
6	Phosphoric Acid, Nitrogen	5	
7	Potash, Nitrogen	4	
8	Phosphoric Acid, Potash	9	
9	Phosphoric Acid, Nitrogen, Potash.	5	
10	Land Plaster.	6	

Geological Formation, Upper Subcarboniferous.

J. W. STRINGER, FRANKLIN, SIMPSON COUNTY, KY.

Mr. Stringer sowed his fertilizer after the corn had come up.

The corn was planted March 23d; came up about April 20th; on May 30th the fertilizer was sown. Up to that time the corn looked thrifty, but on application of the fertilizer it turned a whitish color and stopped growing for two or three weeks, when it started to growing again and did well. The corn was twelve inches high when the fertilizer was sown.

The following are the results obtained:

No. of Plot . . .	FERTILIZER USED.	Yield of Corn in Bushels of 70 Lbs. Per Acre.	Increased Yield of Corn in Bushels Per Acre . .
1	None	32	
2	Nitrogen	36	5
3	Phosphoric Acid	28	
4	Potash	31	
5	None	30	
6	Phosphoric Acid, Nitrogen	39	8
7	Potash, Nitrogen	44	13
8	Phosphoric Acid, Potash	29	
9	Phosphoric Acid, Nitrogen, Potash	31	
10	Land Plaster	29	

Geological Formation, Upper Subcarboniferous.

R. E. GOOCH, OAKVILLE, LOGAN COUNTY, KY.

An acre of thin jaded land of pretty even fertility, or unfertility, broken deep in the fall before was selected. There was enough more than an acre to admit of a row of corn between each of the plots. The ground was well harrowed, rebroken with double shoveled plows, then logged and the rows laid off each way with small plow. The corn was then dropped and lightly covered with the foot with about half inch of dirt to keep the fertilizer from coming in contact with the seed. The fertilizer was then sown broadcast, according to directions, sowing each plot over twice to secure an even distribution. The fertilizer was then harrowed in, running lengthwise of the plots, then a brush was run across, leaving the ground perfectly level and pulverized. Corn was planted April 18th, and, without a drop of rain, was well up in ten days.

The weather continued dry until May 25th, and no difference could be distinguished in the plots. About the 1st of June corn was from 6 to 8 inches high, and seemed a little taller and richer colored on plots Nos. 2, 3, 6, 8 and 9. The corn, which was planted very thickly to secure a perfect stand, was then carefully thinned to two stalks to the hill. When the corn was waist high on the plots named above it was 8 to 12 inches taller and much richer in color than the rest, especially those containing acid phosphate, while those containing potash looked spindling and yellow, especially so was No. 4, containing potash alone. Plots containing acid phosphate tasseled and silked ten days sooner than the rest, and the fodder below the ear began to fire up early in August, when it was raining every day. Potash plots also began to fire up early. Corn on plot No 2 remained perfectly green until the middle of September. Stalks on acid phosphate plot grew about 9 to 10 feet high and large; on nitrogen plot about 8 to 9 feet and large; on potash and blank sappy from 7 to 8 feet high and small. Ears largest on No. 6. Next largest on Nos. 3, 9 and 8. Small ears on all the others.

The results were as follows:

No. Plot	FERTILIZER USED.	Increased Yield of Corn in Bushels Per Acre	
		Yield of Corn in Bushels of 70 Lbs Per Acre .	
1	None	35	. . .
2	Nitrogen	37	6
3	Phosphoric Acid	37	6
4	Potash	29	. . .
5	None	28	. . .
6	Phosphoric Acid, Nitrogen	37	6
7	Potash, Nitrogen	33	2
8	Phosphoric Acid, Potash	35	4
9	Phosphoric Acid, Nitrogen, Potash	36	5
10	Land Plaster	28	. . .

Geological Formation, Upper Subcarboniferous.

G. W. SHAW, FAIRVIEW, TODD COUNTY, KY.

Corn planted April 23d, but owing to dry weather did not come up until May 1. When the corn was three inches high there was very little difference in the plots, No. 6 being the tallest. I did not count the stalks at the time of thinning, but think there was but very little difference in the number on the different plots. At the

time of tasselling the corn seemed to be taller and greener on plot No. 6. The stalks were about ten feet high at maturity, except on plots No. 4 and 5, which seemed to be a little lower in height and a little later in maturing. The ears of corn were a little above the medium in size.

My results were as follows:

Number Plot. . .	FERTILIZER USED.	Increased Yield of Corn in Bushels Per Acre. . . .	
		Yield of Corn in Bushels of 70 Lbs. Per Acre	
1	None	33	. . .
2	Nitrogen	37	. . .
3	Phosphoric Acid	35	. . .
4	Potash	46	7
5	None	45	. . .
6	Phosphoric Acid, Nitrogen	52	13
7	Potash, Nitrogen.	44	5
8	Phosphoric Acid, Potash	40	1
9	Phosphoric Acid, Nitrogen, Potash.	43	4
10	Land Plaster	37	. . .

Geological Formation, Quarternary.

T. M. WATKINS, CRUTCHFIELD, FULTON COUNTY, KY.

There was some delay in getting the fertilizer, and it was applied after the corn had been planted about two weeks. Corn was planted on the 12th of May. Ground was very dry at time of planting, and remained very dry for some time. After the first rain it began to grow right along, Nos. 6 and 9 growing more rapidly than any of the others. Plots 1 to 8 were situated on a level piece of ground between two hills, while Nos. 9 and 10 were in another part of the same field on ground of about equal fertility. The land, from the best information that I can get, has been in cultivation for the last fifty years, having been in clover only twice in that time. The land was plowed to an average depth of seven inches, and corn planted in drills and cultivated with harrow and double shovel. Corn cut and shocked when well glazed. Gathered when thoroughly dry. I did not weigh the fodder, for the reason that very few farmers cut their corn in this county. The following table gives results, calculated per acre, in the ear in shuck:

No. of Plot,	FERTILIZER USED.	Yield of Corn in Bushels of 70 Lbs. Per Acre.	Increased Yield of Corn in Bushels Per Acre. . .
1	None	57	
2	Nitrogen	68	6
3	Phosphoric Acid	69	7
4	Potash	65	3
5	None	67	
6	Phosphoric Acid, Nitrogen	72	10
7	Potash, Nitrogen	66	4
8	Phosphoric Acid, Potash	47	
9	Phosphoric Acid, Nitrogen, Potash.	72	10
10	Land Plaster.	60	

Geological Formation, Carboniferous.

J. O. DeCOURCY, DUNMOR, MUHLENBERG COUNTY, KY.

The experiment was made on old well-worn land Southern exposure. Rolling enough to drain itself well. Plots 1 and 10 were on ground a little higher than the others, there being a little "sway" towards the middle. The ground was dry when the corn was planted, but the clods were pulverized by harrowing and rolling. Corn was cultivated five times. The wet weather interfered materially with the growth. It was slightly damaged by wet weather while being husked.

Field Notes.—August 15, plots 1 and 2 tasseling, some silks, and foliage "firing" sharply. No. 3 in silk, firing sharply; some crab grass in this plot. No. 4 and 5, about half tasseled, few silks, foliage sharply fired. No. 6, in full silk, dark rich color, foliage very little fired; crab grass in this plot. No. 7, in full tassel, few silks, foliage firing. No. 8, in full tassel, half silked, foliage fired; crab grass very thick. No. 9, same. No. 10, in full tassel, few silks, foliage beginning to fire.

August 29, Nos. 1 and 2, in full silk, foliage burnt, irregular. Nos. 3, 4 and 5, drying, slightly burnt. No. 6, silks generally dry, foliage rich in color, little burnt. No. 7, general silk, few dry, some foliage burnt. Nos. 8 and 9, silk generally dry, corn yellowish. No. 10, general silk, some fired.

October 7, corn was cut; was husked and weighed December 24th.

7—3 E. S.

The following table shows the results:

No. Plot.	FERTILIZER USED.	Increased Yield of Corn in Bushels Per Acre	
		Yield of Corn in Bushels of 70 Lbs. Per Acre.	
1	None	14	. . .
2	Nitrogen	15	. . .
3	Phosphoric Acid	33	15
4	Potash	18	. . .
5	None	23	. . .
6	Phosphoric Acid, Nitrogen	48	30
7	Potash, Nitrogen	23	5
8	Phosphoric Acid, Potash	32	14
9	Phosphoric Acid, Nitrogen, Potash	33	15
10	Land Plaster	22	4

It looks as though Phosphoric Acid was the element most needed.

Geological Formation, Lower Silurian.

W. P. COMBS, CAMPBELLSBURG, HENRY COUNTY, KY.

Land has been in cultivation not less than sixty years. Been used for corn, oats, wheat and tobacco for fifteen years out of the last twenty. In '87 it was in oats and sown to clover, but failed to make a stand. Idle in 1888. Soil has great natural drainage. Planted May 15th. Corn came up irregularly. As much as ten days intervened between the first and last. Fertilizers at first made no appreciable difference. When the corn was three inches high on unfertilized plots it varied from three to four on the fertilized. A perfect stand was obtained. At tasseling and silking time the fertilized plots showed a more robust and healthy appearance. At maturity the corn on fertilized plots was 9 feet high, while the unfertilized was only 7½ feet. Ears vary greatly in size. Average longer and larger in diameter on fertilized plots, about as 7 to 5 and 8 to 5. The plots were four hills wide and sixty-four long. Hills four feet apart. Plot No. 1 was near a fence, and "I think was on little better soil than the other plots." "To look at the corn at silking time would not have created the impression that there would be such a difference in the yield."

The following tabulated statement gives the results of Mr. Combs' experiments:

No. of Plot . . .	FERTILIZER USED.	Yield of Corn in Bushels of 70 Lbs. Per Acre.	Increased Yield of Corn in Bushels Per Acre. . . .
1	None	24	
2	Nitrogen	26	4
3	Phosphoric Acid	27	5
4	Potash.	31	9
5	None	20	
6	Phosphoric Acid, Nitrogen	30	8
7	Potash, Nitrogen	32	10
8	Phosphoric Acid, Potash	34	12
9	Phosphoric Acid, Nitrogen, Potash	36	14
10	Land Plaster.	20	

As will be seen, there is no marked increase from the use of fertilizers. Nitrogen has very little effect, as shown by Plot 2, and potash produced the effect, as shown by Plot No. 4. It would appear, from these results on Mr. Combs' land, that a fertilizer containing a small per cent. of nitrogen, and with the average per cent. of phosphoric acid, and well up in potash, would benefit his land most for corn.

Unless, however, the fertilizers cause a greater increased yield than they did this year, the outlay will be greater than the value of the increased yield.

Geological Formation, Upper Subcarboniferous.

MR. B. F. COFER, ELIZABETHTOWN, HARDIN COUNTY, KY.

The land planted in corn was old, worn land, and had not been turned for twenty years. The land was "broke" in April, and lay until the 5th of May, when the corn was planted and fertilizers applied in the following manner:

1	Sodium nitrate.	160 Pounds.
2	Acid phosphate	400 "
3	Muriate of potash	160 "
4	{ Acid phosphate	400 "
	{ Sodium nitrate.	160 "
5	{ Muriate of potash	160 "
	{ Sodium nitrate.	160 "
6	{ Acid phosphate	400 "
	{ Muriate of potash	160 "
7	{ Acid phosphate	400 "
	{ Sodium nitrate.	160 "
	{ Muriate of potash	160 "

Sowed broadcast, and harrowed in until the ground was well pulverized. Ground was laid off with a shovel plow, four feet between the rows and corn planted three feet apart, thinned to two stalks to the hill. It was plowed three times and harrowed twice. Could see no difference in the plots, except in No. 7, where the fodder was somewhat heavier. Left one row between the unfertilized plots, but there was no marked difference.

Geological Formation, Trenton Limestone, Lower Silurian.

R. W. HIGGINS, GREENDALE, FAYETTE CO., KY.

Mr. Higgins applied 150 pounds of cotton seed hull ashes on an acre of ground of red clay sub-soil, which had recently been in blue-grass.

These were his results:

No fertilizer.	59 bushels 67 pounds.
Cotton seed hull ashes 150 pounds	62 bushels 41 pounds.

DR. R. J. SPURR, OF SAME PLACE,

Applied 150 pounds of cotton seed hull ashes on an acre of ground in a field that had been in cultivation for many years, with an occasional crop of clover, with this result:

No fertilizer.	47 bushels.
Cotton seed hull ashes 150 pounds	51 bushels 54 pounds.

2. THE PERMANENCY OF EFFECT OF POTASH FERTILIZERS.

The following table gives the results of a set of experiments made last year on a series of one-tenth acre plots. The series was planned to test the comparative value of different phosphatic fertilizers, but finding our land unsuitable for this purpose, it has been determined to use this plot field to test the permanency of effect of potash fertilizers.

The results last year were as follows :

TABLE 4.—Results in 1888.

Number of Plot.	FERTILIZER USED.	Number of Lbs. of Fertilizer Applied Per Acre.	Yield of Ear Corn Per Acre in Bushels of 70 Lbs.	Yield of Fodder in Lbs. Per Acre.	Increased Yield of Corn in Bushels Per Acre.	Increased Yield of Fodder in Lbs. Per Acre.
1	None.		27.9	3,500		
2	Potash Sulphate.	160	64.1	5,150	37.5	1,580
	Ammonia Sulphate	60				
	Dried Blood	100				
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 following table gives the fertilizers applied to the different plots this year, the yield of corn and fodder, and the increased yield of corn and fodder caused by the use of fertilizers applied this and last year :

TABLE 5.—Results in 1889.

Number Plot.	FERTILIZERS USED.	Number Pounds of Fertilizers 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 Per Acre in Bushels.	Increased Yield of Fodder Per Acre in Pounds. . .
1	None	500	39	2,400	39	860
2	Cotton Seed Hull Ashes	500	78	3,260	30	800
3	None (this year)	200	69	3,200	37	1,540
4	Muriate of Potash	200	76	3,940	39	1,200
5	Sulphate of Potash	200	78	3,600	37	1,570
6	Kainit	800	76	3,970	28	1,080
7	None (this year)	3,000	67	3,480	45	870
8	Tobacco Stems	3,000	84	3,270	32	820
9	None (this year)		71	3,220		

These results show clearly that the fertilizer applied last year was not only of benefit to last year's crop, but to this year's also.

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

In the previous results given we have based our calculations on the weights of field cured corn, because that is the way corn is generally marketed here. It is evident, however, that its true value for feeding purposes depends upon the dry matter it contains and the proportion of corn to cob. For the purpose of studying this question, the corn on Plots 12 to 19 (Acre P) (See Table 1), after being husked and weighed, was spread over the floor of the barn loft, and allowed to cure from November 11 to January 24th. The loft is well ventilated. January 24 it was again weighed and shelled, and samples sent to the laboratory for analysis. The following table shows the data obtained, and

also the number of ears required to make a bushel of ear corn (seventy pounds):

TABLE 6.—Showing Size of Ears, Loss by Shrinkage and Proportion of Kernel to Cob.

No.	FERTILIZER USED.	No of Ears in 70 Pounds	Weight of Field Cured Corn, Lbs.	Weight of Corn After Curing . .	Per Cent Shrinkage	Per Cent. Corn to Cob
12	None	135	132	109	17.4	21.4
13	{ Nitrate of Soda Acid Black Muriate of Potash }	86	309	257	16.8	19.3
14	{ Muriate of Potash Acid Black }	90	305	252	17.3	20.
15	{ Nitrate of Soda Acid Black }	119	174	153	12.3	19.3
16	{ Nitrate of Soda Muriate of Potash }	91	327	270	15.3	18.5
17	None	152	136	108	19.1	20.
18	Muriate of Potash	105	268	215	19.7	20.3
19	Land Plaster	140	115	81	29.5	20.3

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

This is a continuation of our experiments last year. Our samples, etc., were collected the same as last year, for which see Bulletin No. 17, pages 19 and 20.

Analyses of the samples were made, and from the results the following table was prepared:

TABLE 7.—Showing Fertilizer Constituents, Amount Applied and Amount Removed by the Corn Crop.—1889.

NUMBER OF PLOT—ACRE P.	2	13	14	15	16	17
FERTILIZERS APPLIED PER ACRE.	None	Acid Black, 320; Muriate Potash, 160; Soda, 160	Acid Black, 320; Muriate Potash, 160	Acid Black, 320; Nitrate Soda, 160	Muriate Potash, 160; Nitrate Soda, 160.	None
Potash in Fodder, lbs. per acre	9.0	23.3	32.8	10.6	22.6	8.7
Potash in grain, lbs. per acre	6.3	16.2	15.6	9.1	15.8	6.5
Potash in cobs, lbs. per acre	2.1	4.0	3.9	2.6	4.0	1.8
Total in crop, lbs. per acre	17.4	43.5	52.3	22.3	42.4	17.0
Total appl'd in fert'r, lbs. per acre		80	80		80	
Phos. Ac. in fodder, lbs. per acre	8.6	14.6	24.6	12.6	20.8	10.6
Phos. Ac. in grain, per acre	10.7	27.4	26.8	14.8	26.8	8.9
Phos. Ac. in cobs, per acre	0.4	0.8	0.9	0.4	0.8	0.4
Total in crop, lbs. per acre	19.7	42.8	52.3	27.8	48.4	19.9
Total appl'd in fert'r, lbs. per acre		57.6	57.6	57.6		
Nitrogen in fodder, lbs. per acre	18.1	27.1	32.1	26.6	26.1	17.2
Nitrogen in grain, lbs. per acre	24.2	62.0	55.5	25.0	62.5	25.7
Nitrogen in cobs, lbs. per acre	1.1	2.3	2.0	1.5	2.2	1.0
Total in crop, lbs. per acre	43.4	91.4	89.6	63.1	90.8	43.9
Total appl'd in fert'r, lbs. per acre		25.6		25.6	25.6	

The results last year show: That in no instance was there as much potash taken up in the crop as was applied in the fertilizer. This is true also of Phosphoric Acid. In the case of Nitrogen, the maximum crop took up over three-fold the amount applied.

BULLETIN No. 27.*EXPERIMENTS WITH COMMERCIAL FERTILIZERS
ON HEMP.*

The object of the experiment was to study the following questions :

1. The effect of the leading elements of plant food, used in various combinations, on the production of fibre from hemp.
2. Will it pay to raise hemp on worn soil with the aid of commercial fertilizers ?
3. Kind of nitrogenous fertilizer to use.
4. Kind of potash fertilizer to use.
5. The amount of nitrogen required per acre.
6. The amount of potash required per acre.

In planning these experiments, it was not expected that the questions would be solved in one year, but that indications might be shown.

From the year's experience, our conclusions are :

1. That hemp can be raised successfully on our worn Blue-grass soils with the aid of commercial fertilizers.
2. That both potash and nitrogen are required to produce the best results.
3. That the effect was the same, whether muriate or sulphate was used to furnish potash.
4. That the effect was about the same, whether nitrate of soda or sulphate of ammonia was used to furnish nitrogen.
5. That a commercial fertilizer containing about six per cent. available phosphoric acid, twelve per cent. of actual potash, and four per cent. of nitrogen (mostly in the form of nitrate soda or sulphate ammonia) would be a good fertilizer for trial.

The following is a detailed report of our experiments :

*EFFECT OF THE LEADING ELEMENTS OF PLANT
FOOD USED IN VARIOUS COMBINA-
TIONS ON THE PRODUCTION OF
FIBRE FROM HEMP.*

EXPLANATIONS.

By the leading elements of plant food are meant *potash*, *nitrogen* and *phosphoric acid*. One or more of these substances enter into the composition of every commercial fertilizer. For full explanations, and for description of the general character of our soil as well as the character of the season, see Bulletin 26, pages 4 and 5.

The hemp on the Station Farm in 1889 was sown on land very much worn, and would be considered by most farmers unfit for hemp. The field slopes gently to the east, and unlike most of the Station land, has very good natural drainage. A crop of oats was harvested from this land last year. The ground was plowed in the fall after the crop of oats had been harvested, and again in the following spring, and then well worked with a spring toothed cultivator and finally with a smoothing harrow. The plots were each one-fortieth of an acre, being $24 \times 45\frac{1}{2}$ feet. The fertilizer was applied broadcast just before sowing the seed, care being taken to distribute the fertilizer evenly over each plot. Seed was sown with a drill by taking off the hoes and placing a smooth board under the feeders in a slanting position, thus scattering the seed as they fell on the board. The ground was then harrowed both ways with a smoothing harrow.

Except as to fertilizers, the plots were treated in the same manner exactly. Hemp was sown April 28th ; was up evenly on all plots May 6 ; no marked difference in appearance in the plots for about a week. The following is a summary of field notes :

FIELD NOTES.

Plot 1.—May 24, common; June 20, common, about eighteen inches high; July 1, three feet high, not good color; $4\frac{1}{2}$ feet high when cut; very small stalk, wood thin.

Plot 2.—May 24, fair; June 20, fair, about two feet high; July 1, four feet high, good color; $7\frac{1}{2}$ feet high when cut; stalk fine size and even; wood very thin.

Plot 3.—May 24, fair; June 20, medium, about two feet high; July 1, three feet high, bad color; six feet high when cut; stalk even and fine; wood a little thick.

Plot 5.—May 24, fair; June 20, fair, about three feet high; July 1, $4\frac{1}{2}$ feet high, fair color; $6\frac{1}{2}$ feet high when cut; stalk fine; wood thin.

Plot 6.—May 24, fair to good; June 20, very good, about 4 feet high; July 1, 5 feet high, good color; 7 feet high when cut; very fine stalk; a little wood; thin.

Plot 7.—May 14, good; June 20, good, about 4 feet high; July 1, $5\frac{1}{2}$ feet high, color good; 8 feet high when cut; stalk a little coarse but even in size; very thin wood.

Plot 9.—May 24, fair; June 20, hardly fair, about twenty inches high; July 1, about $3\frac{1}{2}$ feet high, uneven, fair color; $5\frac{1}{2}$ feet high when cut; stalk fine; woody.

Plot 10.—May 24, good; June 20, good, about 3 feet high; July 1, 5 feet high, fair color; 7 feet high when cut; stalk fine size; wood thin.

Plot 11.—May 24, poor; June 20, very poor, about 14 inches high; July 1, $2\frac{1}{2}$ feet high, very bad; 3 feet ten inches when cut; small stalk; wood thin.

The hemp was cut by hand sickle August 19th. After cutting it was stacked and spread from the stack, and after retting it was shocked, and after being broken and the fibre weighed, samples of fibre from each plot were taken to Mr. W. J. Loughridge, a hemp manufacturer of this city, who, after hackling it, made a report as to the quality of each sample.

The following table shows the kind and quantity of fertilizer applied; height of hemp when matured; yield of fibre; increased yield of fibre by the use of fertilizer, and quality:

TABLE 1.—Showing Effect of Fertilizers on Hemp.

Number Plot . . .	KIND OF FERTILIZER.	Pounds Per Acre Used . . .	Height of Mature Hemp—Feet . .	Yield of Fibre Per Acre	Increased Yield . .	Quality of Fibre.
1	No Fertilizer		4½	720		Poor; not strong; too short.
2	{ Nitrate Soda . . . 160 Soil 480 }		7½	1,130	410	Good hand-spinning hemp.
3	{ Acid Phosphate . . 320 Soil 320 }		6	860	140	Fair.
5	{ Soil 480 Muriate Potash . . 160 }		6½	1,050	330	Fair hemp; good strength.
6	{ Nitrate Soda . . . 160 Soil 120 Acid Phosphate . . 320 }		7	1,240	520	Too short to make good quality.
7	{ Nitrate Soda . . . 160 Soil 160 Muriate Potash . . 320 }		8	1,500	780	Good—good strength and quality.
9	{ Acid Phosphate . . 320 Muriate Potash . . 160 Soil 160 }		5½	900	350	Can be used only for shorts.
10	{ Acid Phosphate . . 320 Muriate Potash . . 160 Nitrate Soda . . . 160 }		7	1,360	810	Extra hand-spinning hemp.
11	Land Plaster	160	4	550*		

As the land on Plots 1, 2, 3, 5, 6 and 7 appeared to be of slightly better quality than 9, 10 and 11, we used, in showing the increased yield, Plot No. 1 in comparing the former plots and No. 11 in the latter. In using Plot 11 we assume that land plaster had no material effect on the hemp.

It is seen from these results:

1. That nitrate of soda or muriate of potash applied singly materially increased the yield; whereas, phosphoric acid had only a perceptible effect; that the combination of muriate of potash and nitrate of soda produced as large a yield as when phosphoric acid was added also, as in No. 10, the yield being more than double that on blank plot; but that the best quality results from applying all three.

These results suggest, therefore, that a fertilizer containing a

large per cent. of potash and nitrogen, and a small quantity of phosphoric acid, is the kind to use on our soils for hemp.

By reference to table, Bulletin 26, page 6, it will be seen that the fertilizer on plot No. 13 contains $12\frac{1}{2}$ per cent. of potash, 6 per cent. nitrogen, and 9 per cent. phosphoric acid. There is no fertilizer sold in this State at present which contains so great a per cent. of potash, and but few containing this per cent. of nitrogen.

FINANCIAL RESULTS.

The following table shows the cost of the different fertilizers applied, the increased value by their use, and the profit or loss.

In estimating the profit or loss, the value of the fibre is figured at 4 cents per pound, thus leaving one cent per pound for breaking, and for a tare of 12 pounds per hundred:

TABLE 2.—Financial Results.

Number.	FERTILIZER USED.	Cost of Fertilizer used Per Acre.	Value of Fibre Per Acre.	Value of Increased Yield of Fibre Per Acre.	Profit or Loss . .
1	None.		\$28 80		
2	Nitrate of Soda Soil	\$3 60	45 20	\$16 40	\$12 80
3	Acid Phosphate. Soil	3 60	34 40	5 60	2 00
5	Muriate of Potash Soil	3 60	42 00	13 20	9 60
6	Nitrate of Soda Acid Phosphate. Soil	7 20	49 60	20 80	13 60
7	Nitrate of Soda Muriate of Potash. Soil	7 20	60 00	31 20	24 00
9	Acid Phosphate. Muriate of Potash. Soil	7 20	36 00	14 00	6 80
10	Acid Phosphate. Muriate of Potash. Nitrate of Soda	10 80	54 40	32 40	21 60
11	Land Plaster		22 00		

Should Muriate or Sulphate of Potash be used to furnish the Potash in Hemp Fertilizers?—As the potash in the form of muriate can be had at a lower rate than in the form of sulphate, it is better to use the former if both are equally as effective on the yield and quality of fibre. In the case of tobacco and potatoes it is the general opinion that the sulphate produces a superior quality.

In our experiments the high grade sulphate of potash containing a little over 50 per cent. potash, was used; as muriate contains almost the same quantity, the same amount of each was used in this experiment.

TABLE 3.—Showing Effect of Different Forms of Potash.

No.	FERTILIZER USED.	Amount Used Per Acre	Height of Mature Hemp	Yield of Fibre Per Acre	Increased Yield .	Quality.
10	{ Muriate Potash Acid Phosphate Nitrate Soda	{ 160 320 160 }	7	1,360	760	Extra hand spinning hemp.
13	{ Sulphate Potash Acid Phosphate Nitrate Soda	{ 160 320 160 }	7	1,380	780	Extra; fine strength.
16	No Fertilizer		4	600		Only suitable for shorts.

From these results the indications are that it makes little difference as to the quality and yield which form of potash is used to fertilize hemp. Therefore, the muriate, being cheaper, would be preferable.

In what form shall the nitrogen be applied?—Assuming as correct the general opinion among hemp growers, that it is of the utmost importance to have a rapid vigorous growth at the start, we applied the nitrogen only in the form of its most available compounds, namely, nitrate of soda and sulphate of ammonia for comparison. As 120 pounds of sulphate of ammonia contains just about the same quantity of nitrogen as 160 pounds of nitrate of soda, they were applied in this proportion in our experiments.

The following statement shows the effect of each of these two compounds :

TABLE 4.—Showing Effect of Different Forms of Nitrogen Fertilizers.

No.	FERTILIZER USED.	Amount Per Acre	Height	Yield of Fibre Per Acre	Increased Yield .	Quality.
18	{ Nitrate Soda Muriate Potash Acid Phosphate	{ 160 160 320 }	7	1,380	780	Extra; fine strength.
18	{ Sulphate Ammonia Muriate Potash Acid Phosphate	{ 120 160 320 }	7	1,320	720	Fair double dressed; fine strength.
14	No Fertilizer		4	600		

The Amount of Potash Salts to Apply.—In this trial two experiments were made, one with sulphate of potash and one with muriate of potash. Two plots were used in each experiment, one receiving at the rate of 160 pounds of the potash salt; the other double the quantity.

The results follow :

TABLE 5.—Showing Quantity of Potash Applied Per Acre.

No.	FERTILIZER USED.	Rate Per Acre . .	Height of Matured Hemp	Yield of Fibre Per Acre	Quality.
10	{ Muriate Potash Acid Phosphate Nitrate Soda	{ 160 320 160 }	7	1,360	{ Extra hand spinning hemp.
14	{ Muriate Potash Acid Phosphate Nitrate Soda	{ 320 320 160 }	7½	1,360	{ One of the best single dressed hems.
13	{ Sulphate Potash Acid Phosphate Nitrate Soda	{ 160 320 160 }	7	1,380	{ A good grade of double dressed hemp.
17	{ Sulphate Potash Acid Phosphate Nitrate Soda	{ 320 320 160 }	7	1,400	{ Extra double dressed; command increased market price.

From these results, it would appear that 160 pounds of sulphate or muriate of potash applied per acre is all the potash required; whether a less quantity would be equally as well has not been proven. However, if the crop did not use all the potash applied, it would remain for a subsequent crop, as has been shown in our corn experiments. (See Bulletin 26, page 79.)

The Amount of Nitrogen to Apply.—In this experiment four plots were used, two for testing the quantity of nitrate of soda to apply, and two for sulphate of ammonia.

The following table shows the fertilizers and amounts applied per acre, the height of the hemp, and the yield and quality of fibre :

TABLE 6.—Showing Effect of Different Quantities of Nitrogen Fertilizers.

Number	FERTILIZER USED.	Pounds Per Acre.	Height of Mature Hemp	Yield of Fibre Per Acre	Quality.
10	{ Nitrate Soda Acid Phosphate Muriate Potash	{ 160 320 160 }	7	1,360	Extra fine spinning hemp.
19	{ Nitrate Soda Acid Phosphate Muriate Potash	{ 320 320 160 }	8½	1,400	No 2 quality double dressed.
18	{ Sulphate Ammonia Acid Phosphate Muriate Potash	{ 120 320 160 }	7	1,320	Good quality double dressed.
20	{ Sulphate Ammonia Acid Phosphate Muriate Potash	{ 240 320 160 }	8½	1,500	Extra double dressed.

From the above results it seems that 160 pounds of nitrate of soda applied per acre is about the maximum quantity to use, and that it requires a little over 120 pounds of sulphate of ammonia for the best results.

BULLETIN No. 28.*EXPERIMENTS WITH FERTILIZERS ON TOBACCO.*

The object of the experiments was to study the following questions :

1. The effect of the leading elements of plant food on the production of tobacco.
2. Will it pay to use commercial fertilizers to raise tobacco on such a soil as ours ?
3. In what form should nitrogen be applied ?
4. In what form should potash be applied ?
5. The amount of nitrogen required per acre.
6. The amount of potash required per acre.

From one year's experience the conclusions reached are as follows :

1. That commercial fertilizers materially increase the yield and improve the quality of Burley tobacco.
2. That the increase is obtained, whether potash, phosphoric acid or nitrogen are used separately or in various combinations.
3. That potash and nitrogen in combination seem to be required to produce the best results.
4. That there is a handsome profit by using fertilizers in the best combinations.
5. That the effect was the same, whether potash was used in the form of muriate or sulphate.
6. That nitrogen in the form of nitrate of soda seemed to produce the best results as to quality.

A detailed report follows.

8—3 E. S.

1. THE EFFECT OF THE LEADING ELEMENTS OF PLANT FOOD ON THE PRODUCTION OF TOBACCO.

EXPLANATION.

By the "leading elements of plant food" are meant *Potash*, *Nitrogen* and *Phosphoric acid*. These substances are essential to plant growth and development.

It is true that plants feed on other soil elements besides these, and they are just as essential to life as these three, but, generally speaking, other substances or elements are furnished by the soil to the plants in abundance, and therefore in studying what we should put on our soils to make them more productive we concern ourselves only with these three. The manufacturers of commercial fertilizers recognize this, and therefore fertilizers are manufactured and sold for the purpose of supplying potash, nitrogen and phosphoric acid, and it has gotten to be so well understood that these three elements are the ones required, that the market price depends upon them. Not all soils require all three of the ingredients, consequently, some fertilizers contain only one ingredient, some two, and others all three. Generally speaking, however, a commercial fertilizer is a mixture containing phosphoric acid and nitrogen and sometimes potash, the proportions varying in different brands and often in the same brand from year to year.

From the foregoing, it is at once seen to be a difficult if not an impossible task to test all the various brands sold, in order to find out those that produce the best results. It is not such a difficult task, however, to find out whether a given soil needs phosphoric acid, potash or nitrogen, or any combination of these for any given crop. Having found out this by direct experiment in a small way, we have only to look to the analysis of the various fertilizers to tell the brands which could be used to advantage. If the experiment proves that potash is the element most needed then we should buy those fertilizers which contain large percentages of that ingredient. On the contrary, if we find that phosphoric acid produces the best results, and that potash has no material effect, then we should purchase fertil-

izers containing large quantities of phosphoric acid, and but a small quantity, if any, of potash.

In these experiments the above plan was carried out.

For nitrogen we used nitrate of soda, containing nearly 16 per cent. nitrogen, and sometimes ammonium sulphate, containing 20.5 per cent. For potash we used muriate of potash, containing about 50 per cent. of potash, or high grade sulphate of potash, containing 52.5 per cent., or cotton seed hull ashes, containing 32 per cent. of potash. For phosphoric acid we used in one set of experiments acid phosphate, that is, South Carolina rock treated with sulphuric acid or oil of vitriol to make the phosphoric acid available to the plant. In the other we used acid black, that is, waste bone black treated with oil of vitriol.

We made two separate experiments, having mainly the same points in view.

Soil.—The experiments covered an acre, that is, were conducted on ten one-tenth acre plots. The character of the soil is the same as that described in Bulletin No. 26, on page 79. The land is considerably worn, having been in cultivation many years. The year previous to that in which the experiments with tobacco were made, it was in oats. The land had never been fertilized except in the spring of '88, when one hundred pounds each of acid black, muriate of potash, and nitrate of soda were mixed and sowed broadcast over the plot.

EXPERIMENT NO. 1.

Size of the plots one-twentieth acre each. Fertilizer applied broadcast just before the tobacco plants were set. Plants were set 22 inches apart in rows three feet wide.

FIELD NOTES.

Plot No. 1.—July 1st, very small, yellow, tobacco poor; August 1st, very poor, small and uneven.

Plot No. 2.—July 1st, fair, good color, even, leaves eight inches long; August 1st, fair, good size, leaves a little yellow.

Plot No. 3.—July 1st, fair size and color, leaves ten inches long; August 1st, fair size, bad color, uneven and spotted.

Plot No. 4.—July 1st, good color, even, leaves eight inches long; August 1st, very fair, of good size and color, uneven.

Plot No. 5.—July 1st, poor, leaves of a yellowish color, small; August 1st, very uneven, very poor.

Plot No. 6.—July 1st, good, rather uneven, leaves twelve inches long; August 1st, color fair, good size, but a little uneven.

Plot No. 7.—July 1st, good, leaves twelve inches long; August 1st, good, fairly even.

Plot No. 8.—July 1st, fair, good color, leaves eight inches long; August 1st, very bad, yellow and spotted, only medium size.

Plot No. 9.—July 1st, good size and color, leaves ten inches long; August 1st, looks well, rather uneven.

The following table shows the yield of tobacco calculated per acre, also the corrected yield, that is, the yield calculated to a perfect stand :

TABLE No. 1.—Showing Effect of Different Fertilizers on Tobacco.

Number of Plot.	FERTILIZER USED.	Amount Fertilizer Applied Per Acre.	YIELD IN POUNDS PER ACRE.						
			Bright.	Red.	Lugs.	Tips.	Trash.	Total Actual.	Total Corrected.
1	Nitrate Soda. . .	160	230	450	310	90	530	1,610	1,710
2	Acid Phosphate .	320	. . .	400	450	70	490	1,410	1,440
3	Sulphate Potash. .	160	. . .	610	580	20	370	1,590	1,620
4	No Fertilizer. . .	. . .	. . .	200	360	60	540	1,160	1,160
5	{ Nitrate Soda. . . Acid Phosphate .	{ 160 320 }	.	15	200	20	970	1,205	1,230
6	{ Sulphate Potash . Nitrate Soda. . .	{ 160 160 }	190	755	605	120	140	1,810	1,810
7	{ Acid Phosphate . Sulphate Potash .	{ 320 160 }	240	705	425	30	290	1,690	1,770
8	No Fertilizer. . .	. . .	. . .	400	360	40	570	1,370	1,400
9	{ Acid Phosphate . Sulphate Potash . Nitrate Soda. . .	{ 320 160 160 }	310	810	420	10	360	2,000	2,050

EXPERIMENT NO. 2.

Size of plots one-fortieth acre each. Fertilizer applied broadcast as in Experiment No. 1. Plants set as in Experiment No. 1.

FIELD NOTES.

Plot No. 1.—July 1st, looks well, good color, leaves twelve inches long; August 1st, leaves have a yellowish color, badly spotted.

Plot No. 2.—July 1st, looks well, uneven, leaves eight inches long; August 1st, only fair, spotted in places.

Plot No. 3.—July 1st, looks fine, very even, good color, leaves twelve inches long; August 1st, looks well, of good size, and has a yellowish cast.

Plot No. 4.—July 1st, fair, medium size, leaves getting yellow; August 1st, looks bad, very yellow and uneven.

Plot No. 10.—July 1st, fair, medium in size, rather yellow; August 1st, poor, very yellow and uneven.

Plot No. 11.—July 1st, looks well, good color and size, leaves twelve inches long; August 1st, looks fine, growing well.

Plot No. 12.—July 1st, looks well, little uneven, leaves twelve inches long; August 1st, even in size but not rank, good color.

Plot No. 13.—July 1st, looks fair, uneven in size; August 1st, only fair, leaves spotted and very uneven.

Plot No. 14.—July 1st, fine plot, plants of good height, and some of the leaves ten inches long; August 1st, good color, has made fair growth, a little uneven.

The results obtained are given in the following table :

TABLE No. 2.—Showing Effect of Fertilizers on Tobacco.

No. of Plot. . . .	FERTILIZER USED.	Amount Fertilizer Used Per Acre.	YIELD IN POUNDS PER ACRE.						
			Bright . .	Red	Lugs . . .	Tips . . .	Trash . . .	Total Actual . . .	Total Corrected . .
1	No Fertilizer		40	40	330	90	300	800	940
2	Sulphate Potash	160	140	240	590	100	520	1,590	1,613
3	Nitrate Soda	160	200	360	680	100	340	1,800	1,880
4	Acid Black	320	80	540	360	180	380	1,540	1,560
10	No Fertilizer			260	120	110	520	1,010	1,050
11	{ Sulphate Potash Acid Black	{ 160 320 }	420	230	240	200	380	1,470	1,470
12	{ Sulphate Potash Nitrate Soda	{ 160 160 }	160	440	280	280	400	1,560	1,640
13	{ Acid Black Nitrate Soda	{ 320 160 }		430	280	800	620	1,430	1,480
14	{ Sulphate Potash Nitrate Soda Acid Black	{ 160 160 320 }	180	550	400	90	470	1,650	1,690

In comparing tables Nos. 1 and 2 it will be seen that generally the results are the same.

2. FINANCIAL RESULTS.

It is difficult for us to calculate the value of the tobacco on the various plots, as it is well known that it is difficult to grade tobacco. We had, however, one man to do all the grading, and he seemed to be an expert at the business.

In giving the values then to the crop we estimated the value of bright and red leaf to be 15 cents per pound, as valued at the time by an expert, lugs at 6 cents, tips at 8 cents, trash at 2 cents.

The following table shows the results obtained :

TABLE No. 3.—Showing Financial Results.

No. Plot	FERTILIZER USED.	Cost of Fertilizer Used Per Acre.	Value of Tobacco Per Acre . . .	Value of Increased Yield of Tobacco Per Acre	Profit or Loss . .
1	Nitrate Soda	\$3 60	\$138 40	\$56 70	\$53 10
2	Acid Phosphate	4 00	102 40	21 70	16 70
3	Sulphate Potash	4 20	135 30	53 60	49 40
4	No Fertilizer		67 20		
5	Nitrate Soda } Acid Phosphate }	7 60	35 25		*7 60
6	Sulphate Potash } Nitrate Soda }	7 80	190 45	108 75	100 95
7	Acid Phosphate } Sulphate Potash }	8 20	175 45	93 75	85 55
8	No Fertilizer		96 20		
9	Acid Phosphate } Sulphate Potash } Nitrate Soda }	11 80	201 20	119 50	107 70

* Loss.

3. IN WHAT FORM SHOULD NITROGEN BE APPLIED?

In this trial we tried three different forms of nitrogenous fertilizer ; nitrate of soda, sulphate of ammonia and cotton seed meal.

We applied it at the rate of 160 pounds for nitrate of soda, 120 for sulphate of ammonia, and 340 for cotton seed meal.

We applied them in this proportion, in order that each plot might receive the same amount of nitrogen.

The results obtained are given in the following table :

TABLE No. 4.—Different Forms Nitrogenous Fertilizers.

No. of Plot. . .	FERTILIZER USED.	Amount Fertilizer Applied Per Acre.	YIELD IN POUNDS PER ACRE.						Total Cor-rected. . .
			Bri. ht.	Red. . .	Lugs	Tips. . .	Trash	Total Ac- tual. . .	
14	{ Sulphate Potash . Nitrate of Soda . . Acid Black . . . }	{ 160 160 320 }	180	550	400	90	470	1 650	1 690
16	{ Sulphate Potash . Sulphate Ammonia . Acid Black . . . }	{ 160 120 320 }	160	560	270	140	370	1,500	1,580
18	{ Sulphate Potash . Cotton Seed Meal . Acid Black . . . }	{ 160 340 320 }	150	560	280	80	360	1,420	1,590

4. IN WHAT FORM SHOULD POTASH BE APPLIED.

It is generally believed that muriate of potash is injurious to the quality of tobacco, especially smoking tobaccos, and therefore sulphate is generally considered to be the best form for this crop.

The following table gives the results we obtained this year :

TABLE No. 5—Showing Amount Potash Required Per Acre.

Number Plot. . .	FERTILIZER USED.	Amount Fertilizer Applied Per Acre	YIELD IN POUNDS PER ACRE.						Total, Cor- rected. . .
			Bright. . .	Red. . .	Lugs.	Tips. . .	Trash	Total, Ac- tual. . .	
5	{ Sulphate Potash . Nitrate Soda . . . Acid Black . . . }	{ 320 160 320 }	240	940	360	80	260	1,880	1,900
6	{ Muriate Potash . . Nitrate Soda . . . Acid Black . . . }	{ 320 160 320 }	580	660	390	70	450	2,160	2,180
7	{ Muriate Potash . . Nitrate Soda . . . Acid Black . . . }	{ 160 160 320 }	640	520	450	. . .	370	1,980	1,980
14	{ Sulphate Potash . Nitrate Soda . . . Acid Black . . . }	{ 160 160 320 }	180	550	400	90	470	1,650	1,690

5. THE AMOUNT OF NITROGEN REQUIRED PER ACRE.

Six plots were taken for this experiment. From the results obtained it would seem that 160 pounds of nitrate of soda or 340 pounds of cotton seed meal would furnish nitrogen in sufficient quantities for the crop, while it would take rather more than 120 pounds of sulphate of ammonia.

The following table gives the results obtained :

TABLE No. 6.—Showing Amount Nitrogenous Fertilizer Required Per Acre.

No. Plot	FERTILIZER USED.	Amount Fertilizer Applied Per Acre.	YIELD IN POUNDS PER ACRE.						
			Bright	Red	Lugs	Tips	Trash	Total Actual	Total Corrected
14	{ Sulphate Potash Nitrate Soda Acid Black	{ 160 160 320 }	180	550	400	90	470	1,650	1,690
15	{ Sulphate Potash Nitrate Soda Acid Black	{ 160 320 320 }	240	700	260	120	340	1,650	1,760
16	{ Sulphate Potash Sulphate Ammonia Acid Black	{ 160 120 320 }	160	560	270	140	370	1,500	1,580
17	{ Sulphate Potash Sulphate Ammonia Acid Black	{ 160 240 320 }	380	790	330	40	380	1,900	2,040
18	{ Sulphate Potash Cotton Seed Meal Acid Black	{ 160 340 320 }	150	560	280	80	360	1,430	1,590
19	{ Sulphate Potash Cotton Seed Meal Acid Black	{ 160 340 320 }	200	380	210	160	330	1,280	1,400

6. THE AMOUNT OF POTASH FERTILIZER REQUIRED PER ACRE.

Four plots were used in this experiment.

It would appear from these results that rather more than 160 pounds of either sulphate or muriate of potash would be beneficial to the tobacco crop, as shown in table No. 5, page 120.

BULLETIN No. 29.

ANALYSES OF COMMERCIAL FERTILIZERS.

EXPLANATIONS.

In order that farmers may use commercial fertilizers intelligently, they should understand, first, the wants of their soil to produce given crops, and second, the "make up" of fertilizers at their disposal, that they may know whether these wants can be supplied by the use of such fertilizers or not.

Field experiments, conducted on each farm, is the best way to determine the first question. The manner of carrying out these trials has been presented in Bulletins 21, 22, 26, 27 and 28, which give the plan of applying the fertilizers, the results obtained by their use on wheat, corn, potatoes, hemp and tobacco.

The object of this Bulletin is to consider the second question, that is, the materials out of which commercial fertilizers are made, and also to give the analyses of the various brands legally on sale in this State during the year.

Generally speaking, a worn soil is deficient in *potash*, *nitrogen* or *phosphoric acid*, or any two or all three of these ingredients. For this reason commercial fertilizers are manufactured and sold for the purpose of supplying *potash*, *phosphoric acid* and *nitrogen*—in fact, their value depends upon the quantity and form in which these ingredients appear in them.

In making these fertilizers various substances are used to furnish these ingredients.

Nitrogen.—The nitrogen of fertilizers is supplied either in the form of

1. *Nitrate of Soda*, or Chili saltpetre, which contains about 16 per cent. of nitrogen ; or
2. *Sulphate of Ammonia*, which contains some 20 per cent. of nitrogen ; or
3. Organic nitrogen from *dried blood*, *tankage*, waste from

slaughter-houses, *bones*, *fish scrap*, *cotton seed meal*, *castor pomace*, or other vegetable products rich in nitrogen. These organic substances contain from 7 to 16 per cent. of nitrogen.

4. *Guanos*.

Nitrogen, found in the above substances, is the most expensive element in fertilizers. It is also the element soonest exhausted in the soil. If the free nitrogen which is found in nature in immense quantities could be appropriated by plants as food, there would be no need in seeking this element in commercial fertilizers, but most plants are incapable of taking up free nitrogen of the atmosphere as a food.

Phosphoric Acid.—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 :

1. Bone meal.
2. Bone ash.
3. Bone black.
4. Superphosphate of lime, or acid phosphate.
5. Phosphate rock.
6. Thomas slag and guano.

1. *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 ossein. Ossein 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 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 bone 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, such as superphosphates.

2. *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 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.

3. *South Carolina and Florida 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

4. *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.

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 insufficient 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 fertilizer, 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 of "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 almost from the start.

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

1. Sulphate of potash.
2. Muriate of potash.
3. Kainit and sylvinit.
4. Cotton seed hull ashes.
5. Wood ashes.
6. More rarely the nitrate of potash.

The sulphate and muriate of potash, and kainit and sylvinit are imported from Germany, where they are mined in great abundance.

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 as 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 sells for 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 table 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 \$30.60 per ton. He next looks at the analyses and finds fertilizer No. 1 to contain:

Soluble Phosphoric Acid	11 per cent.
Reverted " "	7 per cent.
Potash	None.
Nitrogen	None.

And fertilizer No. 2 to contain:

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

He is now able 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 \$12.75 for the phosphoric acid which he needed, and

\$17.85 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 in 1890, 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; phos-

phoric acid in fine bone, $4\frac{1}{2}$ cents; in medium bone, 4 cents per pound; potash, from muriate, $5\frac{1}{2}$ cents; from sulphate, 7 cents, and nitrogen 20 cents per pound.

Fine bone is all that passes through a seive with meshes 1-25 inch square. Medium bone passes through a seive with meshes $\frac{1}{8}$ inch square, but does not include fine bone.

TABLE 1.—Raw Bone Manures—Analyses and Valuations.

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 .				
1005	P. B. Mathiason & Co., St. Louis, Mo	Increscent Brand Pure Raw Bone Meal	6.91	20.04	2.48	22.52	49.17	3.88	4.71	\$35.54
1020	The Currie Fer. Co., Louisville, Ky. .	Currie's Raw Bone Meal	8.28	10.46	10.09	20.55	44.87	3.37	4.09	30.96
1051	Cincinnati Desiccating Co., Cincinnati, O.	Fine Ground Bone	5.71	16.72	5.19	21.91	47.86	3.58	4.35	33.52
1059	North-western Fer. Co., Chicago, Ill. .	Fine Raw Bone	7.43	22.62	. . .	22.62	49.40	3.66	4.44	35.00
1060	Same	Ralston's Bone Meal	8.09	12.82	3.20	16.02	34.98	3.27	3.97	27.18
1101	Thompson & Edwards Fertilizer Co., Chicago, Ill.	Pig's Foot Brand Chicago Bone Meal	7.49	15.43	1.81	17.24	37.66	2.71	*3.29	28.30
1102	Same	Pure Fine Ground Bone	7.35	25.92	. . .	25.92	56.61	2.20	2.67	32.13
1103	Same	Pure Raw Bone	7.09	13.43	8.60	22.03	48.11	4.09	4.97	35.33
1104	Cincinnati Desiccating Co., Cincinnati, O.	Pure Raw Bone Meal	6.25	17.11	5.82	22.93	50.07	4.34	5.27	37.42
1111	J. B. Jones, Louisville, Ky.	Pure Raw Bone Meal	7.93	11.94	8.73	20.67	45.15	4.06	4.93	33.97
1112	Same	Pure Ammoniated Bone Meal	7.88	9.61	6.98	16.59	36.24	4.39	5.33	31.79
1133	Dunn & Co., Troy, Ind.	Clover Leaf Brand Pure Raw Bone Meal	7.71	15.12	7.22	22.34	48.78	4.42	5.37	37.07
1147	Adair Bros. & Co., Atlanta, Ga. . . .	Adair's Fine Ground Pure Animal Bone	5.55	23.64	. . .	23.64	51.63	3.87	4.70	36.76
1148	The Cleveland Dryer Co., Cleveland, O.	Superior Bone	7.55	18.49	4.35	23.24	50.77	4.36	5.29	37.92
1209	Crocker Fertilizer and Chemical Co., Buffalo, N. Y.	Ground Bone Meal	6.05	25.75	2.61	28.36	61.94	2.66	3.23	25.96
1222	Wm. Skene & Co., Louisville, Ky. . .	Pure Raw Bone Dust (r Meal).	7.30	9.78	10.47	20.25	44.23	3.81	4.63	32.42

* Potash from Sulphate 0.84 per cent.; from Muriate 0.85 per cent.

TABLE II—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. . . .
963	Globe Fert. Co., Louisville, Ky.	Globe Potato Grower	8.10	1.61	6.55	2.33	4.09	4.97	5.46	437 61	
964	Same	Eagle Fertilizer	9.04	2.52	4.57	5.33	2.41	2.93	1.57	26 62	
965	Same	Progress Phosphate.	12.02	3.17	2.71	5.08	1.97	2.39	0.88	0.96	23 22
966	Same	Globe Tobacco Grower	7.90	1.55	6.22	2.49	4.20	5.10	5.53	37 58	
967	Same	Ky. Standard Tobacco Grower. .	9.66	6.20	2.18	2.33	2.92	3.54	3.17	30 82	
997	Crocker Fertilizer and Chemical Co., Buffalo, N. Y.	Wheat and Corn Phosphate . . .	10.74	7.09	1.47	2.29	2.20	2.67	2.44	27 40	
998	Chesapeake Guano Co., Baltimore, Md.	Dissolved Bone.	11.41	11.48	1.84	1.15	0.21	0.25	..	23 48	
999	Same	Bone and Potash	11.42	9.99	1.54	0.75	0.18	0.22	1.82	22 77	
1000	Crocker Fertilizer and Chemical Co., Buffalo, N. Y.	Southern Tobacco Phosphate . .	9.90	5.80	0.87	2.18	4.27	5.18	..	31 78	
1001	Lorentz & Rittler, Baltimore, Md. .	Farmer's Alkaline Bone.	11.99	8.67	1.33	3.17	..	..	..	23 16	
1003	Chesapeake Guano Co., Baltimore, Md.	Corn and Oats Fertilizer.	10.96	8.92	1.44	0.74	0.56	0.68	2.53	23 67	
1004	P. B. Mathiason & Co., St Louis, Missouri	Increscent Brand Tobacco Grow'r.	9.92	6.59	0.74	1.75	3.14	3.81	0.50	29 18	
1015	The Currie Fertilizer Co., Louisville, Ky	Currie's Am'tel Dissolved Bone .	6.53	4.55	1.55	5.91	0.81	0.98	2.92	21 93	
1016	Same	Currie's Guano.	6.31	4.44	2.46	5.25	0.80	0.97	2.89	22 13	
1017	Same	Currie's Corn Grower.	6.37	5.73	3.01	4.72	2.19	2.63	..	0.90	27 44
1018	Same	Currie's Falls City Phosphate . .	6.67	5.77	2.88	5.05	1.93	2.34	..	0.82	26 36
1019	Same	Currie's Falls City Bone Meal . .	5.20	4.31	4.21	5.90	1.04	1.26	0.87	..	23 40

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

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 . . .
1144	Same	Furman High Grade Guano. . .	9.45	7.04	2.58	1.70	3.08	3.74	. . .	3.12
1145	Same	Furman Soluble Bone with Ammonia and Potash	9.36	7.10	2.96	2.20	1.17	1.42	. . .	1.41
1146	Same	Golden Grain Fertilizer	12.36	7.74	2.22	1.78	2.74	3.33	. . .	3.39
1149	The Cleveland Dryer Co., Cleveland, O.	Square Bone	6.62	5.39	4.14	7.96	2.09	2.54	. . .	. . .
1150	Same	Ammoniated Dissolved Bone . .	9.53	7.54	2.66	3.86	1.72	2.09	. . .	. . .
1151	Same	Buckeye Superphosphate	11.06	8.28	1.51	2.67	2.58	3.13	. . .	. . .
1152	Same	White Burley Tobacco Fertilizer.	11.96	8.24	2.15	2.85	2.29	2.78	. . .	3.31
1153	Cincinnati Desiccating Co., Cincinnati, O.	Tobacco and Potato Fertilizer. .	6.18	4.68	4.03	2.15	4.36	5.29	4.66	. . .
1212	The Currie Fertilizer Co., Louisville, Ky.	Currie's Wheat Grower	6.92	5.91	3.53	4.27	1.37	1.65	0.66	. . .
1219	Globe Fertilizer Co., Louisville, Ky.	Globe Bone Dust	11.06	3.94	4.59	2.70	1.45	1.76	. . .	. . .
1220	Same	Golden Harvest Bone Meal	9.70	3.47	4.96	7.04	2.65	3.22	. . .	. . .
1221	Same	Globe Wheat Grower	11.29	4.84	4.31	2.57	2.14	2.60	1.13	. . .

JULY 1, 1890.

M. A. SCOVELL, Director.

BULLETIN No. 30.

EXPERIMENTS WITH WHEAT. 1890.

BY THE DIRECTOR AND C. L. CURTIS, ASS'T AGRICULTURIST.

Our wheat experiments this year were a continuation of last year's work under the following heads:

1. Test of Varieties.
2. Methods of Seeding.
3. Test of Fertilizers.

The experiments were conducted on the Experiment Station Farm. The character of the soil has been fully described in preceding Bulletins.

SEASON.

Up to March 1st the season was very favorable to the wheat. It was very forward at this time, and some of the varieties were jointing. A severe freeze on March 6th seriously damaged the crop. Some of the varieties, as Extra Early Oakley, were almost entirely destroyed. The following table will show the condition of the wheat in the spring and the dates on which the various varieties were jointing, heading, blooming, time when ripe and characteristics of the wheat:

TABLE 1.—Summary.

No. of Plot.	NAME OF VARIETY.	APPEARANCE.		Jointing . .	Heading— May . . .	Cut June. .	Height, feet.	HEAD.		Color Grain.
		March 1.	April 1.					Length, Inches.	S Smooth B Beard.	
1	Red Fultz	Good	Choice . . .	May 1 . . .	20	24	3	2 1/2 . . .	S	Red.
2	Golden Cross	"	"	April 27 . .	26	26	3 1/2 . .	2 1/2 . .	B	Amber.
3	Ontario Wonder . . .	"	"	"	24	26	4	3	S	Amber.
4	Early Red Clawson . .	"	"	April 28 . .	20	24	4	3	S	Red.
5	Golden Cross	"	"	"	"	"	"	"	"	"
6	Everett's High Grade .	"	Choice . . .	May 1 . . .	23	26	4 1/2 .	3 3/4 . .	S	Amber.
7	Fulcaster	"	"	"	24	24	4	2 1/2 . .	B	Red.
8	Velvet Chaff	"	Very good .	April 28 . .	24	26	3 1/2 .	2 1/2 . .	B	Red.
9	Rudy Bearded	"	Fair	May 3 . . .	24	26	4	3	B	Amber.
10	Improved Rice	"	"	April 28 . .	20	24	4	2 1/2 . .	S	Amber.
11	New Genesee	"	Choice . . .	"	26	25	4 1/2 .	3	B	White.
12	German Emperor . . .	"	Good	May 1 . . .	20	24	3 1/2 .	2 1/2 . .	S	Red.
13	Canadian Finley . . .	"	"	April 28 . .	20	24	3 1/2 .	2 1/2 . .	S	White.
14	Hunter's White	"	"	"	25	25	4 1/2 .	3 3/4 . .	B	Red.
15	New Monarch	"	"	"	20	24	4	2 1/2 . .	S	White.
16	Golden Amber	"	Fair	"	25	25	4	2 1/2 . .	B	Amber.
17	Hicks	"	"	May 5 . . .	25	26	4	2 1/2 . .	S	Red.
18	Martin's Amber	"	"	May 3 . . .	27	26	4	2 1/2 . .	S	Amber.
19	Blue Stem	"	Only fair . .	April 28 . .	20	24	4	2 1/2 . .	S	White.
20	Patagonian Trigo . . .	"	"	"	"	"	"	"	"	"
21	Egyptian	"	Good	April 28 . .	20	24	3 1/2 .	2 1/2 . .	S	Red.
22	Browick Red	"	"	May 1 . . .	20	25	3 1/2 .	2 1/2 . .	B	Red.
23	No Name	"	Only fair . .	"	20	25	3 1/2 .	2	S	Red.
24	Maghee White	"	Fair	"	20	24	3 1/2 .	"	S	White.
25	Extra Early Oakley . .	"	Poor	April 24 . .	15	24	"	"	S	Amber.
26	German Amber	"	Good	April 28 . .	25	25	4	2 1/2 . .	S	Amber.
27	Mealy	"	Only fair . .	May 3 . . .	25	25	4	2 1/2 . .	S	Red.
28	Theiss	"	Good	"	20	25	3 1/2 .	2 1/2 . .	B	Red.
29	Buckeye	"	Choice . . .	April 24 . .	20	25	4	2 1/2 . .	B	Red.

TEST OF VARIETIES.

Twenty-nine varieties were tested this year. Each variety was planted in drills seven inches apart. Each plot contained one-fortieth of an acre. The varieties were all planted the 4th of October. The fall growth of all the varieties was good. The soil on which the varieties were planted was cultivated to potatoes the previous year. Like all the rest of the land of the Station Farm, this land has long been in cultivation, and the soil was well worn. At the time of planting the potatoes, the land was fertilized with cotton seed hull ashes at the rate of 400 pounds per acre. The following table gives the yield of the different varieties:

TABLE II.—Yield of Varieties.

No. of Plot.	NAME OF VARIETY.	YIELD PER ACRE.		Weight Per Bushel.
		Wheat, Bushels.	Straw, Pounds.	
1	Red Fultz.	18 $\frac{1}{2}$	2,295	65
2	Golden Cross (Suffern).	17 $\frac{1}{2}$	2,002	64
3	Ontario Wonder (Suffern).	16 $\frac{1}{2}$	2,520	61
4	Early Red Clawson (Everett).	21 $\frac{1}{2}$	2,216	60
5	Golden Cross (Everett).	17 $\frac{1}{2}$	1,912	63
6	High Grade (Everett).	20 $\frac{1}{2}$	2,475	62
7	Fulcaster (U. S. Dep.).	23 $\frac{1}{2}$	2,790	64
8	Velvet Chaff (U. S. Dep.).	20 $\frac{1}{2}$	2,410	64
9	Rudy Bearded (U. S. Dep.).	22 $\frac{1}{2}$	2,453	64
10	Improved Rice (U. S. Dep.).	18 $\frac{1}{2}$	2,070	64
11	New Genesee (U. S. Dep.).	24 $\frac{1}{2}$	3,150	62
12	German Emperor	24 $\frac{1}{2}$	2,565	64
13	Canadian Finley.	17 $\frac{1}{2}$	1,845	63
14	Hunter's White.	24 $\frac{1}{2}$	2,655	63
15	New Monarch.	24 $\frac{1}{2}$	3,375	61
16	Golden Amber.	20 $\frac{1}{2}$	2,295	62
17	Hicks.	17 $\frac{1}{2}$	1,800	62
18	Martin's Amber.	24 $\frac{1}{2}$	2,790	61
19	Blue Stem.	15 $\frac{1}{2}$	1,780	63
20	Patagonian Trigo.	21 $\frac{1}{2}$	2,655	63
21	Egyptian.	19 $\frac{1}{2}$	2,250	63
22	Browrick Red.	24 $\frac{1}{2}$	2,655	63
23	No Name.	15 $\frac{1}{2}$	2,070	62
24	Maghee White.	16 $\frac{1}{2}$	2,130	66
25	Extra Early Oakley.	15 $\frac{1}{2}$	1,890	63
26	German Amber.	17 $\frac{1}{2}$	2,745	64
27	Mealy.	18 $\frac{1}{2}$	2,295	62
28	Theiss.	17 $\frac{1}{2}$	2,160	62
29	Buckeye.	21 $\frac{1}{2}$	2,745	64

From the results it would appear that for such a season as this the New Genesee, German Emperor, Hunter's White, New

Monarch, Browrick Red, Martin's Amber and Fulcaster were about the best yielders. Extra Early Oakley suffered worse from the severe freeze in March, owing to its forwardness. The following table is given to show the comparison of this year's yield with last :

TABLE III.—Comparative Yield 1889-90.

NAME OF VARIETY.	YIELD IN BUSHELS PER ACRE.	
	1890	1889
New Genesee	24 $\frac{3}{4}$	
German Emperor	24 $\frac{3}{4}$	30 $\frac{1}{2}$
Hunter's White	24 $\frac{3}{4}$	27
New Monarch	24 $\frac{3}{4}$	22 $\frac{1}{2}$
Browrick Red	24 $\frac{3}{4}$	25
Martin's Amber	24	22 $\frac{1}{2}$
Fulcaster (U. S. D.)	23 $\frac{1}{2}$	23 $\frac{1}{2}$
Rudy Bearded	22 $\frac{1}{2}$	
Early Red Clawson	21 $\frac{1}{2}$	
Buckeye	21 $\frac{1}{2}$	17
Patagonian Trigo	21	
Velvet Chaff	20 $\frac{5}{8}$	
Golden Amber	20 $\frac{1}{4}$	21
High Grade	20 $\frac{1}{4}$	17
Egyptian	19 $\frac{1}{2}$	30 $\frac{1}{2}$
Mealy	18	16 $\frac{2}{3}$
Improved Rice	18	
Theiss	17 $\frac{2}{3}$	24
Golden Cross (E.)	17 $\frac{2}{3}$	
Golden Cross (S.)	17 $\frac{1}{4}$	
Canadian Finley	17 $\frac{1}{4}$	26
Hicks	17 $\frac{1}{4}$	19 $\frac{1}{2}$
German Amber	17 $\frac{1}{4}$	
Maghee White	16 $\frac{1}{2}$	
Ontario Wonder	16 $\frac{1}{2}$	
Extra Early Oakley	15 $\frac{3}{4}$	15
No name	15 $\frac{3}{4}$	13 $\frac{1}{2}$
Blue Stem	15 $\frac{3}{4}$	
Red Fultz	15 $\frac{3}{4}$	

From this table we find that the German Emperor yielded the maximum crop both years, while the Egyptian, which yielded a full crop last year, did not stand as well this year as the German Emperor and some others.

Hunter's White stood well both years. From the two years' results, it would appear that the German Emperor and Hunter's White are especially worthy of trial by the farmers, while many others are almost equally as good.

DIFFERENT METHODS OF SEEDING.

The series of experiments in testing the different methods of seeding for wheat was continued this year. The variety planted was Extra Early Oakley. The land was the same as that on which the test of varieties was made. The wheat was sown at the same time that the varieties were planted. The following table gives the results:

TABLE IV.—Different Methods of Seeding for Wheat.

Number	METHOD OF SEEDING.	YIELD PER ACRE.		REMARKS.
		Wheat, Bushels .	Straw, Pounds . .	
1	Drilled three inches deep . . .	10 $\frac{1}{8}$	1,485	
2	Drilled one inch deep	16 $\frac{1}{2}$	2,250	
3	Drilled one bushel per acre . .	12	2,205	
4	Drilled three bushels per acre .	13 $\frac{1}{3}$	2,430	
5	Drills fourteen inches apart . .	5 $\frac{1}{4}$	900	Very forward; killed by late frost.
6	Drilled with shoes	10 $\frac{1}{2}$	1,935	Land a little wet.
7	Drilled with hoes	9	1,575	Land very wet.
8	Broadcast, harrowed in	6	1,170	Land very wet.

The season probably had more to do with the yield than the depth of planting or the amount of seed planted, as, for instance, where the drills were fourteen inches apart instead of seven, the growth was very forward, when the freeze on March 6, killed the most of it. The results last year were more favorable where a moderate amount of seed was used and planted at a moderate depth. In each year broadcasting showed smaller results than the drilled.

TEST OF FERTILIZERS.

The land on which these experiments were made is in the same field on which the fertilizer experiments were made last

year. The field is quite level. The soil is of a general character as before described. The plots were each one-tenth of an acre in size, separated from each other by paths three feet wide. The wheat was drilled in October 7, at the rate of five pecks per acre. The drill used was the Buckeye drill with fertilizer attachment. The fertilizer was drilled in at the same time the wheat was planted. The variety planted was Velvet Chaff. The plan for the arrangement of plots, kind and amount of fertilizer used, is shown by the following diagram :

1	No Fertilizer.
2	Acid Black, 320 lbs.
3	Cotton Seed Hull Ashes, 400 lbs.
4	Muriate of Potassh, 160 lbs.
5	Dried Blood, 160 lbs.
6	No Fertilizer.
7	Acid Black, 320 lbs. Muriate of Potash, 160 lbs.
8	Acid Black, 320 lbs. Dried Blood, 160 lbs.
9	Muriate of Potash, 160 lbs. Dried Blood, 160 lbs.
10	Acid Black, 320 lbs. Dried Blood, 160 lbs. Muriate of Potash, 160 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 No. 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. The difference could be seen in the wheat as soon as it was fairly up, but not so marked as that of last year. Plots 3, 4, 7, 9 and 10 presented the best appearance. All the wheat "stooled" in the early fall. A hard freeze March 6th influenced all the Velvet Chaff considerably, especially 1, 2 and 6.

FIELD NOTES.

April 1. All plots improved very much. In places it had been killed entirely out, but not to any considerable extent.

April 24. Wheat jointing on all plots and looking well.

May 20. All plots growing nicely, and but little, if any, difference in stand and appearance.

May 27. Plots 1, 2 and 3 partly headed; others fully headed.

June 15. All plots looked well; all finely headed and all alike in appearance. Plots 5, 8 and 9 probably have some advantage over others in this respect.

June 26. Wheat cut; height three and one-half feet; length of head two and a half inches.

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

TABLE V.—Effect of Fertilizers.

No. of Plot.	FERTILIZER APPLIED.	Amount Used Per Acre, Pounds . .	Yield Wheat, Bushels . . .	Yield Straw, Pounds . . .
1	No Fertilizer.		13 $\frac{1}{3}$	1,720
2	Acid Black.	320	14 $\frac{1}{2}$	1,450
3	Cotton Seed Hull Ashes.	400	12 $\frac{3}{4}$	1,680
4	Muriate of Potash	160	13 $\frac{2}{3}$	1,740
5	Dried Blood	160	16	1,890
6	No Fertilizer.		14 $\frac{5}{8}$	1,790
7	{ Acid Black. Muriate of Potash	{ 320 160 }	13 $\frac{1}{2}$	1,570
8	{ Acid Black. Dried Blood	{ 320 160 }	17 $\frac{1}{2}$	2,100
9	{ Muriate of Potash Dried Blood	{ 160 160 }	17 $\frac{1}{2}$	1,870
10	{ Acid Black. Dried Blood Muriate of Potash	{ 320 160 160 }	13 $\frac{1}{2}$	1,875

CONCLUSIONS.

From the results obtained it appears that fertilizers, whether used singly or in combination, had little effect, if any, on the yield.

The same results appeared last year. They are surprising in that the same soil for corn, hemp, tobacco and potatoes seems to be quite deficient in potash salts.

The same experiment will be continued next year.

CO-OPERATIVE EXPERIMENTS.

Last fall we sent out to over twenty-five farmers in the State the more prominent varieties of wheat, and to some a set of fertilizers for experiment, the same as we conduct here. These

experiments will have to be continued several years in all probability before general conclusions can be reached. Some of the farmers up to this time have failed to send in their results, but we give a summary of reports received.

REPORTS ON VARIETIES.

W. H. INGRAM, ANTHOSTON, HENDERSON COUNTY, KY.—Last winter was unusually warm and wet. The ground used was good tobacco land, comprising four acres. After barring the tobacco stubs and leveling with a harrow, the wheat was put in with a drill. One-quarter of an acre was sown with Hickman wheat, three-quarters of an acre to Extra Early Oakley, and the remaining three acres to Fulcaster. The Oakley made an extremely rank growth, and I was induced to pasture the field when the ground would permit. The freeze in March killed the Oakley outright, but did not affect the Hickman or Fulcaster. The yield of the Fulcaster was sixteen bushels to the acre; Hickman nothing, Oakley nothing.

W. MATTHEWS, MAYS LICK, MASON COUNTY, KY.—On the fifteenth of October I drilled in the Velvet Chaff you sent me in tobacco land. The growth was very rank, but was killed by the freeze in March, seemingly, though, afterwards new shoots sprung up, and gave a yield of about seven bushels.

E. W. McLEAN, ADAIRVILLE, LOGAN COUNTY, KY.—I received three varieties of wheat from you last year for trial, with the following results: Canadian Finley, fourteen bushels per acre; Egyptian, sixteen bushels per acre; German Emperor, twelve bushels per acre. The county did not average over half a crop.

J. W. HARDIN, FINCHVILLE, SHELBY COUNTY, KY.—Sowed three pecks Hicks wheat to the acre, and got a yield of ten bushels. Sowed Fultz wheat alongside of it and got a yield of eighteen bushels per acre. The Hicks wintered finely.

T. T. GARDNER, BARDWELL, CARLISLE COUNTY, KY.—Sowed two bushels of Extra Early Oakley, and it would have made an excellent crop had it not been for the late freeze last winter.

EXPERIMENTS WITH FERTILIZERS.

The following circular was sent to each person making experiments with fertilizers. The fertilizers were mixed and labeled at the Station:

The soil should be well worn and in need of manure of some kind. Select as level a piece of ground as possible, that rains may not wash the fertilizer from one plot into any adjoining plot.

For the experiment mark off ten plots, each one-tenth acre

in area. Separate the plots by paths three feet wide. If convenient make the plots narrow and long, say 163 feet long and 26 feet 8 inches wide. If these dimensions are not suitable to the field, make the plots twice as long and half as wide, or half as long and twice as wide. The object is to get 4,356 square feet in plot, the width of the plot being suitable for all ordinary drills.

Be sure to number the plots and apply the fertilizers as follows:

1.	Acid Phosphate.	40	Pounds.
2.	Muriate Potash	16	"
3.	No Fertilizer.		
4.	Cotton Seed Meal	32	"
5.	{ Acid Phosphate	40 }	"
	{ Muriate Potash	16 }	"
6.	{ Acid Phosphate	40 }	"
	{ Cotton Seed Meal	32 }	"
7.	Blank.		
8.	{ Muriate Potash	16 }	"
	{ Cotton Seed Meal	32 }	"
9.	{ Acid Phosphate.	40 }	"
	{ Cotton Seed Meal	32 }	"
	{ Muriate Potash	16 }	"
10.	Blank.		

Sow each fertilizer on its corresponding plot broadcast, taking every precaution to have the fertilizer evenly distributed over the entire plot while sowing. Do not sow while the wind is blowing. It is best, in order to get an even distribution, to sow in such quantities that each plot will have to be gone over twice to use up the fertilizer.

Mix fertilizers Nos. 1, 2, 4, 5, 6 and 8 with enough dry dirt to make the same bulk as fertilizer No. 9 before sowing.

After sowing the fertilizers drill the wheat in. In place of sowing the fertilizer broadcast, it may be drilled in where the combination wheat drill is used. In such cases all fertilizers will have to be mixed with dirt to make equal bulk, and the fertilizer drill will have to be so regulated as to not quite use up the fertilizer when the plot is gone over, and the balance will have to be carefully taken out and scattered over the plot evenly.

NOTE THE FOLLOWING:

1. Time the wheat was planted.
2. Date the wheat was up on each plot.
3. When the wheat is well up on the plot containing no fertilizer, note the height and appearance of the other plots.
4. How each plot stood the winter.
5. The spring growth.
6. The average height of wheat when ripe.
7. The weight of wheat, when gathered, from each plot.
8. Please note any other observation of interest.
9. Report the results to the Station as soon after the experiments are completed as possible.

REPORTS.

A. B. FREEMAN, SPURLINGTON, TAYLOR COUNTY, KY.—The wheat was sown on worn out land, and fertilizer was drilled in with the seed. Plots all came up about the same. Very little difference between Plots 1 and 2 and blank. Plots 4 and 5 looked better than 1 and 2, and stood the winter better. Plots 6, 8 and 9 were decidedly the best looking, and gave best results.

ANDERSON JEFFRIES, GLENDALE, HARDIN COUNTY, KY.—Fertilizer was first drilled in, and the wheat then drilled crosswise. The experiment was made on one-half acre plots.

No. 1. 150 pounds cotton seed hull ashes, 12 bushels per acre.

No. 2. { 150 pounds cotton seed hull ashes, } 13 bushels per acre.
 { 200 pounds pure bone meal.

No. 3. No fertilizer, 8 bushels per acre.

Plots 1 and 2 came up first. The prospect was the finest I ever saw up to the time of the freeze in March, which killed fully one-half of the wheat as it was jointing. There seemed to be more cheat on Plots 1 and 2 than on No. 3. The plants where ashes alone were applied had a darker green color than the other plots.

This indicates that fertilizer rich in potash would be best on Mr. Jeffries' land.

J. W. STRINGER, FRANKLIN, SIMPSON COUNTY, KY.—I mixed 25 pounds of cotton seed hull ashes with 200 pounds of bone meal, and applied broadcast. It was a very bad year for wheat, but the yield on this acre was about four bushels more than where bone meal alone was applied.

JOHN W. NETHERTON, PROSPECT, JEFFERSON COUNTY, KY.—Wheat was drilled in October 14th, and fertilizer was sown broadcast October 22d. Wheat was up on all plots about the same time. Size of plot, one-tenth of acre each. Below I give my results:

Plot No. 1.	Stood winter well	19 $\frac{3}{4}$	bushels per acre.
" " 2.	Stood winter very well.	11	" " "
" " 3.	Some killed	9 $\frac{1}{2}$	" " "
" " 4.	Stood winter well	11	" " "

10—3 E. S.

Plot No. 5. Stood winter well	23 bushels per acre.
" " 6. Stood winter well	24 " " "
" " 7. Some killed	8 $\frac{3}{4}$ " " "
" " 8. Little killed	14 $\frac{1}{2}$ " " "
" " 9. Stood winter better than any other plot .	21 $\frac{1}{2}$ " " "

This shows conclusively that phosphoric acid is what is needed on Mr. Netherton's land. Also, it seems, that Acid Phosphate, Cotton Seed Meal and Muriate of Potash protect the plant to some extent from winter freezes.

W. B. FLEMING, MIDWAY, WOODFORD COUNTY, Ky.—Sowed the fertilizers broadcast and harrowed them in. In one field I sowed two and one-fifth acres with Potash, putting on four hundred pounds to the acre. Side by side with it I sowed eight and a half acres with bone dust, putting 300 pounds to the acre. Result, fourteen bushels per acre with Potash, and fifteen bushels per acre on the bone dust. In another field I made another experiment, with the following results:

No. 1. No Fertilizer.	18 bushels per acre.
" 2. 800 pounds of potash	13 " " "
" 3. 600 pounds of bone dust	16 " " "
" 4. No Fertilizer.	12 " " "

On all these I sowed the Morton wheat, except on Plot No. 2, where I sowed Velvet Chaff.

The two fields were about alike in character of soil, but the plotted field was sown after corn and the other after wheat. Both pieces were badly hurt by the freeze and both looked very promising before that time. The Velvet Chaff did not yield so well as the Morton, although more vigorous before the freeze, but how it happened that plot No. 1 did better than plots Nos. 3 and 4, I am unable to explain. My neighbors, who had worse land, but who sowed late, had better grain than those who had better land and sowed early.

The year being thus exceptioned, I do not think the experiments above are of any value or shed any light that will help solve the problem we are trying to work out.

A NEW WHEAT FLY

(*Oscinis variabilis*? Loew).

BY H. GARMAN, ENTOMOLOGIST AND BOTANIST.

In Europe, oats and barley are injured by a small two-winged fly, one brood of which mines and destroys the central part of young plants, and another destroys the young kernels of grain. It is known there as the wheat frit-fly, because, Miss Ormerod explains, the worthless grains which result from the injury are

called by the Swedish farmers "frits." The fly was long ago named *Oscinis frit* by the illustrious Linnæus, who also made record of its injurious habit, stating in 1750, that the annual loss from its depredations, in Sweden alone, reached 100,000 gold ducats. Subsequently, Curtis, the British Entomologist, described a wheat fly which he thought was different, naming it *Oscinis vastator*, but Miss Ormerod thinks this is the *O. frit* of Linnæus.

From the accounts of the frit fly given by Curtis and Miss Ormerod it is evident that the insect works on grain much like a small fly which I find in the grub state infesting wheat in Fayette county, Kentucky. In structure and habit, as far as I have observed the latter, it proves so like the European species that it might perhaps be appropriately named the American frit-fly. It was common last fall on young wheat, and especially so on that growing where the wheat shocks had stood in the summer. Infested plants generally have the central leaf dead and brown, and when the green outer blades are stripped off, the cavity within them is found to contain only the dead tissue of the plant, and refuse in which the author of the injury—a small yellowish-white grub—generally occurs. The adult flies were first observed during the fall and winter of 1889, being obtained from wheat which was placed in a breeding cage in order to secure from it the early stages of the wheat bulb-worm, which does an injury similar to that described. The eggs of the bulb-worm were extremely common on this wheat, but only a few bulb-worm flies came from it, while many black flies of another genus and species emerged in the cage in which it was kept. This led to a careful examination of the larvæ and pupæ still in the wheat, with the result of finding two kinds present, the smaller and more abundant of which proved to belong with the strange flies. Most of the flies emerged during the fall and winter, but some larvæ and pupæ were in the wheat until spring. It is very probable that most of them would have remained in the wheat all winter had their changes not been hurried by the very mild weather that prevailed. Since the outbreak among fall wheat of 1889 no injury has been observed to small grain. The adult flies have, however, been common during most of the season, in the spring on

wheat and grasses, and later on the latter alone. The pest is probably widely distributed among wheat and grasses in this country. In one of his recent papers as Dominion Entomologist of Canada, Mr. James Fletcher notes the injuries to grasses of a fly which is very probably the one here treated.

DESCRIPTION.

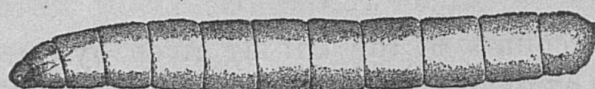


Fig. 1. Larva of American Frit-Fly. Drawing about 15 times larger than the larva.

Larva.—Very close in form and structure to the wheat bulb-worm; cylindrical, white, with a faint yellow cast; body composed of thirteen divisions; no developed head; no legs; mouth with two strong black hooks; hindmost division of body with a pair of knob-like prominences; length of specimens in alcohol .14 inch. This grub differs from the grub of the wheat bulb-worm in its smaller size, yellowish color (the other being pale green), and in the distinct and completely separate protuberances at the hind end of the body. In the wheat bulb-worm grub the hindmost division of the body is simply two-lobed. Under the microscope another difference is apparent. The first two divisions and the under side of those following are roughened with very fine raised lines directed crosswise of the body in the wheat bulb-worm, while in the frit-fly grub the first divisions and the under side of those following, in the region of the joints, are roughened, instead, with numerous scale-like thickenings of the cuticle, with the hind edge of each thickening finely toothed.



Fig. 2. Puparium of the American Frit-Fly. Length of drawing about 15 times that of the puparium.

Pupa.—In this stage the insect is inclosed in the skin of the grub, the skin hardened and embrowned to form what is known as a puparium. The puparium is of a bright yellowish-brown color, with distinct and very finely wrinkled divisions. The two knobs of the grub are still conspicuous at the hind end of the body. The black jaws of the grub are moulted with the skin, and may be seen through the puparium lying along the under side. Miss Ormerod mentions a star-shaped structure, which she thinks is characteristic of the European frit-fly. The obsolete mouth of the grub of the American insect is withdrawn, blackened and wrinkled, producing what I infer is the same appearance. Length of puparium from .10 to .14 inch.

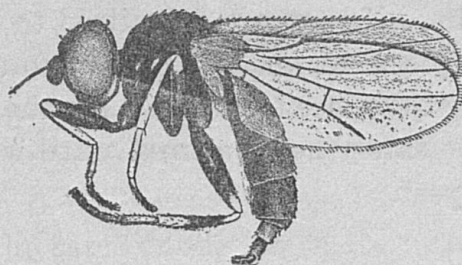


FIG. 11.—Imago of the American Frit-Fly. Length of drawing about fifteen times that of the fly.

Imago.—A minute shining black fly, large examples of which are about .07 inch in length. The eyes are reddish-brown. The wings have brown veins, and are very faintly smoky. Under side of abdomen pale green. Thighs black next to the body, pale yellow at the tips, remainder of legs, excepting the feet and a band on the two hind ones, also pale yellow.

REMEDIAL.

For the European frit-fly Miss Ormerod advises the application of a "stimulating dressing" to the soil as a means of counteracting the injury, or rather as a means of getting a stand of grain over and above that killed by the grubs. The suggestion can, doubtless, be made of use in case of outbreaks of the American species.

Our insect has thus far proved most abundant on volunteer plants. The greater exemption from injury of the late-sown wheat seems to be due to the fact that many of the flies deposit their eggs on the volunteer plants, and disappear before the

sown wheat appears above ground. Late planting may consequently be expected to enable farmers to avoid injury during the fall of the year.

Another matter which I am satisfied is of importance in connection with injuries of insects such as this, is the destruction in the fall or winter of volunteer wheat and oats with the pests they harbor. In getting specimens of the grain insects for examination I have always found these plants to yield the most. They accumulate on them in some cases in great numbers, the Wheat bulb worm, the Hessian fly, the Grain louse and the American frit fly sometimes occurring on the same plants. If such plants can be destroyed, they form a bait to attract pests from the sown grain. If they are permitted to grow during the fall and winter, they are an encouragement to the insects and a menace to the wheat the next spring. Further suggestions as to remedies can not safely be ventured until we know the full life-history of the pest.

BULLETIN No. 31.

SOME STRAWBERRY PESTS.

BY H. GARMAN, ENTOMOLOGIST AND BOTANIST.

THE STRAWBERRY LEAF-BLIGHT FUNGUS

(*Ramularia tulasnei*, Saccardo).

Probably no other enemy of strawberry plants does so much injury year after year as the fungus, which causes the familiar spot disease of the leaves. It is very widely distributed in this country, and attacks more or less destructively all varieties. Its injury consists during the early part of summer in a destruction of the leaf-tissue in spots, so that the functions of the

leaves are disturbed ; and, if the spots become abundant, these may be completely killed before the end of summer. Severe attacks may result in the death of the plants ; and even in seasons the most favorable to them, the injury results in diminishing their vigor, and thus lessening the possible yield of fruit.

CONDITIONS WHICH AFFECT BLIGHT.

Two lots of strawberries, one in a heavy, poorly-drained soil, the other in a lighter soil with an almost perfect natural drainage, have been closely watched the past summer to see if any difference in the amount of injury from blight, attributable to soil influence, could be detected. The two lots were made up largely of the same varieties. The lots were observed and compared from May 20 until September 1, but I could not in this case, see that the difference in soil had the slightest influence on the blight. Varieties badly injured in one lot were invariably badly damaged in the other, and those least injured in one were sure to prove in the same condition in the other lot.

The heat of the sun, on the contrary, has a very decided effect in increasing the blight. Rows which are badly injured where exposed to the sun, are much less affected in places where they are shaded by trees. Wild plants growing in the shade of trees a few yards from badly infested cultivated plants are often entirely free from the spots. The most striking and convincing instance of this preventive effect of shade, which has come under my observation, was brought to my attention by the experiments reported farther on. The old blighted leaves were removed at the beginning of summer from one lot of plants, while others of the same variety and in an adjoining row, were not touched. The old blighted leaves of the latter, one would suppose, would scatter the spores of the fungus on the young plants growing among them so as greatly to increase the injury to the latter. But the shelter from the sun which these old leaves afforded the younger ones more than counterbalanced their evil effect, and the result was that the lot from which the old leaves were removed was, at the close of the summer, much the worst blighted of the two.

These effects of shade and sun seem to have been confounded

in some cases with the effects of moisture and drouth. That moisture by itself accelerates the spread of blight, is shown by the rapidity with which the spots appear after showers in warm weather, leaves previously without a trace of the disease becoming thickly spotted in a single day. The freedom from blight which is to be observed during rainy seasons is, it seems to me, to be attributed partly to the vigor which a proper amount of moisture induces in plants, and to the fact that a prevalence of cloudy weather has much the same influence in checking blight that shade has.

The truth seems to be that the cultivated strawberry has been derived from shade-loving wild plants, and the exposure of the artificially produced varieties, by the usual method of planting, to the sun's heat, is doubtless the indirect cause of much of the blight which appears. Just why the sun should encourage the disease is not so easily explained. It is probable that its heat has a debilitating effect, and, it may be, causes the minute breaks in the tissue of leaves necessary for the ingress of the parasite. However this may be, it seems that sunlight with occasional showers, or heavy dews, are conditions which induce the most destructive blighting of plants. With the plants under conditions natural to them, drought, it may be assumed, would check the blight, as it is known to do in the case of other fungus attacks.

Young plants are not liable to blight until their leaves are nearly grown, and new beds, commonly, show but few of the spots until towards fall. An exception to this rule was noticed this year which is worth recording. Some rows of young plants were put out alongside old badly blighted ones. In the fore part of August it was observed that the young plants next the old ones were becoming badly spotted, the first row being especially affected, while the plants farthest away were but little injured. The explanation of this difference is to be found in the fact that the blight fungus is propagated during the summer by means of microscopic spores, which, of course, fell in greatest numbers upon the young plants nearest the old blight-infested ones. The lesson to be drawn from the fact is too plain to need pointing out. If it were possible, indeed, to isolate beds of young plants so as to prevent the access to the leaves of all spores, plants might be kept free from blight indefinitely.

THE BLIGHT FUNGUS.

Wherever one of the characteristic spots appears on a leaf, a microscopic plant, the blight fungus, has penetrated and is engaged in using up the leaf for its own growth. The growing

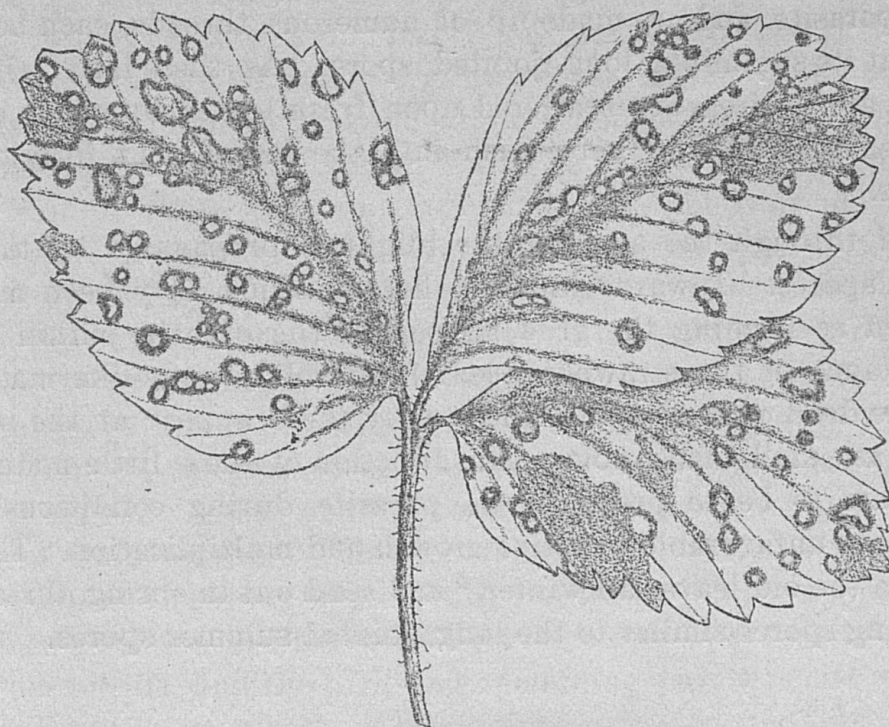


Fig. 1. Representing the Strawberry Leaf-blight as commonly seen.

part of the fungus consists of microscopic transparent threads which penetrate the tissues of the leaf in every direction in the region marked by the conspicuous change in color. The presence of the blight fungus in the leaf is first marked by the appearance, often in warm weather in the space of twelve hours, of small brown spots, varying in diameter from one-sixteenth to one-eighth inch. As they become abundant the spots fuse, forming extensive brown areas, and finally occupy the whole leaf. Eventually most spots show at the upper side of the leaves a rim of dull purple of varying width, due to some change in the contents of the leaf-cells in this region. Towards fall this change in the color of the leaf is more prevalent, and often purple spots are formed with only a minute brown speck at some point marking the place where the fungus entered. If one of the spots be cut through with a pair of fine scissors the leaf will be found at the point where the spot is formed much thinner than elsewhere, because of the killing and drying out of

its substance. Examined under a microscope, the fungus may now be found to have pushed through the tissues of the leaf, and to have formed all over the brown central region of the spot, but most abundantly at its margins, small whitish tufts, looking like microscopic shrubs. These are the fruiting parts of the parasite, and are made up of numerous threads, each bearing at its summit a long, jointed spore. As these latter ripen they are set free, are scattered upon fresh leaves by winds and rains, to germinate there, push into the leaves, and form new spots.

All through the summer the blight is propagated by these long spores. Towards fall the threads which have been mentioned as forming the growing part of the parasite within the substance of the strawberry leaf form solid tissue-like masses in the dead part of spots, and finally these appear at the surface as small black dots. The function of these little nodules appears to be to preserve the parasite during conditions of weather unfavorable to active growth and multiplication. They are in the old leaves all winter,* and send out in spring threads bearing spores similar to the long, jointed summer spores.

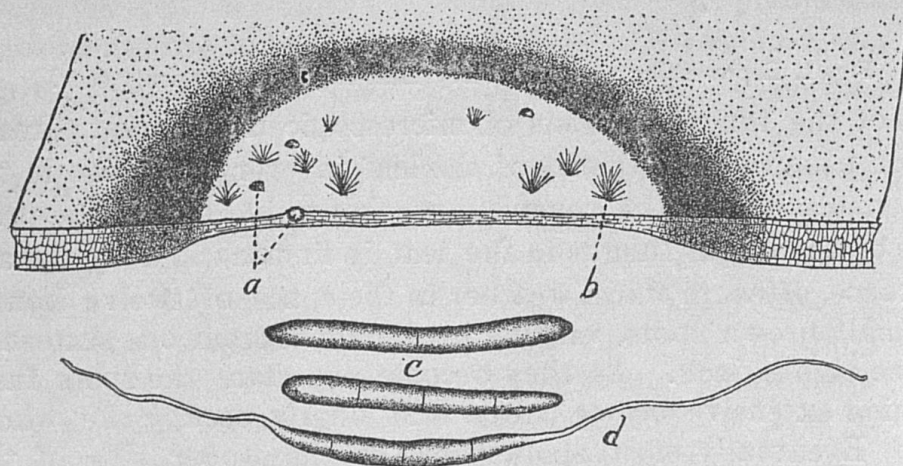


Fig. 2. Representing a blight spot cut through the middle, and greatly enlarged. *a*, the small nodules which appear in the dead leaf tissue in the fall, and carry the fungus through the winter; *b*, showing the tufts of spore-bearing threads which appear on spots in summer and fall; *c*, two summer spores greatly magnified; *d*, a germinating spore.

* It has been claimed that a fungus known to botanists as *Sphaearella fragariae* is one stage of the spot disease fungus.

REMEDIAL TREATMENT.

From the life-history given above it will be plain that the old leaves of winter are the source of contamination for the leaves which develop the next spring. If these old leaves could be raked up and burned, there could be no doubt but that the blight would be lessened. But I am convinced that the old leaves should not be removed at any other season of the year, unless this is followed by applications of some good fungicide. Several preparations of this kind may be used with good effect. The best of these are preparations of bluestone, or of liver of sulphur (potassium sulphide), and should be applied to the plants by means of a good force pump and spray nozzle. The following experiments were made during the past summer with a view to getting exact information concerning the effect of several preparations in preventing strawberry leaf-blight:

On June 30, the crop of berries having been removed, all the leaves showing traces of blight were removed from 230 feet of rows of Ohio berries. This was staked off into five parts of 46 feet each, and one was treated with Bordeaux mixture, another with ean celeste, a third with liver of sulphur, a fourth with London purple, and the fifth and remaining part was left without treatment as a check on the others. The treated lots were sprayed, with the exception noted below, every two weeks, beginning June 30 and stopping September 1. A heavy shower occurred the night after the first treatment, washing the preparations from the plants, and it was thought best to make another application on July 3. The plants were all sprayed, consequently, counting the first application of June 30, seven times. Two quarts of each preparation were used at each spraying, and each lot of plants, therefore, received fourteen quarts in all. The preparations were applied with a large Woodason sprayer, an instrument requiring more time than a force pump, but having the advantage for experimental work in furnishing an extremely fine and penetrating spray.

BORDEAUX MIXTURE.

This was prepared according to the following recipe:

Bluestone	6½ pounds.
Lime	3½ pounds.
Water	22 gallons.

Dissolve the bluestone in two quarts of hot water. Slake the lime in two quarts of water; then add the remaining twenty-one gallons of water to the slaked lime, and finally pour this into the vessel containing the bluestone solution. Keep the preparation well stirred while using.

From the beginning, the plants of this lot were among the best, the only lots approaching it being those treated with eau celeste and liver of sulphur. Taking it through the whole summer, it was very much the best of all. The leaves grew thriftily; the blight which did appear between sprayings was not sufficient to check the plants; and a fine growth of new plants was put out. Looking down the row, this lot could be at once recognized by the fine appearance of its plants, and especially by contrast with the check lot, which was next it.

EAU CELESTE.

The formula used in preparing this is the following:

Bluestone.....	2 pounds 3 ounces.
Ammonia.....	1 $\frac{3}{4}$ pints.
Water.....	88 gallons.

Dissolve the bluestone in four or five pints of hot water, and, when cold, add the ammonia. Finally, stir this into the water.

The lot treated with this preparation was next to the Bordeaux mixture lot in freedom from blight. The plants retained all their leaves throughout the summer, and produced many strong young plants. The preparation seemed not to be so lasting in its effects as Bordeaux mixture. The leaves showed no trace of injury from it.

LIVER OF SULPHUR.

A one per cent. solution of this was used. The lot appeared for a short time after beginning spraying, to be the best of all, but the preparation evidently did not hold its properties long after exposure, and a good deal of blight appeared on the leaves before summer was over. It stood third, however, to the last. I could see no injury from its use.

LONDON PURPLE.

This was used in the proportion of one pound to two hundred gallons of water. My reason for trying this material was be-

cause decisive results obtained with it in laboratory experiments made it seem a promising fungicide, and partly because it was desired to learn its effect as a remedy for the injuries of the strawberry leaf-roller. The lot sprayed with it stood fourth in the matter of leaf-blight, but was easily better than the check lot. The London purple began to injure the leaves towards fall, but none of the plants were killed.

CHECK LOT.

This lot of plants showed an early appearance of blight. Its effect was soon evident in the dwarfed appearance of the plants, and, later, by the number of dead leaves. Few new plants were formed, and at one time in August it looked as if the plants would be destroyed before fall. With the advent of fall rains and cooler weather, however, it improved somewhat.

OTHER OHIO PLANTS IN THE SAME BED.

Ohio plants adjoining those belonging to the experimental lots were watched during the summer with some interest. The rows soon assumed a brown appearance from the spread of the blight on the old leaves, and from the fact that these concealed the young plants. At this time they seemed to be much more affected than the check lot. Towards fall these old leaves were largely used up and subsided, while a new lot of young plants appeared, giving the rows a very thrifty appearance. Eventually they were in much better condition than the check lot, having produced more and stronger young plants. I attribute this surprising difference, as already stated, to the protection which the old leaves afforded the young ones during the hot weather of July and August, and to the complete exposure of the young leaves of the check lot to the heat of the sun.

CONCLUSIONS.

1. Injury from strawberry leaf-blight can be largely prevented by the use of Bordeaux mixture and eau celeste, and, to some extent, by potassium sulphide and London purple.
2. Bordeaux mixture is much superior to the other preparations used.
3. Applications of Bordeaux mixture should be made as often

as once in two weeks. From the complete exposure of the leaves to rain, the mixture is removed from strawberry leaves much sooner than from grape leaves or those of trees.

4. Prepared according to the formula given above, it may be sprayed freely without the slightest injury to leaves.

5. Twenty-two gallons of the mixture is sufficient for spraying during one summer 337½ feet of strawberry plants, as commonly planted in rows; and will cost for materials, considering bluestone worth 8 cents per pound, and lime worth 1 cent per pound, fifty-six cents. By buying materials in quantity, this cost can be reduced.

6. A removal of the blighted leaves in summer, without subsequent spraying, will increase instead of diminish injury from blight.

A COMPARISON WITH REFERENCE TO BLIGHT, OF VARIETIES OF
• STRAWBERRIES GROWN ON THE EXPERIMENT FARM.

At the suggestion of Prof. Scovell, I made notes during the past summer on strawberries grown on the farm, with a view to learning the relative amount of injury which the different varieties suffered from blight. The observations here recorded relate only to plants which had been set out longer than one season. It was found that a fair comparison could not be made between varieties set out this season and others which had been out longer, for the reason that peculiarities with reference to blighting are not apparent the first year. To be strictly just, varieties compared should be of the same age. None of the varieties were entirely free from leaf-spots, but I think those mentioned below under 1 and 2 were not at all retarded by them. Those, on the other hand, on which the blight fungus was noted as abundant, were materially checked, and varieties on which the blight was very abundant, looked as if they might succumb before another season, and must have had their bearing power for next spring seriously impaired. The varieties were observed from May 20 until September. At the first examination, on May 20, some differences with reference to blighting were apparent, which did not continue through the summer, and were probably due to difference in the earliness of the varieties, those

first to become active in the spring being the ones likely to show the disease soonest.

It is not possible to establish an exact scale showing the relative injury for the season, but the following arrangement of the forty-seven varieties under observation will give a comparative view sufficiently accurate for practical purposes :

1. *Blight very rare*.—Daisy, Eureka, Jewell, Triumph de Grande.

2. *Blight rare*.—Belmont, Lady Rusk, Scarlet Queen.

3. *Blight frequent*.—Annie Forest, Bomba, Bubach, Burt, Captain Jack, Covill, Crawford, Cumberland Triumph, Dutter, Gandy, Gold, Gypsy, Haverland, Henderson, Itaska, Jessie, Lida, Logan, Mammoth, May King, Miami, Ontario, Perry, Pearl, Phelps, Pine-apple, Primo, Summit, Sunset.

4. *Blight abundant*.—Barton's Eclipse, Cloud, Gandy Pride, Great America, Loudon's 15, Piper.

5. *Blight very abundant*.—Mammoth, Ohio, Photo, Sanafee, Warfield.

THE STRAWBERRY LEAF-ROLLER.

(*Phoxopteris comptana*, Frohl.)

Next to the leaf blight fungus, this insect is perhaps the most injurious of the enemies of the strawberry. It occurs throughout the Northern United States, and is found also in Europe, but is, strangely, not known there as a strawberry pest. In this country it occurs in larger or smaller numbers in most strawberry beds, and lurks among the plants in one or another of its stages at all times of the year. With us, it is pretty closely limited to the strawberry as a food plant. On a few occasions it has been observed folding the leaves of raspberry and blackberry.

Where plants are neglected, or where berries have been grown on the same land for a number of years, it becomes common, and is quite capable under these circumstances, of destroying beds completely. Certain facts known to entomologists seem to indicate that it is a northern insect which has gradually extended southward. In 1878 the State Entomologist, of Illinois, wrote that it seldom occurred south of central Illinois. In 1883

it was found to be very common and injurious in southern Illinois, and has since then continued abundant there. It is one of the commonest injurious strawberry insects in Kentucky, though

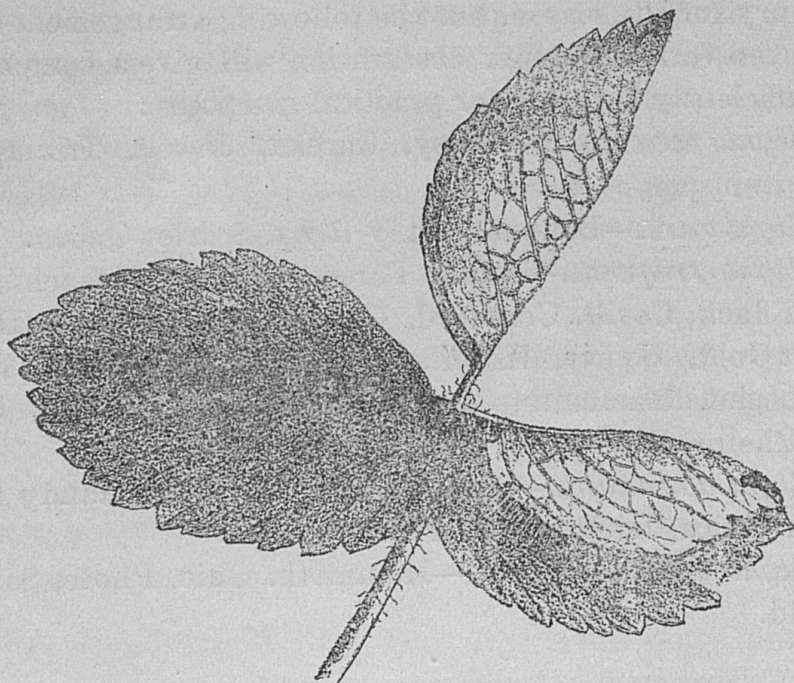


Fig. 3. Representing the work of the Strawberry Leaf-roller.

I am unable to say from my own observation how long it has been here.

The injury done by the leaf-roller is all accomplished while it is in the caterpillar or larva stage. At this period of its existence it is a small, faintly greenish worm, a trifle less than a half inch long. Soon after it hatches from the egg it begins to fold the leaves together, bringing the upper side of one-half of a leaflet in contact with the upper side of the other half, and fastening them so with bands of silk. In the retreat thus formed it spends its whole larval existence, feeding upon the

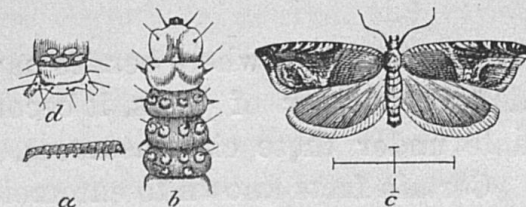


Fig. 4. The Strawberry Leaf-roller; *a*, larva, natural size; *b*, head end of larva, enlarged; *d*, hind end of larva, enlarged; *c*, moth, enlarged, the hair lines showing natural size.

leaf, and ultimately causing it to turn brown and shrivel up. When it has its growth as a larva it changes within the leaf to a brown quiescent pupa about one-fifth inch long. Finally it assumes the adult form, emerging as a small, obscurely marked brown moth, with a wing expanse of about one half inch.

AT LEAST THREE ANNUAL BROODS IN KENTUCKY.

Two annual broods of the pest are known at the North, the first becoming moths in the first half of July, and the second changing to pupæ in the folded leaves in September, and staying there all winter. Here in Kentucky, with our long summers, the leaf-roller has a different life-history. At least three broods develop in this State each year.

Grown larvæ occur in the leaves during the first week of June, and change to pupæ soon afterwards. The moths from these pupæ begin to emerge about June 11, become most abundant between the 20th and 24th, and are all out before the end of the month, the last three moths of the brood observed last spring having appeared on June 26.

The next brood begins to appear as larvæ about July 4, and is common by the middle of the next month. These larvæ reach their full growth during the last week in July, and begin to emerge as moths about August 3.

The next and last brood of the season begins to fold leaves about September 1, becomes common by September 9, is about two-thirds grown September 17, and fully grown October 20. At this date the past season nearly every folded leaf examined contained a living larva. As cold weather came on, the larvæ of this lot began to desert the folded leaves, and on November 18 only forty-five out of one hundred and thirty-nine examined contained larvæ. On November 25 the larvæ which had deserted the leaves were found among mulching under the plants, but still feeding on bright days on the leaves within their reach. A good many, however, continued in the folded leaves on December 6.

It is apparent from the above record that the late brood passes the winter as larvæ, and matures in the spring. Whether it does so early enough to give rise to an early spring brood, re-

mains to be determined by further observation. From the condition of the larvæ observed in early June last spring, I am disposed to believe they were not those which had passed the winter among the plants, but had developed from eggs laid by moths earlier in the spring. If this is the fact, we have, at this latitude, four annual broods of the Strawberry leaf-roller.

REMEDIAL TREATMENT.

Spraying with poisonous mixtures cannot, of course, be practiced while there is fruit on the plants. Applications of London purple or Paris green after the crop is gathered ought to be a complete remedy. For some reason, however, they do not appear to be very effective. The lot treated with London purple at the Experiment Farm last summer was observed closely to see if the leaf-rollers were affected, but I could not see that they were less common on the experimental lot than elsewhere.

Fortunately there is a remedy that is about all that can be desired. The leaf-roller can be almost exterminated in a field by mowing the plants while larvæ or pupæ are in the leaves, allowing the mowed leaves to dry a short time, then burning over the bed, perhaps with the aid of a little straw or rubbish. This can be done without the slightest injury to the plants. Some growers even burn over their beds more than once during a year, but considering the evil effect here on young leaves of the hot sun, I do not think this advisable. For all ordinary cases it is probable that burning over in October will suffice. Treatment at this time is especially to be recommended because it will serve for both blight and leaf-rollers.

THE STRAWBERRY CROWN-BORER.

(*Tyloderma fragariæ*, Riley.)

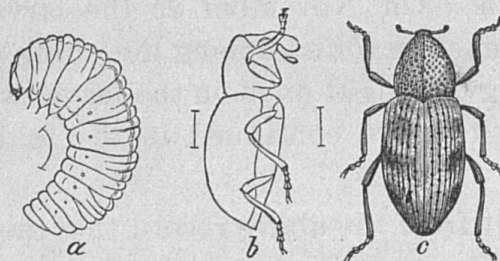


Fig. 5. The Crown-borer. *a*, grub; *b*, side view of beetle; *c*, beetle as seen from above. The hair-lines show the natural size.

This in its adult state is a small brown snout-beetle belonging to the same family as the plum curculio. From the eggs which it places on plants, hatch small, stout, legless grubs which mine the crowns of plants. When ready to become pupæ they are about one-fifth of an inch long, pure white in color, with pale yellow heads. The change to the pupa stage is effected in the burrows made in the crowns, and after becoming adult beetles they appear to remain there for some time. In color the beetles are chestnut brown, with several imperfectly-defined black spots on each side of the back. These colors seem to be acquired slowly, and examples not fully matured often occur, which are of a nearly uniform yellowish brown color. A single brood develops each year, larvæ occurring in the burrows from July to late in September. The beetles desert the crown shortly before winter sets in to hibernate in the earth. This species appears to feed exclusively on strawberry plants. The crown-borer is generally most common on old strawberry land, where it has been known to ruin whole plantings. It is to be feared mainly because, from its small size and retiring habits, growers generally have no practical knowledge of it. Its injury may consequently be accomplished before the culprit is detected.

REMEDIAL TREATMENT.

The beetles are incapable of flight, having no functional wings, and are thus dependent for locomotion on the usual three pairs of legs. These they use with no great facility, and as the grubs lack legs altogether, the species, as may be supposed, does not migrate readily from infested beds. There is little danger of the borer getting among plants on new land, at a distance from infested beds as long as the plants for new beds have not been obtained from infested ones. Grubs and pupæ spend all their lives in the crowns of plants, being found there from the middle of June until late in September. Plants removed from infested beds during this time are, therefore, liable to convey the borers to localities to which such plants may be transferred. Those who have had experience with the borers have found that care with regard to selecting plants and ground for new beds was their best means of avoiding injury. No fear need be entertained of the borers attacking seriously other crops which may

be grown on infested land, and there is every probability that one season in corn or potatoes would rid land of them. No practicable method of using insecticides against the crown-borer is known to me.

THE STRAWBERRY FALSE-WORM.

(*Emphytus maculatus*, Norton).

This insect belongs to the same order as the common honey bee, and is a near relative of the rose and pear slugs. As an adult it is a small black fly, a little less than a quarter of an inch in length of body, with four smoky wings, which it holds close along the back when they are not in use.

These flies emerge from the ground in early spring, and insert their eggs in the leaf-stalks. The grubs which hatch from these are pale yellowish, or greenish, and are from about a half to two-thirds of an inch long when fully grown. They are to be recognized at this stage, among strawberry insects, by their peculiar manner of coiling themselves up when at rest on the under side of the leaves. The injury consists in riddling the leaves with holes. They abandon the plants when ready for the pupa stage, and enter the ground, from which they emerge

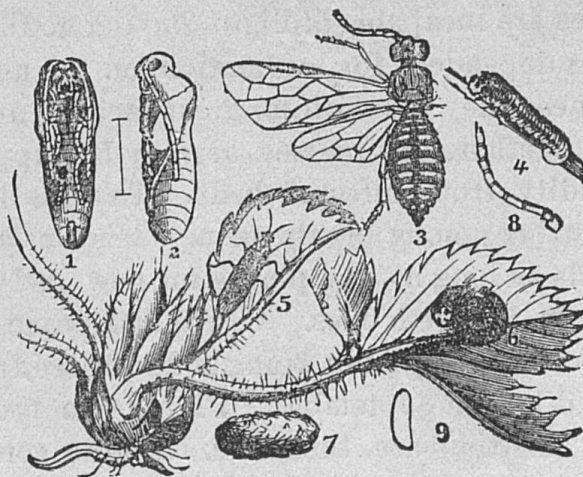


Fig. 6. The Strawberry False-worm; 1, 2, different views of pupæ which have been removed from the cocoon, enlarged; 3, winged adult, enlarged; 4, larva, natural size; 5, adult, natural size; 6, larva, as seen coiled up on a leaf; 7, the cocoon in which the larva becomes a pupa; 8, an antenna of the adult fly; 9, outline of an egg, enlarged.

again as flies in the latter part of June. A second brood is to be seen in the grub state during August, and enters the ground in the fall of the year to remain there during the winter.

REMEDIAL TREATMENT.

Pyrethrum or Persian insect powder can be safely used to destroy the false-worms while the plants bear fruit, and can be quickly dusted on leaves by means of a powder bellows, such as that made by Thomas Woodason, of 451 E. Cambria street, Philadelphia. If fresh, and carefully applied, this powder should prove all that is needed. For the late brood, Paris green may be used with certainty of destroying the worms.

WHITE GRUBS.

Grub worms are sometimes very common and injurious among strawberry plants growing on land which has recently been in grass or weeds. They are the early stages of several species of brown beetles belonging to the genus *Lachnosterna*, and are known in the northern States as June bugs, because of their activity during the warm weather of late spring. Most of these grubs spend the greater part of the summer in the earth, feeding on roots. Towards fall they change to pupæ in earthen cells, and either remain in this condition all of the following winter, and become beetles the next spring, or else change to beetles in the fall, and remain through the winter in the beetle state. The occurrence of both stages of the same insect during the winter seems to have led to the mistaken belief that these insects spend more than one year in the grub state.

The main injury which these grubs do is to grasses, and they are often very destructive to lawns, completely killing, in some cases, the grass over extensive areas. The adult beetles also do considerable injury by gnawing the leaves of plants, being especially injurious to shade trees, which they may almost strip of their foliage in a few nights.

The grubs attack strawberries apparently because deprived of their accustomed food. The mischief is done chiefly the first summer after plowing land from grass or weeds. As the grubs mature in such land, they desert it, the adult beetles resorting

to grass land again to deposit their eggs for the next generation of grubs.

When grubs are at work in strawberry beds, the fact is to be recognized by the sudden wilting and drying up of occasional plants. If examined, the fibrous root and perhaps a large part of the crown of such plants may be found gnawed away. The simplest and most certain method of checking injury under such circumstances is to dig up the infested plants and destroy the grubs. Gas lime has been found useful as a dressing for land infested with grubs. It must be applied to the ground and worked in a month or so before planting in berries.

It is sometimes claimed that the white grubs which injure plants have been brought into the fields in stable manure, a mistake due to the resemblance between the large grub worms of manure heaps and those found in the soil. The grubs from manure, however, belong to a different insect genus from the root-eating kinds, and feed exclusively on dead vegetable matter.

THE JUNE BUG.

(*Allorhina nitida*, Linn).

In the more northern States, this insect is replaced by a number of species of another genus, (as already remarked), which are known there as June bugs when adult, and as white grubs when larvæ. The present species is common all over the southern States. When adult it is a beetle about three-fourths inch long and one-half inch in greatest width, and is of a peculiar dull green color above, the surface presenting an opaque velvety effect; beneath, the body is highly polished. As a beetle it is often injurious to ripe fruits into which it eats its way. In the South Atlantic States it has received the name of "Fig-eater," because of its fondness for ripe figs. Here in Kentucky it is extremely common during July on wild blackberries, quantities of which it devours.

The early stages of the June bug are very similar to those of the northern June bugs. The larva is a stout, rather hairy, white grub, which, when exposed from its underground retreats, progresses by turning over on its back, and pushing itself along

by movements of its body segments. Its history also is much like that of the white grubs just described, and like them it appears to feed by preference in grass land. It has been observed occasionally in the grub state among strawberry plants, where its injuries are not distinguishable from those of other white grubs, and call for similar treatment.

THE STRAWBERRY ROOT-WORMS.

(*Paria canella*, Fab., *Graphops nebulosus*, Lec., and *Colaspis brunnea*, Fab.)

Small white grubs, very similar in general character to the large white grubs of strawberry fields, are sometimes injurious to the plants. When fully grown they are only about one-sixth inch in length. They generally confine their attentions to the fibrous roots, but, like the large grubs, occasionally gnaw into the crowns. In this latter case their injury may be known from that of the crown-borer (*Tyloderma fragariæ*) by the fact that the latter insect mines almost entirely the interior of the crowns, working downwards from the bases of the leaf-stalks, whereas the root-worms now under consideration gnaw into crowns from any point, and make irregular open galleries. All these root-worms, too, have three pairs of jointed legs, while the grub of the crown-borer has none. These root-worms are all closely related members of the same family (Chrysomelidæ), and while in most cases readily enough distinguished from each other when they are beetles, it is not so easy to distinguish the grubs without resorting to the microscope, and characters available to the fruit-grower for ordinary examination can not be given. As far as known all the species produce a single brood in a twelve-month; all pupate in the earth in strawberry fields; all feed as beetles, more or less freely, on strawberry leaves; several species pass the winter among the plants in one stage or another.

Paria canella, Fab.—The species commonly reputed by entomologists as injuring strawberries is *Paria aterrima*, in its adult state a small black, shining beetle about one-eighth inch in length. The species which has thus far been found in Kentucky fields proves to be *P. canella*, the beetle of which is somewhat smaller than that of the other, but is otherwise not

very different. The common variety is brown in general color, with black markings; more rarely it is largely black. The grubs of these species occur at the roots of plants during July and August, and are likely to be found most abundant in old beds. The Kentucky species is carried through the winter by beetles which hibernate among mulching or rubbish under the plants.

Graphops nebulosus, *Lec.*—The beetle of this is of the same general shape as the preceding, and is of about the same size. It is of a uniform brown color, with a metallic coppery lustre. The grubs feed in exactly the same way as do those of the several species of *Paria*, and can not readily be distinguished at this stage from them. They occur in early spring, producing beetles in June and July. The beetles deposit eggs for the next brood in the latter part of summer, and the grubs of this generation pass the winter in ground, where they remain to injure the plants the following spring.

Colaspis brunnea, *Fab.*—When mature, this is a beetle about three-sixteenths of an inch long, of a uniform yellowish-brown color. It is common during a large part of the summer on the leaves of a large number of plants, more especially on red clover, strawberry and grape, to which plants it may occasionally do considerable harm. In its grub state it appears to occur most commonly on plants which have been placed on new land, and it is very probable that it is not at all dependent on strawberries at this stage of its existence. The grubs differ from the other root-worms in the greater prominence of certain tubercles along the under side of the body—a difference which may be made out with a hand magnifier. They occur among plants during May, June and a part of July. The manner of passing the winter is not yet made out. A single brood appears each season.

REMEDIAL TREATMENT.

The beetles of the three genera all feed on strawberry leaves in the summer, the species of *Paria* being especially destructive to foliage. They may be destroyed easily after the fruit is removed by spraying the plants occasionally during July and August with London purple, a treatment which will not only

save the foliage, but also reduce the number of root-worms for the next season.

The eggs of beetles have been thought to have been transferred in some instances on plants from infested fields to newly planted ones. To avoid stocking his new beds with root-worms, a fruit grower of Southern Illinois, destroys all the transplanted plants after these have put out new plants, and believes that by so doing he reduces the injury from these insects in his new beds. The efficacy of the practice does not seem beyond question, since the worms often feed on the fibrous roots at some distance from the crowns, and would, in such cases, not be taken up and destroyed with the plants. The crown-borer, from feeding in the interior of the plants, would be more easily managed in this way. Care in such matters must, however, be depended on to a considerable extent for avoiding injury. It is certainly possible by constantly selecting clean, sound plants for setting, then putting out new beds in clean soil at some distance from old plantations, to avoid much of the injury commonly suffered from root insects. This, in connection with the occasional use of Paris green on the foliage, is about the only preventive treatment that can be recommended with confidence at present.

I must not omit mention of the useful work which is constantly being done for the strawberry grower by the common toad. An examination of stomachs taken during a number of years has shown that this little-appreciated friend devours numbers of the beetles of the three common root-worms, having, apparently, an especial fondness for the *Colaspis*. Still another friend to strawberry culture was unexpectedly encountered last summer by the examination of stomachs of the Purple Martin, examples of which, taken in July, being found to have fed very largely on *Colaspis* beetles, probably captured on the wing over meadows.

THE SMEARED DAGGER.

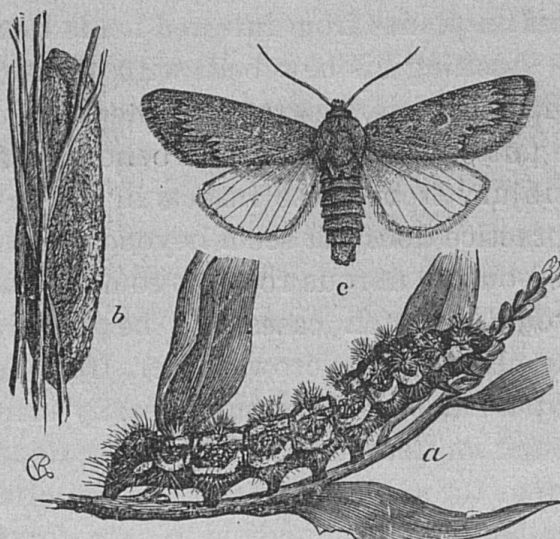
(Apatela obliqua, Sm. and Abb.)

Fig. 7. The Smeared Dagger. *a*, caterpillar, *b*, cocoon; *c*, moth. All of natural size.

A common insect enemy of the strawberry in Kentucky is a large, brightly-colored caterpillar about one and a half inches long, which gnaws the leaves. Its head and the ground color of its body are brown or black, and it is ornamented with spots, and four more or less broken longitudinal bands of bright yellow. From tubercles on the back arise many brown, black or yellow spines, and in some examples the divisions of the body are marked each with a cross band of crimson. An early brood of this caterpillar appears on plants in June, and a second brood in September. When done growing as a caterpillar, it leaves the plants, and in some retired corner among rubbish or against fences spins a thin, gray, silken cocoon, in which it becomes a dark brown pupa. The adult insect is a gray moth, the body of which is about three-quarters of an inch long, and with a wing expanse of from one and three-quarters to two inches. The front division of the body and the fore wings are ashen gray, with obscure black markings; the hind division of the body is paler, and the hind wings are nearly white.

The winter is passed in the pupa stage. In addition to strawberries, it feeds on apple, asparagus, corn, cotton, grape, hazel, lombardy poplar, peach, raspberry, smart-weed and willow.

Upon strawberry plants it is generally scattered, so that not-

withstanding its large size and voracity, its injuries are not marked. Where it becomes abundant in strawberry beds, the use of London purple or Paris green will prove sufficient to destroy caterpillars of the fall brood. The spring brood is not often common enough to call for treatment. Fresh pyrethrum is the only material which can safely be used while berries are on the plants. Small insect parasites of several species are known to destroy many of the caterpillars.

THE TARNISHED PLANT BUG

(*Lygus pratensis*, Linn.).

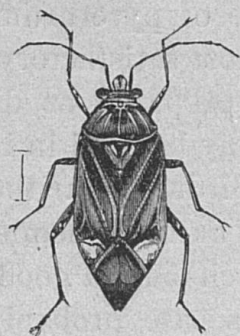


Fig. 8. Representing an adult Tarnished Plant Bug, enlarged.

The Tarnished Plant Bug has been accused of occasioning loss to berry growers by puncturing the forming berries, causing them to develop irregularly (to button), or if the injury is more severe, checking their growth and causing them to shrivel up and blacken. The insect is a small brown bug, about one-fourth of an inch long to the tips of its folded wings. It is very variable in color, ranging from pale brown, with a few obscure dark marks, to almost uniform black, with a yellowish or reddish spot towards the tip of each front wing. It both runs and flies with facility, and is an active feeder all its life from the time it leaves the egg. It has no quiescent pupa stage. The winter is passed as an adult insect hid away among mulching or about plants, numbers being lodged usually at the bases of mullen plants.

As soon as spring opens it is abroad for mischief. Besides its injury to strawberries, it often plays havoc at this time to the young twigs and leaves of pear, grape, currant, potatoes and a variety of other plants. It not only injures plants by punctur-

ing and abstracting the sap, but the wounds produced by its beak are followed by an extensive blackening of the surrounding parts, perhaps due to some fluid injected by the bug at the time of making the puncture, an effect very different from that caused by the punctures of other bugs. Writing of the Tarnished Plant Bug, some years ago, Mr. F. S. Earle, of the firm of Earle & Sons, stated that he thought they had lost in one spring from the injuries to young berries between \$5,000 and \$10,000. Of all the strawberry pests, it is perhaps the most difficult to deal with. If it were dependent on some one plant we might hope to combat it with more assurance of permanent success. It can not be poisoned with Paris green or London purple, because it does not take solid food. The use of pyrethrum, dusted on the plants, has thus far proved the most satisfactory remedy for injuries to strawberries. Kerosene, prepared as directed in Circular 3, page 3, of this Station, may be used in infested plants after the fruiting season is past. Birds devour the bugs occasionally. It appears to have few other natural enemies. Damp weather has, as in the case of the chinch bug, a good effect in reducing its numbers, an effect in this case probably due in part to a new parasitic fungus (an *Empusa*), which I have observed attacking it in Kentucky.

CIRCULAR NO. 3.

MEANS OF LESSENING INJURIES FROM INSECTS AND FUNGI.

BY H. GARMAN, ENTOMOLOGIST AND BOTANIST.

- I. INSECTICIDES.
 - II. FUNGICIDES.
 - III. APPARATUS.
 - IV. ORCHARD TREATMENT.
-

The preparations and instruments for combating injurious insects and fungi have multiplied at an exceptional rate during the past five years. A good many of those now sold have stood the test of real use in the garden and orchard, and some of them are doubtless to be considered a permanent part of the farmer's equipment for the successful prosecution of his profession. It is with the purpose of calling more general attention to those which have proved good that the present account of insecticides and fungicides, and of means of applying them, is drawn up. I shall mention chiefly the spraying apparatus of three establishments, but this is not to be understood as implying that the instruments sent out by others are not also good. I should have been quite as well satisfied to commend the work of any other firm if I had chanced to have the same assurance of its excellence.

I. INSECTICIDES.

Under the head of insecticides I have included substances such as oils, soaps, poisons and the like, which prevent insect

injury by destroying the insects when applied to their bodies, when eaten by them, or which effect the same object by rendering plants obnoxious.

Kerosene.—Ordinary kerosene is excellent both as a repellent and as an insect destroyer. It is especially good for insects, such as bark-lice and plant-lice, which have piercing mouth parts, and so cannot be poisoned. An objection to its use has been that it injured foliage. It will generally do this when used pure, though some plants, it is asserted, will endure applications of the pure oil. The objection is now obviated by the use of the oil in the form of an emulsion, in which condition it may be diluted to any extent with water. The formula for its preparation is the following:

Dissolve one-half pound of laundry or whale oil soap in a gallon of hot water. While this is still hot, add to it two gallons of kerosene, and then pass the whole rapidly through a pump, returning it to the vessel whence taken. Continue this (three or four minutes) until it assumes the consistency and color of thick cream. It may now be bottled and kept until wanted for use. When used, this quantity of emulsion should be mixed with from nine to twelve gallons of water, according to the character of the plant upon which it is to be sprayed. Small quantities of the emulsion may be prepared by shaking vigorously in a bottle, or by the use of an egg-beater.

Pyrethrum.—Under the name "Persian Insect Powder" this material is sold everywhere in drug stores. It is nothing more than the pulverized flowers of a plant belonging to the same family as the solidagos, asters and sunflowers of roadsides and neglected fence rows. The powder most commonly sold is imported from Asia, but the plant (*Pyrethrum roseum*) is now cultivated in the United States, and a related plant, from which an insect powder known as "buhach" is made, is grown in California for commercial purposes. The powder has the advantage over most powders recommended for the same purpose in being perfectly harmless to man and to the foliage of plants. Indeed, it is surprising to find a substance so completely harmless to man and plants having so destructive an effect on insects. The effect it has on the latter is believed to be due to a volatile oil in the powder. This is soon dissipated when the powder is ex-

posed, consequently it is necessary to keep it in a close jar or other vessel to preserve its value as an insecticide. Applied to the bodies of insects, it has commonly a benumbing effect, followed by death, or, if the powder is not good, by complete recovery. If it does not destroy them when first applied, or soon afterwards, it will have no further useful effect, as it becomes perfectly inert when exposed to the air, and insects may then eat it without suffering harm. For use it should be mixed with wheat flour, road dust, sifted ashes, etc., using from two to ten times as much of the flour or ashes as of the insect powder. When used in the form of a powder it may be dusted over plants infested with insects, or, better, may be blown upon them with a powder-bellows, such as is described below. A solution of the powder possesses the same qualities as the dried material. Pyrethrum is best when fresh, and in buying it is to be remembered that powder not kept in air-tight receptacles is not worth using.

Hellebore.—This is a powder sold as white hellebore by druggists, and is the powdered root-stocks of a plant (*Veratrum album*) which grows among the Alps and Pyrenees of Europe. We have in this country a related plant (*V. viride*) from which a similar but less poisonous powder is made. It is applied as a powder, or by spraying, in the latter case three or four table spoonfuls being used in an ordinary bucket of water.

Paris Green.—This is a bright green powder which is valued as a pigment, and beside the above, is sold also under the names, emerald, imperial, mitis and Schweinfurth green. Its properties as an insecticide are due to the presence in it of a compound of arsenic. It was originally tested on the Colorado potato beetle, and is now widely sold as a means of stopping the injuries of this insect, and for protecting orchards from the codling moth. It is a rank poison, a fact to be kept in mind in handling it. In use, it may be mixed with flour, or dust of any kind, and then be dusted on the leaves of plants, but is more conveniently applied suspended in water, by spraying.

The proportion of the powder to be used varies with the character of the plant. One pound of Paris green may be used in from 150 to 200 gallons of water. It must always be stirred while being sprayed upon plants.

London Purple.—London purple also owes its virtues as an insecticide to the arsenic, in combination, which it contains. It is used in the same way as Paris green—suspended in water—in the proportion of one pound of powder to 200 gallons of water. It divides honors with the preceding in efficiency as a protection against the codling moth, and has the advantage of being cheaper.

Lime.—Dusted on the leaves of plants liable to be eaten by insects, lime is often found useful in gardens. It is very commonly used to prevent the gnawing of flea beetles and the striped cucumber beetle.

Carbolic Acid.—In solution this substance has little value as an insecticide when used in the small quantities necessary to avoid injury to plants. Quite recently Prof. A. J. Cook has recommended its use in combination with land plaster as a protection against the plum curculio, and says it is quite as complete a defense as Paris green or London purple. He uses one pint of crude carbolic acid mixed with 50 pounds of plaster, and throws the mixture over the trees so that it reaches all the fruit.

Gas Lime.—This is a waste product in the manufacture of ordinary illuminating gas, and may be obtained at gas factories for the trouble of hauling it away. It has a powerful and sickening odor, but possesses valuable properties for the destruction of root-infesting insects and worms. It is commonly applied to land in the fall of the year, and worked in later. By spring it has lost its caustic properties, and is changed largely to lime sulphate, a condition in which it is thought to be a valuable manure in some soils. In England it is now very extensively used by gardeners, being considered especially valuable as a preventive of the disease known as the "club-root" of cabbage.

Tobacco.—This is an excellent remedy for the injuries of plant lice. In hot-houses it is commonly applied as a vapor, tobacco "stems" (mid ribs of leaves) being the best part of the plant to use for burning. Hot houses or frames may be filled with the smoke for a few minutes without ill effect on the growing plants. A solution of tobacco made by placing stems in hot water, and allowing them to remain there over night, is also very effective for clearing plants of aphides, and has the advan-

tage over the other method of using, in that it can be sprayed out-of-doors. Its harmlessness to plants, its cheapness, and its efficiency, make it the best material we have for preventing plant lice injury.

Bordeaux Mixture.—This preparation has, for some years, been employed in European countries as a preventive of fungus attacks upon grapes. More recently, at the recommendation of the Department of Agriculture at Washington, it has been tried with good effect for the same purpose in this country. From experiments made last summer at this Station, I am satisfied that, besides its value for this purpose, it is also a valuable protection against the injuries from gnawing insects. Not the least of its many valuable properties is the tenacity with which it holds to leaves, thus making unnecessary the frequent applications required of other materials.

A number of recipes for its preparation have been published. That which I have found useful is the following:

Sulphate of copper (blue vitriol, bluestone)	6½ pounds.
Lime	3½ “
Water	32 gallons.

Slake the lime in a part of the water; dissolve the blue vitriol in another part; when cool, pour the blue vitriol solution into the other, stirring meanwhile. The resulting mixture after standing a short time consists of a clear fluid, with a blue precipitate consisting of the greater part of the lime and copper. In using, it must be kept agitated to keep this precipitate in suspension.

Sulphur.—Flour of sulphur is a very useful substance for use against the injurious work of mites, such as the red spider. It is commonly dusted in the leaves of infested plants. It is sometimes recommended that the fumes be employed for similar purposes, but in my own experience it has proved so destructive to plants when so used that I cannot recommend this manner of applying it. If it is desired to apply it by spraying or dipping plants into it, this may be accomplished after first preparing it according to a formula given by Miss Ormerod, as follows: “One pound of flour of sulphur and two pounds of fresh lime boiled together in four gallons of water.”

Water.—It is sometimes possible to relieve plants of insects, especially if these be exposed on the leaves, by thorough and repeated drenchings with water. Mites are especially sensitive to its influence. Plants are much less sensitive to hot water than insects, and may be immersed for a few moments in water heated to 120° F. By dipping plants infested with mites or aphides in such water, the pests can be quickly removed.

II. FUNGICIDES.

I have included here preparations which are intended to ward off or in any way put a stop to the injuries of parasitic fungi. The best of these protect both as fungicides and insecticides. It is quite important in many cases that a preparation intended to avert the injuries of a parasitic plant should be obnoxious to insects, because these latter, by gnawing fruit, afford ready access to the fungi, and may be responsible for most of the cases of invasion. So commonly are the two injuries associated on plums, for example, that it was a very common belief at one time that the curculio was the cause of the brown rot of plums.

Bordeaux Mixture.—This mixture stands first in value for preventing rots and blights of fruit and leaves. It has proved especially good for the black rot and mildews of grapes. The formula for preparing the mixture which I have used is presented under the head of insecticides. Several others have been found useful, of which the following may be given :

6½ pounds copper sulphate.

3¼ pounds lime.

22 gallons water.

Dissolve the copper sulphate in four gallons of water ; slake the lime in two quarts of water. Then add the remaining water to the slaked lime, and pour this into the vessel containing the copper solution, rejecting while doing so the undissolved lumps of lime.

Prof. Galloway, of the Department of Agriculture, recommends a mixture made by dissolving six pounds of copper sulphate in sixteen gallons of water, and in another vessel, slaking four pounds of lime in six gallons of water ; then mixing the two after they are cool.

These mixtures should always be prepared and kept in wooden,

copper, earthen or lead-lined vessels, and if possible all the parts of the pump with which the mixtures come in contact while being sprayed should be of brass. This matter should be looked to in buying a pump for throwing the mixtures. If ordinary nozzles are used, they should be cleaned and oiled at once when through spraying.

The copper sulphate sells in quantity for about eight cents per pound. Lime can be obtained anywhere for less than a cent per pound. This latter, when first prepared, has a caustic property by which it destroys the spores of fungi. It loses this on exposure, and in the mixture seems to act finally as a fixative and preservative for the more directly useful copper.

Poudre Podechard.—This is Bordeaux mixture in the form of a powder. It has been used in France as a remedy for grape mildew. It consists of ordinary lime slaked with a solution of copper sulphate, and then passed, when dry, through a fine sieve. It may be prepared by the following recipe:

Make a solution of lime by slaking eleven pounds of lime in two and a half gallons of water. In another vessel dissolve eleven pounds of copper sulphate in five gallons of boiling water. When cold, mix the two, and with the mixture slake two hundred and twenty pounds of lime placed on hard ground, or in a wooden box. When the lime is slaked and dry, pass it through a fine sieve, and store for use.

Eau Celeste.—This is much used by the vine-growers of France and Italy as a preventive of fungus attacks upon grapes. It would seem to have the advantage over Bordeaux mixture in not marring the appearance of fruit. The subjoined formula for its preparation has recently been published by Charles Whitehead, Esq., of England:

"Dissolve two pounds three ounces of sulphate of copper in four or five pints of hot water in an earthenware or iron [wooden?] vessel. When cold, one and three-fourth pints of ammonia are added. This is then mixed with eighty-eight gallons of water, and the whole is said to be sufficient for sprinkling two and one-half acres of vines.

Sulphur.—Flour of sulphur is a common and useful remedy for several mildews; but, when dusted on leaves, is liable to be blown or washed off again, making necessary frequent applica-

tions. I would suggest that it will probably be found to retain all its qualities as a fungicide when prepared and applied as has been suggested under insecticides—by boiling with lime, and then spraying it upon plants.

Potassium Sulphide (liver of sulphur).—One of the best of fungicides, but more costly than some others. It may be bought in quantity for thirty cents per pound. A one per cent. solution may be sprayed upon plants without danger of injuring the foliage.

Hyposulphite of Soda.—This has been strongly recommended as a remedy for the scabbing of apples. It is prepared for spraying by dissolving one pound of the soda in ten gallons of water. It is injurious to foliage. It sells for about six cents per pound.

Copper Sulphate (blue vitriol, bluestone).—While very good for most of the purposes for which Bordeaux mixture is used, this compound burns foliage very badly, and is not so lasting in its effects as a fungicide. It sells in quantities for about eight cents per pound.

Iron Sulphate (copperas, green vitriol).—This has been recommended for certain parasitic fungi, but seems to be exceedingly damaging to the leaves of plants in any useful strength which I have experimented with. Its price in quantity should be about three cents per pound.

Carbolic Acid.—A good fungicide in its first effects, but its usefulness is soon gone after it has been dried upon leaves, and insects are not then deterred by it from eating sprayed foliage. The crude material is catalogued by dealers at twelve cents per pound or seventy cents per gallon.

INSTRUMENTS FOR APPLYING INSECTICIDES AND FUNGICIDES.

For applying powders, such as pyrethrum, lime, sulphur, ashes, and the like, there is no more convenient and effective device than the powder bellows manufactured by Thomas Woodason, of 451 E. Cambria street, Philadelphia, Pennsylvania. A small bellows made by him, measuring eighteen inches in length, very good for applying powder in small quantities, sells for one dollar.

A larger bellows, measuring about three feet in length, of a

size convenient for dusting garden crops, such as potatoes, sells for four dollars.

For use in hot-houses, hot-beds or gardens, a small spraying bellows made by the same gentleman is an excellent tool. It consists of a bellows with a tin cup for holding the liquid to be sprayed soldered near the tip of the nozzle, so that air forced from the bellows passes over the opening of a tube which extends down into the cup and draws up the fluid to scatter it in a fine, mist-like spray. It is nothing more than a large atomizer, working on exactly the same principles as the small affairs sold by druggists for scattering perfumes or disinfectants in sick rooms. Bellows and cup measure twenty-two inches in length. The list price is two dollars.

The Field Force Pump Company of Lockport, N. Y., sell a small pump which is a very good instrument for spraying shrubbery, small trees, etc., and may even be used for grapevines where only a small number are to be sprayed. A bar with an expanded foot-plate enables one to hold the pump steady while it is used. The pump weighs eight pounds. With "two feet of one-half inch hose, and a tin nozzle and sprayer," its retail price is \$2.50 when made of tin, or \$3.50 when of brass. It will be furnished with longer hose, and any of the nozzles which the company sells, at additional price.

For spraying large orchards or field crops, larger and stronger pumps fixed to barrels or other vessels, though costing more at first, are cheaper in the end. For the use of Bordeaux mixture it is well to get a pump with the parts which come in contact with the mixture made of brass.

A machine made in the form of a wheelbarrow by the Field Force Pump Company is well adapted to spraying grapevines, potato patches, and small plots of almost any crop. Mounted in a wagon, it may be used for most of the spraying called for on a farm. It is one of the most generally useful of the machines sold for work of this kind. It is in size 35x14x22 inches, "holds 40 gallons; is mounted on two strong iron wheels, with tires 2½ inches wide; total weight 175 pounds." With three feet of hose and a "boss" nozzle, this machine is catalogued at \$20. Those buying this outfit for spraying will do well perhaps

to get the graduating spray nozzle, and at least ten feet of hose with it.

A machine very similar to the preceding, and adapted to the same work, is made by the Nixon Nozzle and Machine Company, of Dayton, Ohio. It holds forty gallons, is mounted on iron tricycle wheels, and is provided with an "agitator" for keeping the poisons in suspension. It is sold, with sixteen feet of hose and two nozzles for \$35.

The Climax Pump No. 2, made by the Nixon Nozzle and Machine Company, is one of the best and cheapest pumps made for orchard spraying. It is made of iron and brass. The legs are made of gas pipe, and screw firmly into the base. This pump, with four feet of suction, and sixteen feet of discharge hose, and with two nozzles, is sold for \$15. An "agitator" costs \$1.00 additional. No vessel is furnished with the pump; but it may easily be connected with an ordinary kerosene barrel.

Another outfit of similar grade with the last is represented. It is the "Perfection Spraying Outfit," made by the Field Force Pump Company. The pump and attachments, ready to be fitted to a barrel, with ten feet of discharge hose and a graduating spray nozzle, is catalogued at \$12. An excellent feature of this pump is three foot of hose so attached to the pump that with each stroke of the handle a quantity of the fluid is sent back into the barrel with force enough to keep the poison well stirred up.

The Gould Manufacturing Company of Seneca Falls, N. Y., make a good pump of about the same grade as the two just mentioned. It is furnished with two discharge pipes, one of which may be used to keep the poisons in suspension. This "Double Acting Spraying Pump," with brass cylinder and piston, sells for \$14.

The "Eureka Sprayer," made by Adam Weaber & Son, of Vineland, N. J., is constructed with especial reference to spraying the preparations containing copper sulphate upon grapevines, and is very efficient for this purpose. "It consists of a copper tank (capacity six gallons) to be carried like a knapsack. Within this tank is an air chamber, with pump inside of it, made entirely of brass. The elasticity of air in the chamber maintains a continuous discharge of liquid from the spraying nozzle. This machine is so made as to be not liable to corrosion

from the mixtures used." When filled with water, its weight is sixty-four pounds, and it is claimed that five acres of grape-vines, or one acre of potatoes, may be sprayed with it in a day. With fittings for ordinary spraying, its price is \$21.

The most complete outfit for spraying with which I am acquainted is the "Victor Spraying Apparatus," made by the Field Force Pump Co. It consists of a tank, pump and fittings, which can be mounted on any wagon. Without the tank the apparatus weighs one hundred and fifty pounds. A wooden tank, which they furnish if desired, weighs 116 pounds, and holds 115 gallons. The pump is worked by a mechanical contrivance, consisting of a cogged wheel fastened to the wagon wheel, another smaller cogged wheel which runs upon the first, and thus turns a crank-shaft which operates the pump. The hands of the one using the apparatus are thus left free for driving and handling the hose. The price of this outfit, without the tank, is \$30.

It is very important that the nozzle used in spraying should be simply made, should furnish a fine, even, and, when desired, widely-distributed spray, and should be so constructed that particles which may clog the apertures can be quickly removed.

Several nozzles now on the market meet these requirements perfectly. The best of those of which I have personal knowledge are the Nixon nozzles, made by the firm at Dayton, Ohio, and the Graduating Spray Nozzle, made by the Field Force Pump Company, of Lockport, N. Y. The retail price of both nozzles is \$1. The Nixon nozzle depends to some extent on the coarseness of the wire screen at the end for the character of its spray. The outer part of the nozzle bearing the wire screen is easily removed, so that there is no difficulty in getting rid of particles which may interfere with the passage of mixtures used. The character of the spray thrown by the graduating spray nozzle can be regulated by simply turning the outer part of the nozzle. If clogged, it can, by the same mechanism, be opened in a moment to permit the escape of particles.

The "Vermorel Nozzle," also sold by the Field Force Pump Company, appears to me to be one of the best, but I have had no experience in its use. Its retail price is \$2.00.

IV. TREATMENT OF ORCHARDS FOR INSECT AND FUNGUS ATTACKS.

Within the past few years a means of preserving apples, plums and cherries from the attacks of insects has been brought into use to the great pecuniary advantage of orchardists. It is now possible by spraying with London purple, or Paris green, to save the greater part of the fruit, which has been for years lost from the burrowings of insects. I believe that similar benefit will result from spraying for rot and blight fungi. The time and expense which this treatment of fruit trees costs is no longer an objection to spraying. With an oil barrel, a force pump and a few feet of hose, a large orchard can be gone over in a couple of days with trifling cost.

The Time to Spray.—The spraying with London purple or Paris green should be done soon after the fruit has "set," and a second spraying should follow for late apples, in from two to three weeks. One spraying should suffice for early fruit. Never spray with London purple or Paris green late in the season, or near the time of ripening of fruit.

Spraying with these poisons will serve in the early part of the season for both insects and fungi. Later in the season the rots may appear if nothing is done to prevent. For early fruit I would advise a single spraying with the Bordeaux mixture mentioned under insecticides and fungicides above. Late fruit should be sprayed twice during the summer with this mixture. In the case of one or two trees of special value, it may sometimes be well to make more frequent applications.

How to Spray.—The spray should be as fine as possible—a mist so fine that it will reach every part of the foliage, as well as the fruit. From a gallon to a gallon and a half of fluid is enough for most orchard trees. It should not take more than a minute to spray one tree. For convenience in getting the fluid over the trees, spray from the windward side. If the trees are very tall and large, it will be well to fasten the nozzle to the end of a pole so that it can be elevated. Keep the fluid well stirred while using, else the last used will be so strong as to do injury, and the first may not be strong enough to do good.

Danger to Stock in Sprayed Orchards.—It is just as well to keep stock out of orchards for a few days after spraying the

trees; but, really, there seems to be small danger from allowing stock the run of an orchard at all times. Prof. Cook has even cut the grass under sprayed trees, and fed it to his horse. If the spray has been properly applied, very little of it drops from the leaves afterwards.

Danger to Man from Sprayed Fruit.—It has been shown, both by experiment and by practice, that there is no danger to be apprehended from eating fruit sprayed, either with the compounds of arsenic, or with Bordeaux mixture.

Removal of Bordeaux Mixture.—A more serious objection to the use of Bordeaux mixture on such fruit as grapes is the fact that it adheres, if applied late, so as to affect the market value of the fruit. As I have suggested above, this may be obviated largely by avoiding late applications of the mixture, and, where necessary, using carbolic acid instead.

However, it has recently been shown at the Delaware Station that the mixture can be easily removed by suspending fruit in a tub of water to which has been added a couple of quarts of cider vinegar.

Some other Precautions.—In addition to spraying, it will be wise in combating the rot fungi (*Monilia* and *Gloeosporium*), so injurious in this State, to see to it that all waste fruit is destroyed. The refuse from cider mills, and the imperfect fruit under the trees, should always be given to the hogs. All through the winter one may see upon apple trees shriveled fruit, which was rotted by these fungi the preceding season. These apples, and others which lie upon the ground, convey the spores of the rot fungi to the growing fruit. They should, of course, all be destroyed.

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