CAN the cotton boll weevil be controlled profitably? If you are a cotton raiser there is hardly anything you would rather know. An affirmative answer to the question, eagerly sought ever since the weevil invaded this country, has at last been found. The weevil can be controlled by means of a calcium arsenate dust, if the dust is applied at the right season, at the right intervals, and in the right way. This may sound hard, but it isn't. All it means is that the job must be done right. It is no good to build a house and leave the roof off; if you are not going to make a complete job, it will not pay to start.

The method now recommended by the Department of Agriculture for poisoning the weevils is the outgrowth of a long series of experiments. The first announcement of success in weevil poisoning was made by Prof. Wilmon Newell and Mr. G. D. Smith as a result of experiments conducted with powdered lead arsenate in Louisiana during the season of 1908. The farmers, however, did not adopt this method, and experiments conducted by the Department of Agriculture during the next few years gave such variable results that definite recommendations could not be made regarding it. But as a result of technical experiments by the author in 1913-14, the problem was attacked from a new angle; in new field tests the poison used and the methods of application were changed, and striking results were obtained. More ex-
haustive studies followed these experiments, and it was found possible by poisoning to reduce the number of weevils sufficiently to keep them under control. It was also found, however, that this control usually did not last long after the poisoning was stopped, and, furthermore, that the weevils were merely reduced in number—never exterminated. Applications of poison made early in the season, with the view of killing the hibernated individuals and thus preventing their multiplication, were not profitable, and far better results were obtained by poisoning later in the season. Apparently enough weevils survived the early-season treatment to keep up the infestation. The poisoning period was therefore deferred to a time, later in the season, when the plants are fruiting more heavily and are better able to take advantage of a short period of protection.

Free Fruiting of Cotton Favors Poisoning.

The cotton plant puts on much more fruit than it can mature, and about 60 per cent of the squares which are put on are shed. This shedding varies as the plant develops, starting with a fairly light shed early in the season and increasing until it reaches the point where all new fruit is shed. Up to a certain point, shedding due to boll-weevil injury merely takes the place of this natural shedding, and thus a certain amount of weevil activity can be permitted without any loss of crop.

With these facts in view, the poisoning of the weevils is begun just before they become abundant enough to offset this natural shedding of the plant, and is continued long enough for the cotton plants to put on a crop of bolls and develop them beyond the danger of weevil injury. Then poisoning is stopped and the weevils are allowed to multiply unchecked.

The most serious obstacle to bringing about the general adoption of such a system of poisoning is the difficulty of giving explicit instructions regarding the best time for starting and for stopping poisoning. Arbitrary rules can not be established. Conditions vary from field to field and from season to season. Probably it will never be possible to give instructions for poisoning which will not leave much to the
discretion of the individual; but continued use and the adoption of local practices which most nearly fit local conditions will overcome this drawback in a measure.

Increasing Success with Dusting.

The fact having been established that weevil control was possible, it became necessary to make it both profitable and practicable under farming conditions. This has meant development of the methods of dusting and improvement of the material utilized.

From 1915 until 1917 the department's experiments consisted entirely of small-plat tests of different methods of poisoning, the results in each case being ascertained by careful comparison with those in plats of unpoisoned cotton. These experiments resulted in rapid improvement in dusting methods until uniform gains of from 250 to 1,000 pounds of seed cotton per acre were obtained from the tests.

The first really practical work on an extensive scale was undertaken in 1917, when several hundred acres of cotton on one plantation were poisoned late in the season with profitable results. This experience led several owners of large cotton plantations to undertake poisoning work on their entire properties in 1918, the work being supervised by experts of the Department of Agriculture. During that season about 35,000 acres were included in the experimental work, and the results on the whole were profitable.

Following the success of 1918, the department issued its first publication on poisoning, which aroused interest among the farmers in several localities. As a result some 3,000,000 pounds of poison were used for weevil control during the summer of 1919, the work of the department during that season involving about 75,000 acres. Again results were favorable and interest in the poisoning spread rapidly among cotton growers.

Dust Every Four Days.

In the earlier work poison was applied every seven days, but it has since been determined that an interval of approximately four days is much better. As the primary aim in poisoning is to keep the cotton thoroughly poisoned from the first application until the weevils are under control, weathering and plant growth make it necessary to repeat the applica-
tions about every four days. The poison reaches only the adult weevil and has no effect on the immature stages, protected as these are within the squares and bolls. These would produce weevils daily for about two weeks after the first application was made, even if no eggs were laid after the first application. When the applications are seven days apart a sufficient number of weevils emerge, escape poisoning, and lay their eggs to perpetuate the infestation; but by keeping the cotton continuously poisoned it is possible not only to kill the adults present when the first application is made but also to destroy the majority of their progeny.

It is generally found in the field that about three applications at the short-time interval of four days will reduce the number of weevils below the point of danger.

Raise a Cloud of Dust, and Let It Settle.

Any attempt to blow the poison directly onto all portions of the cotton plant is out of the question. Fortunately, however, this is neither necessary nor desirable. Technical studies indicate that most of the weevils are poisoned not through their feeding but through their habit of drinking moisture from the surface of the plant. Therefore the
Killing Boll Weevils With Poison Dust.

Weevils will be killed if the fine powder is caused to settle on all portions of the cotton plant that may retain moisture, and this is accomplished by the dust-cloud method of application. The poison is blown out in such a manner as to form a dense cloud of dust, which drifts through the plant and covers all exposed surfaces.

Night Applications Best.

Practically all poisoning work must be done at night. The plants are unusually moist at this time and thus retain the poison better; furthermore, atmospheric conditions at night are such that the dust cloud will remain over the plants and settle upon them, whereas during the day it is likely to rise above them and drift away. On occasional days, of course, the plants are moist and the air is calm, but as a rule satisfactory dusting conditions occur only at night.

Use Calcium Arsenate.

At the outset of the work powdered arsenate of lead was utilized for poisoning. As the grades of this arsenical which were then standard did not give the requisite degree of weevil control, an improved grade was prepared. This gave fair results, but it was still not thoroughly satisfactory.

Calcium arsenate was then tried and was found to be far more poisonous to the weevil than any form of lead arsenate, a better material for dusting, and far cheaper. The calcium arsenate first used, however, burned the cotton plants seriously, owing to the presence of too much water-soluble arsenic oxide. Improved methods of manufacture have eliminated this difficulty. Calcium arsenate containing different proportions of total arsenic were tested, and it was found that the product containing from 40 to 42 per cent total arsenic pentoxide gave very satisfactory weevil control and could be made so as not to contain too much water-soluble arsenic.

It is important that the material have the right physical properties, especially those which make possible the best dust cloud with the least possible material. Eventually a material bulking 80 to 100 cubic inches per pound was selected as most satisfactory for this work.
Getting a Good Dust.

Prior to 1918 only one manufacturer was producing calcium arsenate, and this in very limited quantities. In 1919 about a dozen more manufacturers undertook its production, and in 1920 the number was increased to at least 25. Unfortunately, calcium arsenate proved not so easy to manufacture as was anticipated; and with so many new producers making it the quality of the product was naturally exceedingly variable, especially since it might be unsuitable in three different ways: First, it might contain too much water-soluble arsenic and thus injure the cotton plant; second, it might not contain sufficient total arsenic to control the weevil; third, the physical properties might be such that it could not be satisfactorily dusted on the cotton plant.

To give the farmers as much protection as possible, all purchasers of calcium arsenate have been invited to send samples to the department, at Tallulah, La., for analysis. More than 2,000 samples have been analyzed, and the farmers have been advised as to whether their material was satisfactory for use for boll-weevil control. In addition, the Federal Insecticide and Fungicide Board has devoted considerable attention to sampling the larger shipments of calcium arsenate, and wherever these have been found to be made up of unsuitable material they have been seized and condemned. On the whole, this has resulted in a fairly thorough degree of protection to the farmers, and much calcium arsenate which could not have been used safely has been eliminated from the market, although on several occasions unsatisfactory material was used before it was possible to detect it. It is hoped that this difficulty will soon cease to exist, and the improved quality of the material sold during the latter part of the season of 1920 indicates that the majority of the manufacturers have now had sufficient experience in the making of this chemical to turn out a very satisfactory product. Owing to the rapid development of this industry, however, the material on the market still requires careful inspection.

Dusting Machines.

Suitable machinery for dusting is highly important. The original plat tests were conducted with hand "guns," but as
soon as practical control work was started it became necessary to have equipment of larger capacity. The first machines used were adaptations of types then on the market, but it was soon found that they were unsatisfactory and it became necessary for the department to organize a mechanical branch. This was done by the Bureau of Entomology and the Division of Rural Engineering of the Bureau of Public Roads working together.

On account of the large area under treatment at that time, the first machine developed was a gasoline-power duster. Gas engines proved unsatisfactory, however, owing to night operation and the quality of labor available for running these machines. Another difficulty at that time lay in the feeding of these machines, for it was found impossible to dust an acre of cotton with less than about 15 pounds of material. Improved feeding devices were therefore developed, capable of delivering any desired quantity of material per acre, and thus permitting the use of the desirable dosage of 5 to 7 pounds per acre.

To avoid the use of the gas engine, experimental models of machines which derive their power from the wheels were built and found to be very satisfactory. Blue prints showing all details of construction of a machine of this type were furnished all interested manufacturers. As a result several hundred machines of this type were distributed during 1920, and at present a half dozen or more manufacturers are building machines based on this design.

Hand guns, on the whole, have proved decidedly unsuited to extensive weevil-poisoning work. Notwithstanding every effort to improve existing models, the hand gun has two great drawbacks—laboriousness of operation and lack of durability. Of course such machines will always be of use on very small areas or where, owing to stumps, roughness of ground, or other conditions, the operation of a larger machine is impossible.

Following the development of the cart duster, the need of a smaller and cheaper machine became very apparent, and during the 1920 season the department worked on the development of a one-mule type of machine which will meet the needs of small farmers. It is expected that this machine will be comparatively cheap and will dust about 50 acres of cotton
during the season. Experimental models of such a machine have proved satisfactory, and several manufacturers are becoming interested in its construction for the 1921 season.

In addition to these standard types of machines, several other models are now being developed. For example, at the suggestion of the department some manufacturers have undertaken the construction of a two-row machine to be carried on mule back. Other designs include machines modeled somewhat on the order of the hand gun but carried by two men; and still others will undoubtedly be forthcoming soon, as is desirable.

All machines designed and developed by the department engineers have been covered by patents dedicated to the public. These designs are then available for any manufacturer or individual who cares to utilize them.

The mechanics of the department have also served in an advisory capacity for manufacturers engaged in the production of dusting machines and have assisted in every way possible in making these designs satisfactory. In the same manner the farmers have been assisted by advice regarding the best type of machines for the conditions under which each man is trying to poison.

**Poisoning Schedules for Each Locality.**

In the interest of the best experimental work, all the earlier experiments were conducted in one district, the Mississippi Delta. This was unfortunate in a way, for although detailed information could be given regarding the poisoning methods best adapted to that district, these methods do not necessarily apply in other localities. The work has therefore been extended as rapidly as possible and substations established in many representative districts throughout the cotton belt. The simultaneous collection of data at many points, at each of which conditions differ radically from those elsewhere, will permit the preparation of schedules for poisoning more nearly adapted to each locality. At each of these stations plat tests of weevil control were conducted during the 1920 season, largely with the view of determining the margin of profit for operation at these different points. It is already apparent that profitable gains from poisoning may be looked for in the Alabama black belt, southern Louisiana, eastern Georgia, and southern South Carolina.
Yields of Poisoned and Unpoisoned Cotton.

Above: Dividing line between poisoned and unpoisoned cotton in check-plant work conducted near Tallulah, La., during the season of 1920. Neither plat has been picked. The poisoned plat produced over 500 pounds of seed cotton per acre more than the unpoisoned plat.

Below: Piles of cotton showing difference between yield of poisoned and unpoisoned cotton in commercial poisoning work in the Mississippi Delta during 1920. This farmer left 3 acres of a 10-acre cut unpoisoned, and the piles were picked from a quarter acre each of the poisoned and unpoisoned cotton. The increase of seed cotton per acre due to poisoning was over 900 pounds.
Success and Failure in 1920.

The large-scale poisoning work under the supervision of the department was still further extended during the season of 1920, especially to embrace additional districts. Seasonal conditions made the experiments of that year particularly interesting. The mild winter of 1919–20 permitted the emergence of an unusually large crop of hibernated weevils in the spring of 1920. Following this, the excessive and frequent rains which were almost universal caused a rapid multiplication of weevils. In addition, the spring of 1920 was so unfavorable to planting that the cotton crop was from two to four weeks late. These conditions combined produced an unusually heavy damage by the weevil, probably the heaviest in the history of its activity in this country, a fact which gave large margins for gains from the poisoning work, though this advantage was more or less offset by the difficulty of operation in the face of the almost incessant rains. On the whole, the conditions were decidedly against poisoning, yet the gains from poisoning were more general than ever before, and these gains as a rule were larger than usual.

During this season 10,000,000 or more pounds of calcium arsenate was sold for cotton dusting. Evidently a large number of farmers attempted poisoning. Their operations extended from southern Texas to South Carolina, but only in separate localities or sections, poisoning being a recent development and still unknown to a majority of the cotton farmers.

Early in the season it became apparent that the suitable dusting machines would fall far short of the number required. As a result many farmers bought calcium arsenate with little or no likelihood of being able to obtain machines for applying it. Furthermore the shortage of other machines gave a great opening for the sale of hand guns, which were available in rather large numbers. The only types of machines to be had were the hand guns and the large cart dusters. The latter were selling at from $300 to $500 and were therefore out of reach of the farmer who planted less than 100 acres of cotton; consequently many farmers tried hand guns on entirely too large a scale. Not more than
Killing Boll Weevils With Poison Dust.

8 acres of cotton can be treated throughout the season with a hand gun. Furthermore, owing to the inadequate supply of labor and the reluctance of plantation hands to operate these guns for any length of time, it is ordinarily impracticable to use them on more than 25 acres in one organization. In spite of this, many farmers purchased one hand gun for 40 acres or more of cotton, and in other cases several hand guns were purchased for very large areas. Naturally, many failures resulted.

A survey has been made to determine the degree of success attained by the farmers in the different districts, and also to determine the cause of the failures. The results are interesting. In many districts success was general, in some a few individuals succeeded while the rest failed, and in others weevil poisoning was almost invariably a failure.

Reasons for Failure.

A careful scrutiny of the methods of application used showed that an unfortunately large number of farmers had in no way approximated the recommended methods. In many cases they had applied the poison only once, in others they had tried two applications from a fortnight to a month apart. Other farmers, with hand guns, attempted to dust areas so large that it was impossible to cover them, and so gave it up in disgust. The one saving feature of the situation was that in practically every case in which recommended methods of application were used the results were at least fairly satisfactory.

The failure of many farmers to follow the proper method in dusting seems to have been due usually to lack of information, or at least to lack of correct information. Poisoning, when done as recommended, is an expensive operation, but some salesmen have tended to minimize its cost and its difficulties. For instance, if the salesman had an idea that the farmer would not try poisoning if told that it would be necessary for him to make three or more applications, he would affirm that one application would control the weevil. If the farmer showed disinclination to buy more than one hand gun he was often informed that this would quite suffice for treating whatever area he had in cotton, whether 10 acres or 50 acres.
These conditions, of course, will be remedied rapidly, but unfortunately they have served unwarrantably to discourage many men and undoubtedly have led to a number of losses. Fortunately the smaller machine adapted for the small farmer will be available for use in a short time, so that it will no longer be necessary for him to depend upon hand guns.

Many failures were evidently caused by the use of unsuitable calcium arsenate. In some cases the total arsenic content was so low that it would not kill enough weevils to secure control. Furthermore, a considerable quantity of calcium arsenate sold to the farmers was sandy or granular, not ground finely enough, so that instead of drifting through and remaining on the cotton plants it failed to adhere and fell to the ground. With such material it was almost impossible to secure any weevil control.

One important cause of failure is carelessness of operation. All publications on weevil poisoning have thoroughly explained the fact that the operation is useless unless thoroughly done; and since the method is so entirely new to the laborer, it is futile to hope for satisfactory results from equipment turned over to tenants for operation without any instruction or supervision.

Some farmers, having made one or two applications of poison on the cotton and, upon examination, finding live weevils still present, have become discouraged, inferring that the work was useless, and have discontinued it. No matter how poisoning is conducted, it is always possible to find live weevils in the field, and their presence in no way precludes obtaining a full crop of cotton and a very good profit from the poisoning operations.

Do it Right or Not at All.

To recapitulate, the results of poisoning in 1920 were exceedingly variable. While there were many failures, there were many more successes, and on the whole the experience of the season showed more plainly than ever that it is possible to control the weevil if the work is done properly. It emphasizes the repeated advice of the department, "Do it right or not at all."