實業部中央農業實驗所

特刊 第七號 • Special Publication No. 7. • 民國二十三年十二月 • Dec. 1934

DIRECTIONS FOR COTTON IMPROVEMENT IN CHINA

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中國棉花改良法

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PUBLISHED BY
THE NATIONAL AGRICULTURAL RESEARCH BUREAU
MINISTRY OF INDUSTRIES
NANKING, CHINA

實業部中央農業實驗所印行
所址 南京孝陵衛

實業部中央農業實驗所刊物目錄

Publications of the National Agricultural Research Bureau
Ministry of Industries

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DIRECTIONS FOR COTTON IMPROVEMENT IN CHINA

H. H. Love[1]

Introduction

Since cotton is one of the chief crops of China and since not enough is produced by the country to satisfy the needs for manufacture, it is important that steps be taken to improve the yield as well as the quality of lint. There is no doubt that cotton production can be increased by the utilization of land that is now devoted to growing other crops and by the reclamation of certain areas. In replacing other crops with cotton, however, it is important to keep a proper balance between the different crops so that the supply of foodstuffs will not be seriously affected. While it is possible that some increase in total production can be obtained through the use of reclaimed land and other land, yet it is necessary that every mow now planted to cotton be made to produce a larger crop.

With cotton there are two important considerations. One is the increase in total production, and the other is the production of better types to meet the market demands. There are different ways to bring about an increase in production such as through better cultural methods and the improvement of the soil, but it may be expected that the greatest increase will come as the result of obtaining better seed for the important cotton-growing regions.

Better seed can be obtained in two ways: first, by finding, through extensive varietal or regional tests, varieties that may be better adapted to a particular region than the varieties now being grown; second, by producing better types as the result of plant breeding.

There are two important methods for developing better varieties by means of plant breeding: one is that of selection and the other that of hybridization. While some increase in yield may be brought about as the result of better cultural methods and improved soil, such methods will have little effect in producing better quality, such as longer lint, higher quality of lint, and the like. For this it is necessary to depend either upon obtaining a new variety as the result of variety trials or, better, upon producing the desired type by applying the methods of plant breeding. Since it is a well known fact that, when the proper methods of plant breeding are carefully followed, it is possible to improve the yield or quality or both of any crop it is the purpose of this paper to discuss the methods of crop breeding that may be applied to cotton.

[1] The author desires to acknowledge the assistance rendered by Mr. Y. S. Chen, Technical Assistant, National Agricultural Research Bureau, who has aided in the preparation of some of the Tables.

Errata

page 11 - third line from bottom: "and so *on*"

page 23 - at head of first column: ***10***

page 30 - line 8: "amount of land in accordance with the number of strains one has ***to test***"

second line from bottom: ***8.64*** instead of ***8.62***

bottom line: ***7.04*** instead of ***7.74***

page 35 - second column: = ±.6745 302.8

數字勘誤

1. 第二十三頁第三表第二縱行之第一格應加「10」字

2. 第三十頁第五表自下至上第一橫行之第一縱行「六行區」應改為「七行區」第五縱行之「7.74」應改為「7.04」

又同表自下至上第二橫行之第三縱行「8.62」應改為「8.64」

1. 第三十五頁第六表A右首第一行 P. E.M 之中文應為「平均誤差」非為「平均成差」

又右首第六行應為±.6745 302.8 原文缺一「±」號。

Better Varieties

What is meant in connection with the question of better varieties is that of attempting to find some variety that may already be in existence that would be better adapted to a particular region than those varieties already grown in that region. Cotton is grown in China over a wide area and under very different soil and climatic conditions and, as a result of these environmental differences, different sections of the country require different types for growing.

In the hope of finding superior varieties, a considerable amount of seed of various foreign types has been introduced during the last twenty-five or thirty years and, in some cases, perhaps for a longer period; but, even so, there is not now sufficient definite information to answer satisfactorily the question as to what type is best for a particular cotton-growing area. In some cases it has been determined that either Chinese or foreign cotton is better but, for the most part, the information that is available is not based on sufficient evidence to enable one to decide this question for all sections of the country. Where it is possible to say that the Chinese or foreign type is the better, it has not been definitely determined which particular variety in either case is the best for the community.

Since this is a fact, one of the first steps in cotton improvement for any particular region is that of determining, first, which is better adapted for the locality, the Chinese or the foreign type; and, second, which particular variety of the adapted type is the best. This means that it is desirable for the investigators at the cotton stations to conduct a thorough variety test in which they will include different varieties of Chinese and foreign cotton. Such a test must be conducted on a large enough scale and for a long enough period of time so that the results will be conclusive and satisfactory. The final decision as to which variety is the best should be based on the quality of lint, including length, strength, and other desirable characteristics, and on the yield per mow. One cannot depend on judgment alone. It is necessary to have careful notes and to have the test so conducted that the results from the yields are satisfactory. This means that all varieties should be treated in a similar manner so far as testing in the field is concerned and that each variety should be replicated in the field a sufficient number of times to give reliable results.

The methods of testing will be discussed later but, as a result of such a well-planned and well-conducted test, it will be possible for each investigator to determine what variety is best for the locality in which he is working. The best seed of this variety should then be obtained and distributed to the growers to be used until such time as other better improved varieties are obtained as a result of the processes of plant breeding.

Cotton Improvement

For more permanent results and for larger increases with respect to yield and quality it is necessary, as already indicated, to depend upon the methods of plant breeding to develop better varieties for particular cotton-growing regions. The first method to be discussed and the one that, for the present, is the more hopeful as far as China is concerned is that of selection.

Making Selections — Selection is a very hopeful method for the improvement of the yield and quality of cotton. By selection we mean that one would select plants or bolls from fields of those varieties which one has reason to believe are adapted to the locality where he is working. If one has already found a variety that is especially adapted to his region it will be desirable, if it is not a pure strain, to plant a large field from which individual plant or boll selections may be made.

The best method of making these plant or boll selections is to have access to many fields early in the season so that one may study the development of the plants and mark for selection those plants that seem to be the most desirable. In deciding which plants to select one should pay attention to the growth habit of the plant as some plants tend to develop more vegetative branches than fruiting branches, and some plants may develop into strong vegetative plants but produce very little cotton. This is true with all types of cotton, but it is especially true with certain of the Chinese types where there is a tendency for some plants to grow very tall and yet produce very little cotton. The inexperienced cotton breeder may be misled by such vigorously-growing plants and might select these with the idea that they will be better than some of the smaller plants.

If it is possible to have a number of fields from which selections may be made and to study the plants through their early development, it will be possible to designate those plants that are to be selected by marking them with bamboo stakes or some other cheap material or by tying pieces of cloth to the top of the plant. As the holdings of the Chinese farmer are small, it will not be possible to make plans to select a larger number of plants without making special arrangements with the farmer to pay him for the loss that may be incurred by taking the seed of these selected plants out of the field.

One of the important points in connection with selecting these plants early is that there is likely to be a considerable amount of natural crossing in the field since cotton is a plant that crosses very freely. If arrangements can be made to select the plants early and mark them, it will be possible to self the flowers and, in this way, obtain purer seed than will be the case if the plants are allowed to cross.

There are different methods to be used for selfing. While cotton is readily adapted to open pollination, it will also set seed when self-fertilized; and results have indicated that several years of self-fertilization do not cause any deterioration of the plant or any loss of vigor in growth or production. Since crossing is largely the result of pollen being carried by bees, wasps, and other such insects, selfing may be accomplished by covering the flowers with paper bags before they open or by covering the plant with cloth which is thin enough to permit the passage of air, although this latter is not so satisfactory as the use of paper bags. The method that is most generally used is that of holding the flower closed by wrapping wire around the tip of the flower before it opens or of holding it closed by means of paper clips. This latter method has been found to be very satisfactory. Since the flowers have to be tagged to know which ones are selfed, the tags themselves may be used for selfing by making a slit in the middle of the tag and slipping it over the end of the flower. This accomplishes selfing and tagging at the same time.

The advantage of being able to select these plants in the field and self them is two-fold: one is that one may gain practically a year's time by starting with plants rather than with individual bolls; and the other is that he may start with purer seed than if he starts by selecting bolls or plants from a field where cross-pollination has not been prevented.

Since it is important in all selection work in plant breeding to have a large number of individual selections with which to begin work, it may mean that - by selecting the plants in a few fields and selfing them - one will be limited as to the number with which he starts his work the first year. It should be kept in mind that a large number of individuals is important; pure seed and more seed from each individual are also important factors, so what one needs to do is to obtain as many selfed plants as he can.

It may not be possible to follow the method just suggested in all cases; and, if not, it is necessary to make plant selections if possible (if not, boll selections) from the fields of those varieties which previous experience or knowledge indicates may be adapted for a particular region.

In order to have material of different types, it is desirable the first year to make some selections from a different number of localities; but, in general, one should select only from localities that are similar in general environmental conditions to the region for which he is planning his work. As already stated, a large number of selections should be made. In answer to the question, how many, it may be stated that the number should be as large as possible considering the land and funds that are available for such work. It is not possible to name any definite number, but it should be stated that if one plans to begin by making only a few selections, such as forty or fifty, it is hardly worthwhile to undertake work in cotton improvement.

The selections should be made, as far as possible, by someone trained in the work. Inexperienced assistants should not be sent out to make selections unless they have been given thorough instruction as to the types to select and as to what constitutes good cotton fibre and the like. It is always better for the investigator in charge to make the selections himself or to accompany his assistants. Much information will be gained by the investigator while visiting the different cotton regions for the purpose of making these selections. He will obtain a better idea of the types that are grown, and he will learn more about the farmers' problems in connection with cotton improvement.

If the first method suggested can be followed for making these selections (that of selecting the plants early in the season, marking them, and then selfing them), it will be very satisfactory provided it can be done on a large enough scale. If this method cannot be followed and it is necessary to select bolls, then at the time when the selections are to be made one should equip himself with a sufficient quantity of bags and tags so that the bolls or plants that are selected from a particular region may be kept separate. That is, if one makes a collection of varieties near a certain village, it is desirable to designate the location by naming the village. This has two advantages. One is that it gives the investigator a knowledge of the type of cotton grown in a particular region; and the other is that, if he should obtain some unusual types from a particular region, it will be possible to go back again to make other selections.

When making the selections one would select from different fields, and the question may arise as to how many individual bolls or plants should be selected from an individual field. There is no definite number that one should endeavor to get. The point is that so far as possible a good many samples from the representative type should be obtained, provided the type is a good one; and, if there are any new or unusual types, such as an individual outstanding plant, seed from such individuals should also be saved. If time permits while making these selections, it is desirable to examine the lint, even combing it out if possible. At least one will have time to pull out some of the fibres and obtain a rough idea as to the length and quality of fibre. There is no need to select plants of inferior quality as they would naturally be discarded later. When making selections from the field, it is desirable to select from all parts of the field, and one should not make selections from the best part of the field only. It may well happen that a plant that yields fairly well in an unfavorable part of the field may be just the type that one is seeking. In another part of the field where the fertility is better one might obtain a plant that yields twice the amount of the particular plant in the poorer part of the field, yet from the standpoint of heredity this plant may not be so desirable as the plant that yields fairly well under unfavorable conditions in the poorer part of the field.

When making the selections in the field, one needs to observe the type of plant, such as its branching habit and quality of lint, and to select plants that are free from disease, or as free as possible. It is also important to select plants that hold the cotton tightly in the bolls and do not shed. There seems to be a considerable difference among varieties and types as to the shedding habit, or the dropping of the cotton after the bolls open. This is an undesirable character as it means that the cotton that drops on the ground is apt to get wet and full of dust and dirt and, if it is added to the picked cotton, it renders the sample less desirable.

Care of Seed — In handling the bolls that have been collected it is important to be sure that the seed is properly dried. If it is possible to make arrangements to select a lot of individual plants near the station grounds, the bolls from each plant will be saved separately in paper bags or envelopes or some other suitable container and a special number will be given to the bolls coming from one plant or to the bolls themselves, where bolls have been selected. Care should be taken to see that all the bolls are thoroughly dried, which can usually be accomplished by thorough sunning. Unless this is done, there is danger of some of the seed molding which will result in low germination.

When collections are made from fields far removed from the station grounds, it may be necessary to carry the collections back or to send them back to the station by mail. When such handling is necessary, it is very important that the bolls be thoroughly dried so that they will not mold. Since the Chinese farmer, at least in many places, picks his cotton very frequently, it may often be necessary to pick bolls that are just opening. This will mean that they contain a considerable amount of moisture and, for this reason, the greatest care should be taken to insure that the bolls are dried thoroughly if possible before the seeds are packed for shipping or they may be spoiled.

As soon as the selected bolls arrive at the laboratory it is desirable to make certain that they have been thoroughly dried and, even so, it is always desirable to make sure that they are kept dry, and this may be accomplished by frequent exposure to the sun. It will usually be found convenient to use a paper bag for the bolls from one plant and if, in drying, it is necessary to remove the bolls from the bag great care should be exercised to see that the bolls are not mixed while being dried and that they are replaced in the proper bag. If small cloth bags are used, the drying may be accomplished without removing the bolls from the bag or even opening the bag.

Laboratory Study and Seed Preparation — As already stated, it is desirable to make as careful study as possible of the quality of the lint while making the selections. Usually, it is not possible to make as thorough study in the field as one would like, and therefore it is desirable to make a laboratory examination of the material. At some cotton stations a considerable amount of time is given to making a very thorough study of the selections that have been made. In general, it is not so important to make a complete detailed study of these selections the first year, because one does not know anything about the yielding capacity of the various strains. That is, if one were making a comparison of lint lengths with some new selections, he might be inclined to discard a strain with slightly shorter lint length than another one; and yet, possibly, the one discarded might yield a great deal more and be more profitable for the farmer to grow in spite of its shorter lint. As environmental conditions, especially the moisture content of the soil, will affect the length of lint to a certain extent it is not desirable to make too rigid a selection based on lint length of those selections made from different localities. This does not mean that one should save all the types with a short lint, but it does mean that it is *not* necessary to make an elaborate, detailed study with the intention of making a rigid selection based on laboratory studies alone.

It is desirable, however, to make a laboratory study as it is important to make some examination relative to the quality and length of lint; but these studies as to length of lint, weight of seed, percentage of lint, and the like need not be made in great detail for the first year's selections. It is sufficient to make a general examination, saving all the selections that are of satisfactory lint length and quality or fineness.

Naturally the number of the selections that are to be saved will depend on the land that is available for cotton testing and on the other facilities, such as laboratory room, labor, and the like. It must be remembered that, in general, the success to be expected in plant selection depends on the amount of material or, in other words, on the number of individual selections with which the work is begun. As it is largely a matter of chance whether one obtains a high-yielding plant as a result of selection, naturally the larger the number of individuals the greater is the chance of obtaining a superior strain.

In the beginning, therefore, it is best to obtain a large number of selections; and, rather than to eliminate too many as the result of laboratory studies, it is better to keep all those that seem to possess satisfactory lint characteristics, determining later by a field trial the yielding ability as well as the general type of plant. Since there is nothing from a laboratory study that will indicate which particular type or types will be high yielding, it is desirable to keep a large number of strains and carry them through one or two years' test in the field. This is important since, as already indicated, a strain may be found that may be somewhat shorter in length than others and yet may possess a satisfactory length of lint; and it might be superior in yield and hence, for the present, it might be the most profitable type for the farmer to grow. Since environment, such as the amount of moisture during the critical growing period, influences the length of lint and since the selections have been made from many different localities where the environmental factors are different, it is best not to discard too large a number from this first lot of material.

After the laboratory examination has been completed, the seed may be prepared for planting. It will be necessary to remove the lint from the seed; and the seed should be sorted, discarding all of the light or unfilled seed and keeping only the sound seed for planting. After the lint has been removed, the seed should be placed in small envelopes and given an appropriate number in preparation for planting.

The question naturally arises as to what system of numbering should be followed with work of this kind. One point to be kept in mind regarding any system of numbering is that it should be simple so that one will have as few numbers as possible to write on the envelopes and in the records. One of the simplest systems that can be followed is to group the selections made from any one particular locality without numbering. Another system is to group them and to give them merely a serial number. That is, one may have a collection from Nantung and these may be numbered by naming the place, as Nantung, and then numbering the different selections 1, 2, 3, and on up to as many selections as have been obtained, say, 100. Thus one would have Nantung 1, Nantung 2, and so on. If one has a second lot of seed as, for example, from Sian, he may name the place and begin with 1 and continue as before. This will keep the size of the numbers very low. Some may prefer to continue the numbers serially rather than to start with number 1 with each new locality. That is, suppose we have 100 selections from Nantung, then when changing to another locality, for example Sian, the first selection would be Sian 101, the second Sian 102, and so on.

The method one follows is a matter of preference. With the first system, one would have several selections bearing number 1 or number 2, but this will not be confusing if the name of the place from which the collection was made is included. It may be stated also that, for the first years, it is not necessary to give any special number to the individual selections other than to keep a record of the source of the selection, assigning the different selections a row number when they are planted in the field. One of the chief reasons for not giving every strain* a number the first year is that probably three-fourths or more of them will be dropped at the end of the first year. If they have all been assigned a special number, then a great many selection numbers

* A strain refers to the plants coming originally from an individual selection.

will have been used and will be of no further use since, as stated, many selections will be dropped.

Under ordinary conditions, cotton seed is usually planted as it comes from the gin or after the lint has been removed by hand, especially in the case of the small amounts one has from plant or boll selections. Experience, however, has shown that, when possible, it is desirable to delint the cotton seed by treating with sulfuric acid for from fifteen to thirty minutes. While soaking, the mixture should be stirred occasionally so that the delinting will be thoroughly done. The seed is not injured by this treatment, and the lint is practically all removed. After soaking, the seed should be washed thoroughly with water or with water to which has been added a little lime water or ammonia in order to remove all acid. Such acid treatment will hasten the germination and will remove any seed-borne diseases. It may be considered expensive to use acid to delint the seed but, since it will give a better stand of plants and therefore better results, it is expense well justified. That the germination is accelerated by such treatment is shown by the results in Table 1.

Table 1 — Effect of Concentrated Sulfuric Acid on the Germination of Cotton Seed
(100 seeds used in each test)
表一 — 濃硫酸浸種對於棉籽發芽之影響
(每次試驗用種籽一百粒)

Kind of Treatment 試驗種類	Number of Seeds Germinated after 經下列日期後種籽之發芽數						Average of Duplicate Tests 二次試驗平均數
	7 days 七日	9 days 九日	11 days 十一日	13 days 十三日	16 days 十六日	20 days 二十日	
Check A soaked in water 15 minutes 標準A浸於水中十五分鐘	12	26	52	78	82	83	
Check B soaked in water 15 minutes 標準B浸於水中十五分鐘	9	36	62	78	81	82	82.5
Treatment A soaked in concentrated sulfuric acid 15 minutes 試驗A浸於濃硫酸中十五分鐘	56	71	83	90	90	91	
Treatment B soaked in concentrated sulfuric acid 15 minutes 試驗B浸於濃硫酸中十五分鐘	54	70	84	88	92	92	91.5

After all the lint has been removed either by hand or by means of acid, one may then prepare the seed for planting. In order to be able to compare the new selections with some standard, it is desirable to have an adapted variety to be used for this standard or check. If the station where the work is to be undertaken does not already have a good variety that may be used for this check, it will be well, while making the selections, to arrange with some farmer to obtain a quantity of seed of that variety which seems to be the most common as well as the most satisfactory for the particular region where the station is located. If this cannot be done, then steps should be taken to obtain a large amount of some variety that may be expected to give good results at the station. A large quantity of such seed should be obtained; probably at least a picul or more will be needed to be used as a check, leaving some for multiplication for further use.

Plan of Planting — Before it is time to plant the seed, one should make a plan of planting which will indicate the source of the seed, the number of selections from each locality, and any other information that may be had regarding the selections together with the row number in which any particular selection is to be sown. In preparing this plan of planting, it is important to group the different selections in accordance with the type as, for example, Chinese cotton or foreign cotton. If the selections have been made from different varieties of Chinese or foreign cotton, it will be desirable to make further groupings with reference to the varieties. Such a grouping may mean that the selections made from a particular region will not all occur together in the plan of planting as some of them may have come from Chinese varieties and some from foreign varieties; but it is better, as far as field technique is concerned, to group the varieties according to type rather than to adhere to a grouping according to locality.

If, in beginning this work, one is not sure whether the Chinese or foreign type is better adapted to his station and if one is handling a large number of selections of both types, it may be desirable to have a plan of planting for the foreign type and another for the Chinese type. This is a matter of convenience. The chief point is that, for all of the selections that are to be planted, it is necessary to have a plan of planting. As has been suggested, it is desirable to have a standard variety to be used as a check and a row of this check variety should come at frequent intervals throughout the plan of planting. At least every tenth row should be sown to the check variety; if land is available, it will be desirable to have a check every fifth row. If a large number of selections have been made from both Chinese and foreign types, it will be desirable to have a Chinese variety for a check for the Chinese selections and a foreign variety as a check for the foreign selections.

In preparing the seed for planting, it is desirable to use envelopes or paper bags of one color for the selections and of another color for the check. For example, the selections may be kept in brown paper envelopes or bags and the check in white ones. This is a convenience when distributing the material in the field for planting.

If all the selections have come from individual plants, one would have a plan of planting made for plant rows. If all of the selections have come from bolls, the plan of planting would be for boll rows. If both kinds of selections-namely, from plants and from bolls-have been made, it is desirable to have two plans of planting since they will be planted in rows of different length. The plan of planting for boll rows will be as follows:

Plan of Planting for Boll Rows 1935

Selection Number or Source of Seed	Row Number
Check	0
Nantung or Tinghsien, etc. 1	1
2	2
3	3
4	4
Check	5
5	6
6	7
7	8
8	9
Check	10
9	11
10	12
11	13
12	14
Check	15
13	16
14	17
15	18
16	19
Check	20

and so on until all selections from one locality according to type or variety have been included in the plan of planting. Then one would continue with the selections of the same type or variety of cotton made from another region and so no until all the bolls have been given their proper row number. As already stated, if land is not available, the check row may be placed every tenth but it is better to have one every fifth row, if possible.

The system of numbering the selections will depend on the system that it is desired to follow. It was pointed out earlier that one may follow any one of three methods: One is that of giving merely the place from which the selections are made and not assigning any number; another is that of naming the place and giving a number, continuing with the numbers in order until all the selections from a single locality have been planted and then numbering the selections made from another place by beginning with 1 and so on; the third method is that of naming the place and giving each selection a number, continuing the number serially when changing from the selections made from one locality to those made from another.

Which one of these methods one desires to follow is a matter of preference but, as already pointed out, it is desirable to keep the numbers low and the first method will accomplish this better than either of the other methods. The plan of planting as made above, however, is based on naming the locality and giving the selections a number. It is perfectly satisfactory if the records are carefully kept to give only the location for the first year, keeping the selections straight by following the row number only. If this were done, the only numbers appearing in the plan of planting would be the row number. In all cases in crop improvement work, the method to be followed should be one that will make for accuracy and, at the same time, for simplicity. One should strive to keep his pedigree numbers as low as possible, for the fewer numbers one has to write for any particular selection the less chance there is of making an error.

After the plan of planting has been completed and all the check rows have been put in place, it should be thoroughly checked before any planting is done. In doing such checking work, it is always best to have two people work together so that one may watch the plan of planting while the other reads the number representing the source of seed and the row number from the envelopes.

After the plan of planting has been checked, the material should be carefully stored where the order of the envelopes will not be disturbed by any one. When it is time for planting, the seed should be taken to the field with as little handling of the envelopes as possible. This is to insure that the order of arrangement has not been disturbed.

Field Methods for the First Year — One of the points to keep in mind in any field experiment is that of having as uniform a piece of land as is possible. It must be understood that there is no field that is absolutely uniform but, naturally, some fields are more uniform than others. Merely because a field is level does not mean that it is uniform so far as fertility is concerned. Where there is a choice of land, one should select for testing work the field that past experience has shown to be fairly uniform.

The method of arranging the rows and planting will depend somewhat upon local conditions. That is, if one is in a locality where there is no danger of floods or high water during the summer, one would treat his field all as one level field. If drainage is a problem, it will be necessary to prepare beds or narrow strips of land with furrows or ditches between them for drainage. The width of such beds or strips of land will depend on the seriousness of the drainage problem. When it is necessary to prepare such beds, it is always best to make them a little wider than need be to accommodate the length of row that is desired. That is, it is best not to have the beds so narrow that it will be necessary to plant too close to the drainage furrow or ditch.

In planting boll rows, if it is found that preparation for drainage is necessary, it is desirable to have each bed or strip of land wide enough to accommodate at least two boll rows. If high water is a very serious menace in the summer, it may be that the beds may be wide enough for only one boll row. The length of such boll rows will depend of course on the amount of seed available, but usually there is seed enough to plant four or five hills. The length of row chosen should be the same for all selections so far as possible. For Chinese cotton, the hills may be eight inches (new system) apart; for five hills it would then be necessary to have rows forty inches long. As already stated, where drainage is necessary, the beds should be a little wider than needed so that it will not be necessary to plant the end hills right on the edge of the beds as these may suffer from washing during heavy rains. The distance between the rows for Chinese cotton would be one and a half feet.

For foreign cotton, the hills should be a foot apart in the row, thus calling for a row five feet in length, and the rows should be two feet or two and one-half feet apart. If land is available, it is better to have the rows plantted two and one-half feet apart. It may be argued that the wider distance is not so desirable as the plants may not be able to use efficiently all of the land, but it is best to have the rows far enough apart so that the plants from the different selections may develop normally in order that one may judge as to their habits of growth and other qualifications.

If plants have been used as the unit with which to begin the first year's work, then naturally more seed will be available and the rows will be longer. The distance between hills and between rows will be the same as for boll rows, but it will be desirable to have the plant rows as long as the amount of seed will permit, up to twenty to twenty-four feet, but of course all of them should be the same length.

In handling these longer rows in the field, the question will again arise as to whether it is necessary to prepare for surface drainage. If this is necessary and it is not possible to make the beds ten to twenty feet wide, it will be necessary to arrange the planting so that the rows may run lengthwise of the beds. When the question of arranging for drainage (when this is necessary) has been settled, the field will be prepared for planting the seed.

Planting the Seed — It is desirable to have the field surrounded by one or two border rows; that is, it is best not to plant the selected seed on the edges of the field as it is desirable to have some protection, such as will be furnished by border rows. After the length and width of row have been decided depending on the need for drainage and the like, the rows may be marked off and hills made at the proper distance. The rows may be marked with a marker and then the hills opened at the proper distance; or the rows may be opened with a hoe and then the hills planted at the proper distance apart.

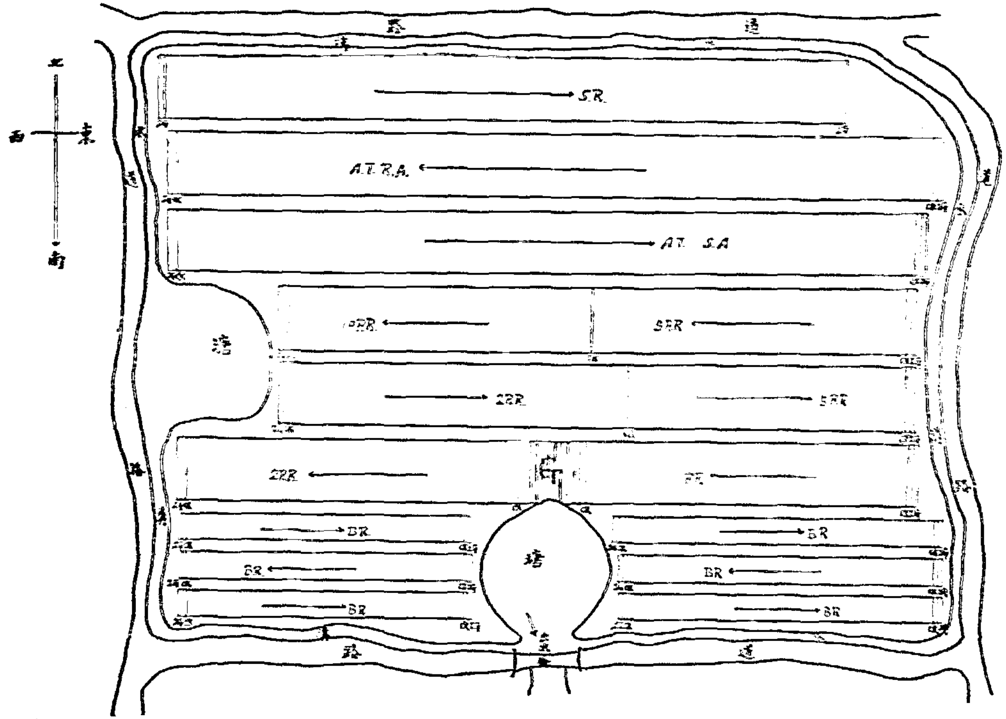
In handling cotton experiments, it is always best to practice thick seeding with the expectation of thinning to the proper number of plants. This is for the purpose of insuring a good stand. In some heavy soils, it is difficult for cotton to break through and this is especially true if heavy rains occur soon after planting. When a number of seeds are sown in a hill, it is easier for the young plants to force their way through the soil.

After the rows are marked out, the seed of the selections and checks will be distributed in order according to their row number, keeping in mind the fact that it is always desirable to plant the first row or two to guard rows. One would begin by planting a check row first and then continuing the planting in order until the end of the field is reached, keeping in mind that it is desirable here to have one or two guard rows also. The arrangement of the rows is shown in Figure 1. It is desirable to have stakes of some suitable material, such as pine or bamboo, and these stakes should be placed every ten to twenty rows. If sufficient stakes are available, then one should be placed in every tenth row as, for example, No. 10, No. 20, and so on. A stake should also be placed at the first check so as to show where the first row of the test begins; a stake should also be placed with the guard rows, indicating whether one or two guard rows have been planted.

It is important that each series or block end with a check occurring in its regular order. That is, when nearing the end of the field, one should determine whether it will be possible to end with a check without having to place the check out of order. Thus for the boll rows, if a check occurs every tenth, the last row number of the series should be some multiple of ten. If it has been decided to use a check every fifth row, it should be some multiple of five. If the check should come at a place where it is still possible to plant one or two boll rows before reaching the end of the field, this should not be done. One should fill in those one or two rows or extra rows with guard rows and then begin planting on the second series by placing an extra check first and then proceeding in regular order. A stake sh[illegible] be placed in this extra check row

Figure 1 — A Diagram Representing the Arrangement of the Different Kinds of Tests for Cotton Beginning with Boll Rows and Continuing for the Two Row Test on up to the Advanced Test and Seed Rows

圖一——各種棉作試驗田間排列圖



G = Guard Row 保護行
CK = Check 標準行
B.R. = Boll Row 單鈴行
P.R. = Plant Row 單株行

2 R.R. = Two Row Test 二桿行
5 R.R. = Five Row Test 五桿行
10 R.R. = Ten Row Test 十桿行

A.T. = Advanced Test 高級試驗
S.A. = Systematic Arrangement 順序排列
R.A. = Random Arrangement 隨機排列
S.R. = Seed Row 種籽行

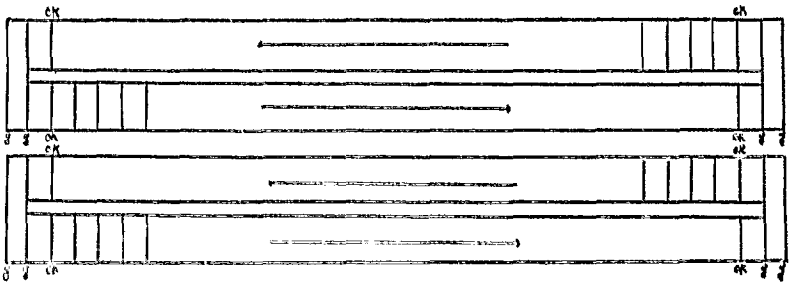
and should be labeled *Extra check*, and the row number coming immediately after should be recorded too as *Extra check before row 301*, or whatever the row number is. This method should be followed at the beginning of each series or block or wherever it is necessary to interrupt the planting due to the presence of graves or other obstructions.

After the envelopes containing the seed have been placed in order according to row number, they should be carefully checked before any planting is done to see that no mistakes in order have been made. Having the stakes placed at every tenth row will aid in checking. As already indicated, one would plant from one end of the field to the other and then return, beginning at the end of the field and planting back. There should be a path between the boll rows; if narrow beds have been made as already discussed, then the furrow between the beds will serve as a path. If it is possible to use beds wide enough to hold two boll rows, then it will be well to arrange to plant in the following way:

The first planting will be made by arranging the boll rows so that they will go one-half the way across the bed, and the stakes will be put in next to the furrow. On reaching the end of the field, one would turn and plant back on the other side of the bed placing the stakes next to the furrow, leaving a narrow division between the ends of the boll rows in accordance with Figure 2.

Figure 2 — Diagram Illustrating the Method of Sowing Boll Rows on Narrow Beds Where Surface Drainage Is Necessary. A Very Narrow Border Is Left between the Blocks of Rows, and the Stakes Are Put on the Outside of the Block next to the Furrow.

圖二—鈴行種植圖，表示狹畦上播種鈴行二排，二排鈴行間，留一小道，木牌插於區之外邊，即近於畦溝處



If the beds have to be so narrow that they will be wide enough for only one boll row or if the planting may be made on a level field where it is not necessary to take care of surface drainage, then the plan of planting will be in accordance with Figure 1, leaving a path between each series of boll rows.

After the envelopes have been checked to see that they are in the proper row, the seed may be dropped in the hills, trying to have practically the same number of seed in each hill so that each hill will be given an equal chance. It would be well to inspect the planting to see that it has been uniformly done and that every hill is planted; then the seed may be covered by means of hoes. It is best not to cover cotton seed too deeply. It is best not to have a narrow, deep hole for the hill so that all of the seed are piled together; it is much better to have the seed scattered a little so that when they are covered, the seed in each hole will be covered at different depths. This is of advantage in the case of heavy rains which may pack the soil and make it difficult for those covered too deeply to emerge. It is desirable to make sure that all the seed are covered.

After the planting has been completed, it is desirable to make a field map. This field map would show the location of the different blocks, the row number with which each block begins and ends, the number of guard rows, and the like. After the plants are all up, the field map should be checked with the field again to see that no mistakes have been made and that no rows have been missed.

During the growing season, it is desirable to take notes as to the growth, disease-resistance, earliness, and other characters that will aid in helping to pick out a good type of cotton. It is desirable to take notes on the germination and stand of the different rows. If damping-off is a serious trouble affecting the young plants, it may be well to take notes to determine whether any of the rows show any resistance to this disease. If any rows are badly affected by any serious disease that is easily transmitted from plant to plant, it may be well to pull out the entire row.

The notes that have been taken will aid one in selecting some of the more promising rows and, since cotton is easily cross-fertilized, it will be desirable to select some of the better rows early, if possible, and to self several of the best plants in each of the selected rows. This selfing may be done, as already indicated, by means of paper bags or by wrapping wire around the tip of the flower or by holding it closed by means of paper clips or by holding it closed with the slit tags as described earlier. Using either the wire clips or the tags is found to be very satisfactory. Whatever method is followed, it will be necessary to place a tag on each of the flowers that is selfed so that one may be sure to harvest the selfed seed separately. Since there will be a considerable amount of shedding, it is always desirable to self many more flowers than would be needed if all of them set seed.

The need for selfing may vary with locality. If one wants to be absolutely sure of having pure seed, it is necessary always to self. It does mean a considerable amount of work and expense, but it insures pure seed. It may be well for each station to determine how much natural crossing is taking place. The amount of natural crossing will vary depending on locality, as already stated, because in some localities there are a good many bees and other insects that will visit the cotton flowers and carry pollen from one to the other. In other places, there are very few insects so that the amount of crossing is very small. Local conditions may change so that there might not be much natural crossing for a while yet the amount might increase later, especially if a large number of bees were introduced into the neighborhood. Table 2 will give some idea of the variation in the amount of crossing in different places.

If one is working in a station where the amount of natural crossing is very low and he is handling only one type of cotton, he might conduct his work without selfing for the first few years, beginning to self the more promising strains as they are developed. As already stated, however, if one wants to be sure to have pure seed, selfing is absolutely necessary.

While it is desirable to self all the seed that is to be used, it is difficult to be able to get enough seed for the tests each year. For example, from the boll rows it is difficult to obtain enough seed from selfing one or two plants so that one will have sufficient seed for the tests the following year. If the station is able to obtain plenty of help, selfing can be done on a large scale. While it is important to have pure seed, and this means selfed seed, if natural crossing is taking place it may be that - due to lack of help - it will be impossible for a station to obtain enough selfed seed for all of the tests. If enough selfed seed cannot be obtained, there are different ways by which the work may be handled.

If a station is working with one type only and there is found to be very little natural crossing, the station may conduct the work the first three or four years without selfing and then may begin to self the better strains by having special seed rows for this purpose. If there is much natural crossing, however, selfing is the only way to insure having pure seed.

If it is impossible to obtain a large enough amount of selfed seed so that the test rows may be planted from selfed seed, the following method may be used: One may self one or two good plants in a boll row and then, from the

Table 2 — Showing the Variation in the Amount of Natural Crossing in Cotton When Grown in Different Localities

表二一 棉花天然雜交百分率在不同地域內之差異

Kind of Treatment and Place of Treatment 試驗種類及其地點	No. of Flowers Treated 試驗之花數	No. of Bolls Formed 結實棉鈴數	Percentage of Bolls Formed 結實棉鈴百分數
Data for 1932 民國二十一年之結果			
Nanking-Foreign Cotton 南京 美棉			
Tagging flowers to determine percentage of shedding 不去雄蕊以定天然落鈴百分率	615	327	
Emasculation 除去雄蕊	615	128	39.1%
Emasculation and washing pistil 除去雄蕊并洗滌雌蕊	615	89	27.2%
Nantung-Chinese Cotton 南通 中棉			
Tagging flowers to determine percentage of shedding 不去雄蕊以定天然落鈴百分率	493	300	
Emasculation 除去雄蕊	493	6	2.0%
Emasculation and washing pistil 除去雄蕊并洗滌雌蕊	498	3	1.0%
Hsuchow - Chinese Cotton 徐州 中棉			
Tagging flowers to determine percentage of shedding 不去雄蕊以定天然落鈴百分率	722	365	
Emasculation 除去雄蕊	724	9	2.5%
Emasculation and washing pistil 除去雄蕊并洗滌雌蕊	715	8	2.2%
Hsuchow - Foreign Cotton 徐州 美棉			
Tagging flowers to determine percentage of shedding 不去雄蕊以定天然落鈴百分率	716	166	
Emasculation 除去雄蕊	715	17	10.2%
Emasculation and washing pistil 除去雄蕊并洗滌雌蕊	714	13	7.8%
Yuyao - Chinese Cotton 餘姚 中棉			
Tagging flowers to determine percentage of shedding 不去雄蕊以定天然落鈴百分率	519	446	
Emasculation 除去雄蕊	521	7	1.6%
Emasculation and washing pistil 除去雄蕊并洗滌雌蕊	481	6	1.5%

Data for 1933 民國二十二年之結果			
Nantung - Chinese Cotton 南通 中棉			
Tagging flowers to determine percentage of shedding 不去雄蕊以定天然落鈴百分率	482	312	
Emasculation 除去雄蕊	478	4	1.3%
Emasculation and washing pistil 除去雄蕊并洗滌雌蕊	479	6	1.9%
Nantung - Foreign Cotton 南通 美棉			
Tagging flowers to determine percentage of shedding 不去雄蕊以定天然落鈴百分率	478	265	
Emasculation 除去雄蕊	475	52	19.8%
Emasculation and washing pistil 除去雄蕊并洗滌雌蕊	476	64	24.2%
Hsuchow - Chinese Cotton 徐州 中棉			
Tagging flowers to determine percentage of shedding 不去雄蕊以定天然落鈴百分率	2,000	1,212	
Emasculation 除去雄蕊	2,000	10	0.8%
Emasculation and washing pistil 除去雄蕊并洗滌雌蕊	2,000	12	1.0%
Hsuchow - Foreign Cotton 徐州 美棉			
Tagging flowers to determine percentage of shedding 不去雄蕊以定天然落鈴百分率	2,000	729	
Emasculation 除去雄蕊	2,000	19	2.6%
Emasculation and washing pistil 除去雄蕊并洗滌雌蕊	2,000	16	2.3%

† 上列結實棉鈴之百分數，係根據天然落鈴率計算而求。例如：在南京試驗，有615朵花掛牌，而祇有327朵結實；有615朵花去雄者，而有128朵花結實。其結實棉鈴之百分數乃以128被327除之，再乘100即得。其他結果亦由同樣方法計算而得。

† The percentage of bolls formed is calculated on the basis of the amount of natural shedding. For example, from 615 flowers that were tagged at Nanking there were 327 bolls formed. From 615 flowers that were emasculated 128 bolls were formed. The percentage is obtained by dividing 128 by 327. The other results are obtained in a similar way.

附註：上述之試驗結果乃由金陵大學農學院彭[illegible]先生，南通江蘇省立棉作試驗場吳[illegible]先生，徐州江蘇省立麥作試驗場李[illegible]與唐[illegible]先生，及餘姚浙江省立棉業改良場蕭[illegible]先生等所供給。

Note: These data were very kindly furnished by Mr. S. P. Peng, College of Agriculture, University of Nanking, Nanking, Kiangsu; Mr. P. G. Wu, Provincial Cotton Experiment Station, Nantung, Kiangsu; Mr. L. Y. Li and Mr. K. S. Tang, Provincial Wheat Experiment Station, Hsuchow, Kiangsu; and Mr. F. Siao, Cotton Improvement Station, Yuyao, Chekiang.

very beginning of the work, have special seed rows for selfing. The selfed plants from the boll rows would be planted in the seed rows. The open-fertilized seed from the boll row may be used for the yield test the next year. The second year selfing will be continued in the seed row by using two or three of the best plants; the remainder of the seed of this row will be used for the yield tests the following year, and this may be continued each year, making the seed rows larger each year to furnish plenty of seed for the tests.

This will mean that the seed for the tests will be coming from selfed seed which has been allowed to be open-fertilized in the seed rows just one year. While this does not give the purest seed, it is about the best that can be done if it is impossible to self enough material for the tests each year. This method will be less objectionable in the later years of the experiment because the seed rows that are continued will be from the best strains each year. The amount of crossing in the seed rows that might affect the tests when using this open-fertilized seed from the seed rows for the yield tests will perhaps not affect the yields seriously, especially as year after year what crossing occurs is between the better strains.

Another modification which does not seem so desirable would be not to conduct a yield test for the first two years but to handle the work in this way: The best plants from the boll rows may be selfed, and this seed used for planting the following year. Selfing would be continued the second year, and one would select the better rows by judgment and then try to self enough seed to begin the yield tests the third year. This method is not so satisfactory as the other one just described.

On account of the possibility that there will be considerable natural crossing, it is important for a station, as early as possible, to confine its work to one general variety of cotton. Then, if the natural crossing amounts to only a few per cent, the testing may be continued (if labor is not available for selfing) with open-fertilized seed and then selfing may be begun by having seed rows about the third or fourth year of the test.

After the more promising rows have been designated for further study, it will be desirable to prepare bags for picking. These bags may be of either paper or cloth; bags made of thin cloth are more desirable for this purpose than paper bags since, after picking, it is necessary to dry the samples by exposure to the sun. If thin cloth bags are used, the drying may be accomplished by laying the bags on a dry platform in the sun without opening them. If paper bags are used, it would then be necessary to open the bags to permit drying; and such procedure offers a chance for the mixing or loss of seed since the bags may be blown over or the material lost out of the bags in one way or another. If one is not careful, some thoughtless workman may attempt to replace the seed that is lost out and get it in the wrong bag. Paper bags have the advantage that one may write the row number or selection number on the bag, while with cloth bags it is necessary to have them tagged.

For picking the boll rows or the plant rows where individual plants have been selfed, it is desirable to have a bag for each plant. That is, for the first year - since there is a possibility that there may have been some natural crossing in the field from which the selections were made - it will be desirable to save the plants from each row separately. The bags or tags may be given a number to designate this. For example, suppose row 4 is one of the rows saved, then the numbering system may be either 4(1), 4(2), or 4-1, 4-2, and so on. The first system is more satisfactory if it is likely that the plants may be bulked later. The second method would be used if it is intended to keep the seed from each selected plant separate in all future tests.

By saving the plants separately, one is more sure of having a pure strain than if the plants from a single boll or plant row are mixed together. If one has made selections only from regions where it is known that natural crossing occurs very seldom, the seed of the plants from a single boll or plant row may be bulked together, provided the plants are alike so far as one is able to judge.

The bags would be taken to the field each time picking is to be done and distributed in accordance with their row number. In order that the plants in the row may be placed in the proper bag, it is desirable that the picking should begin at the same end of the row each time and that the first selfed plant be given number 1, the second number 2, and so on. If this is done, it will not be necessary to use stakes or tags to number the plants.

After the picking has been completed, care should be taken to see that the samples are thoroughly dried and then stored in a dry place until time permits for making the laboratory examination. The laboratory examination of the individual plants from boll or plant rows will be made in more detail than was the case for the first boll or plant selections. Examination will be made as to lint length, quality, and percentage, and seed index. The examination will be made by taking individual seed from the different bolls at random. Relative to the number of seed that it is necessary to take for a fair sample, reference may be made to Table 3 compiled from data furnished by Mr. S. P. Peng of the College of Agriculture, University of Nanking. From this Table it is seen that the results are about the same no matter what size of sample has been used. The accuracy, as measured by the probable error, is a little greater on the larger samples; but the difference is not really significant. Since one will have a very large number of rows to be examined, it will therefore be satisfactory the first year to examine only ten or twenty seeds from each plant or from each strain.

Table 3 — Means and Probable Errors for Lint Length and Lint Percentage in Different Size of Samples

表三 一試驗材料之多少對於纖維長度與衣分之平均數及或差大小之關係

No. of Seed Examined 考查棉籽數		20	30	40	50	60	70	80	90	100
Mean Lint Length 纖維長度平均數	64.9±.20†	64.8±.17	64.8±.17	64.8±.17	64.8±.17					
Mean Lint Percentage 衣分平均數	30.30±.17	30.40±.13	30.50±.12	30.50±.12	30.50±.12	30.50±.13	30.60±.11	30.60±.11	30.60±.11	30.60±.11

†This is the total length of lint measuring on both sides of the seed, but since the study is to determine the proper size of sample the measurements are all comparable.

†上列纖維長度乃係棉籽上二旁纖維合計之長度，此研究爲決定試驗材料之適當數，故此種纖維長度亦可作爲比較。

After the examination of all the selections has been completed, the notes may be studied and the more promising types saved for planting the following year. On the basis of the notes taken, one will discard a certain number of the selections. It is not necessary to follow a definite rule as to the number to be discarded. One should not discard too rapidly since the field performance is a very important point in connection with cotton improvement. The laboratory tests give us certain information regarding the quality of the lint and the percentage of lint, but it is necessary that we know also regarding the yielding ability as well as the other facts of field performance. Therefore, it is better to keep a larger number of selections in the test than it is to discard too freely and handle only a few selections.

After the selections have been made, they should be delinted and the seed prepared for planting. The seed should be examined and the poor seed discarded so that only good seed will be used for planting. The selections should be grouped according to type and variety. That is, if both Chinese and foreign types have been selected, all the Chinese types should be planted together and all the foreign types together. Again, where it is possible that one would have more than one variety of either the Chinese or foreign type, it is best to make further groups within the Chinese or foreign cotton. This is done so that when the plants are grown in the field those types more nearly alike will be grown together, thus making for a better field comparison and avoiding the possibility of competition between rows or plots.

Methods for the Second Year— The field test for the second year will consist of having rows longer than those of the first year. It is desirable for Chinese cotton to have rows at least twenty feet long and for foreign cotton to have them at least twenty-four feet long. If land and seed are available, longer rows may be planted. It is better, however, to have two or more shorter rows than it is to have one long row. The lengths designated here are convenient from the standpoint of the calculation of the results, as will be discussed later. If the quantity of seed is sufficient, it is desirable to plant at least two rows from each selection: but the two rows coming from the same strain must not be planted side by side in the field.

A check row will be planted every fifth row, using the same variety as was used in planting the boll rows unless for some very important reason it has been found necessary to change the check. It should be pointed out that in testing work of this sort the check should not be changed frequently. If it is found that the first check selected has not been satisfactory, one may change to another one; but, from the standpoint of the comparisons, it is best to keep the same check or standard for several years.

With a knowledge of the different types and varieties one would group the sorts and arrange the seed for planting by making a plan of planting.

This plan of planting will indicate the strain or selection number and source of seed, the row number or numbers in which the seed is to be planted, and the last year's row number. The planting plan will be so arranged that one row of each strain will be planted until all the selections have been represented. Then the plan will be duplicated, starting with the first selection and continuing for all the strains.

The plan of planting for the second year will then appear as follows :

Plan of Planting for Two Row or Second Year Test

Last Year's Row Number	Variety or Strain		Row Number Series I	Row Number Series II
	Check		0	
8	Nantung	7	1	1001
11	,,	9	2	1002
13	,,	11	3	1003
26	,,	21	4	1004
	Check		5	1005
133	Tinghsien	133	6	1006
139	,,	139	7	1007
146	,,	146	8	1008
151	,,	151	9	1009
	Check		10	1010

and so on. This is assuming that one has enough strains - namely, eight hundred - so that, with a check every fifth row, there will be one thousand rows for the first series. The replication then will begin with row number 1001 and continue to 2000. If one has enough seed and land available, it is desirable to have a third series; thus there would be three rows for each strain. If one is using selfed seed, it is not likely that he will have seed enough for a third series, and perhaps not enough for more than one series.

After the plan has been made, the seed of the different strains will be placed in small envelopes and numbered with the proper row number. The numbers on the envelopes must be checked with the plan of planting to see that the correct row number and selection number have been used in each case. The seed will then be stored in a safe place until time for planting.

The details of planting will be much the same as those used for boll rows with the exception that the rows will be longer. If the station is located where surface drainage must be provided, then it may be possible to make the beds wide enough to contain the proper length of row, which would be at least twenty feet for Chinese cotton and twenty-four feet for foreign cotton. If it is not possible to have the beds this wide on account of too much water during the summer, they will have to be made narrower and the rows will have to run lengthwise in the beds.

A stake should be placed in every tenth row. The rows will be marked off and the hills made according to the same distances that were used for the boll rows. At some stations it may be preferred to sow the seed for the regular tests in drills rather than in hills. Either method may be followed; the point that should be kept in mind is that it is important to have a uniform stand. Guard rows should be planted at the beginning and end of each series; and, in beginning a new series, it is desirable always to begin with a check. This check will be marked by a stake which should be labeled with the words *Extra check* and the number of the row which it precedes as, for example, *Extra check before row 301*.

Before any planting is done, the envelopes containing the seed will be laid out and carefully checked to see that they are in the proper order. Then the seed will be dropped in the hills, taking care to plant about the same number of seed in each hill. To insure a good stand, it is desirable to practice thick seeding. One of the difficulties in cotton testing is that of obtaining a good stand, and missing hills in cotton tests are not uncommon. It is always desirable to reserve seed whenever possible for replanting; and, if missing hills do occur, it is desirable to replant. If it is not possible to save seed for replanting, the effect of missing hills may be reduced somewhat by planting soy beans or some other crop in the missing hills.

After the seed has had sufficient time to germinate, notes should be taken as to the rapidity of early growth; and the field map should be carefully compared with the field to see that no mistakes have been made in planting or in recording the proper numbers on the field map. During the growing period general field notes will be taken indicating such facts as disease resistance, earliness, branching habit, and any other characters that are of importance in selecting promising types. If seed rows are not grown and selfing is practiced, it is desirable to self the flowers on several of the best plants in the row. It may be sufficient to use the first series for selfing. The point to be kept in mind, however, is that a sufficient quantity of seed must be obtained, and this can be done best by having the special seed rows as discussed earlier.

If selfing has been done on some of the plants of the yield tests, then at picking time it is desirable to put the selfed seed of the different plants from each row in separate bags unless one is convinced that the row is pure or homozygous. If one is certain of this, the seed of several plants may be bulked together. If a sufficient quantity of seed can be obtained from one plant, however, it is more desirable to continue the testing by using the seed of only one plant for each strain. The same care that was practiced with the boll rows should be observed in the picking and the drying to be sure that no mixtures occur. It is desirable to weigh the yield of each row, keeping the cotton from the selected plants separate from the rest of the row.

After the picking has all been completed and the samples are thoroughly dry, laboratory studies may be made. These laboratory studies will consist of determining the length and quality of lint, percentage of lint, seed index, and any other factors that will be of use in making the selections. After the laboratory notes have been completed, it is desirable to compare the yields of the different strains with the check yield. For more exact comparisons, the percentage of lint may be used and the total weight of seed cotton may be multiplied by the percentage of lint, giving the yield of lint per row. Those strains that yield better than the check and have other desirable characters will be designated for further study.

The question may arise as to how to select the strains on the basis of yield performance as compared with the check. This will depend somewhat on the check; that is, whether it is a superior variety for the locality or a mediocre one. If it is a superior strain, then any of the new strains that show a little higher yield and also possess the desired lint characters would be saved for further testing. If the check is of only average value, then those strains that are considerably higher in yield than the check would be saved.

It is not necessary for this second-year test to make special calculations of the probable errors for the different strains. It may be desirable to use the check rows and determine a probable error for the whole experiment, so as to give some general idea of the amount of variability that may be expected. For convenience in selecting the different strains it will be desirable to compare the yields of the different strains with the check yield. This comparison may be made as is done in Table 4, which shows the plan of planting and some assumed yields for a two row series. The average yield of seed cotton for each two rows will be obtained. This is done for each strain as well as for the check rows. With the yields of the check rows, it is possible to obtain a theoretical or calculated check yield for each row. The check rows are placed every fifth row, and it is possible to obtain the calculated or expected yield for the intervening rows had they been sown to the check variety.

This may be done in any one of several ways: The yield of all of the check rows for the two row series may be used to obtain the average yield for the checks, and this average yield may be used as the expected yield for any of the other rows. The second way that may be used is that of taking the average of the two nearest checks for the yield of the intervening rows. The third way is that of using what is known as the graded method, which takes

Table 4 — Plan for Planting Two Row Cotton Test with Method for Calculating Results

表四一棉花二行試驗種植計劃書及產量計算法

Last Year's Row Number 去年種植行號數	Variety or Strain 品種或品系	Row Number* and Yield 種植行號與各區產量* Series 區別 I	II	Total Yield 產量總數	Average Yield in Catties per Mow (total × .2) 每畝平均產量(斤數)(總數乘.2)	Calculated Check Obtained by Grading Method 推算標準(用等級法計算)	Gain or Loss 產量增減比較	Percentage of Lint 衣分
	Check 標準	*0* 205	*195*	400	80.0			34%
8	Nantung 7 南通	*1* 254	*1001* 232	486	97.2	79.2	18.0	33%
11	Nantung 9 南通	*2* 260	*1002* 244	504	100.8	78.4	22.4	30%
13	Nantung 11 南通	*3* 182	*1003* 154	336	67.2	77.6	-10.4	36%
26	Nantung 21 南通	*4* 160	*1004* 132	292	58.4	76.8	-18.4	32%
	Check 標準	*5* 198	*1005* 182	380	76.0			34%
38	Nantung 31 南通	*6* 176	*1006* 144	320	64.0	74.8	-10.8	34%
44	Nantung 36 南通	*7* 158	*1007* 140	298	59.6	73.6	-14.0	38%
51	Nantung 41 南通	*8* 236	*1008* 228	464	92.8	72.4	20.4	34%
57	Nantung 46 南通	*9* 142	*1009* 156	298	59.6	71.2	-11.6	37%
		10 18	*1010* 169	350	70.0			34%
		. . .	. . .					
		1000	*2000*					

*The Row Number is Printed in Italics　　*行號係用斜體字印

the yield of the two nearest checks and grades the yield for the rows between in accordance with the change in the yields of the check. This last-named method is preferred since studies have indicated that in general it is more reliable than the other methods.

In using the graded method, one proceeds in the following way: Taking the yield for the average of the first two checks as 80 catties of seed cotton per mow and that of the next two checks as 76 catties per mow, we obtain the difference in yield, which is 4 catties per mow. Now, since the checks are removed from each other by the distance of 5 plots, we assume that the soil varies as we proceed from one check to another and that the change is gradual. Since the second pair of checks yields the lower, it is assumed that the soil gradually decreases in fertility and that the amount of this decrease is indicated by dividing the difference between the checks by 5, the number of plots they are apart. Thus for these data we have $\frac{76-80}{5}$ $-.8$. Since the sign of this value is minus it is assumed that, if the check variety had been sown in rows 1 and 1001, it would have yielded .8 of a catty less than the check that was planted in rows 0 and 1000. Therefore, the calculated check yield for rows 1 and 1001 is 79.2 catties of cotton, and the calculated yield for the next rows is 78.4 and so on.

In obtaining the graded difference, it is always desirable to put the yield of the second check first since the subtraction will indicate whether the average difference is to be added to or subtracted from the value of the first check. In the case just cited we have 76-80, and the sign of the difference is negative which shows that .8 is to be subtracted from 80 and that .8 will be subtracted for each succeeding check. Since the pair of checks next below the pair in rows 5 and 1005 is less than 76, the difference will have a minus sign; and, in this case, the graded difference is to be subtracted from 76. This method will be used for obtaining all the expected or calculated check yields. This method of comparing the yields with the checks has been based on the yield of seed cotton per mow. One may, if he chooses, make the final comparison after the percentage of lint has been obtained; and then by multiplying the yield of seed cotton by the percentage of lint, one may express the final results as catties of lint per mow.

The difference for each strain as compared with the calculated check will then be obtained as is recorded in the column headed *Gain or Loss Compared with Check*. Those strains that are poorer than the check will then all be discarded unless, for some particular reason, it may be desirable to save an occasional strain. For example, a strain may yield a little less than the check and still have a very superior lint or it might be resistant to disease, and therefore it may be desirable to continue it in the test for a longer period. Those strains that show an increase will be saved for further testing. Only the outstanding strains should be saved unless for special reasons certain of the low-yielding ones may be continued on account of good quality of lint or disease resistance.

Under ordinary circumstances one would not consider that a strain that yields only one or two catties of lint per mow more than the check is really any better than the check. One that yields several catties per mow more may be expected to continue to give a somewhat better yield. It should be kept in mind, however, that this will not always be the case as conditions may be such that a strain may be promising for one year but, over a period of years, it may fail to maintain its high yield. Those strains that are promising from the standpoint of yield and lint characteristics will be designated for testing the following year. These will be delinted and the seed prepared for testing.

The Methods for the Third Year — The test for the third year will be more extensive than the one for the second year in that more rows from each strain will be grown. It is desirable to have at least five rows of each strain if this is possible. This will be determined by the amount of seed available and the amount of land in accordance with the number of strains one has tot est. If it is possible to have five rows of each variety, then five lots of seed will be prepared and placed in separate envelopes. The row length and width may be the same as in the previous year. If it is felt desirable, the length of row may be increased.

For convenience in calculating the yields, it is desirable to use some length of row that, when multiplied by the width, will give a fraction of a mow such that it will be easy to obtain the yield in catties per mow by simple multiplication. For example, with Chinese cotton when we have rows twenty feet long with the distance between rows of one and one-half feet, we have each row occupying thirty square feet; since there are six thousand square feet in a mow, this means that each row is one two-hundredth of a mow. In the case of foreign cotton, when the rows are twenty-four feet long with the distance between rows of two and one-half feet, each row occupies sixty square feet, or one one-hundredth of a mow. If a longer row is to be used, say for Chinese cotton, it is best to use some length that will give a convenient factor. In order to show the difference in length of row so far as accuracy is concerned, some data presenting the probable errors for rows of different lengths are shown in the following Table:

Table 5 — Giving the Probable Errors in Per Cent for Rows of Different Lengths and for Plots of Different Numbers of Rows

表五—行長及區之大小與誤差之關係(誤差以百分數示之)

Number of Rows in Plot 每區行數	Length of Row 行之長度				
	20 feet 二十英尺	25 feet 二十五英尺	30 feet 三十英尺	35 feet 三十五英尺	40 feet 四十英尺
Single row 單行區	12.56	11.97	11.34	10.68	10.09
Two row 二行區	10.36	9.74	9.61	9.05	
Three row 三行區	9.37	9.02	8.74	7.85	7.54
Four row 四行區	9.50	8.93	8.67	7.96	
Five row 五行區	8.82	8.62	8.57	7.57	7.19
Seven row 六行區	8.38	7.86	7.75	7.74	

While the probable error for a single row decreases as the length of row increases, it does not decrease rapidly. When one considers the additional amount of land needed for a thirty foot row as compared with a twenty foot row, it is apparent that greater accuracy will be obtained if more replications of the shorter rows are used, especially if land is limited. If the station has plenty of land and labor, the longer rows may be used but it is necessary to have them replicated several times. It should be kept in mind that, in general, more replications of shorter rows will be more accurate than the same amount of land used for longer rows with fewer replications.

A plan of planting will be made for the third year test, which we call a five row test. The plan of planting will appear as follows, placing a check every fifth row and having five rows of each strain :

Plan of Planting for Five Row or Third Year Test

Last Year's Row Number	Variety or Strain	Row Number Series				
		I	II	III	IV	V
	Check	0				
3	Nantung 11	4001	4801	5601	6401	7201
8	Nantung 41	4002	4802	5602	6402	7202
16	Nantung 54	4003	4803	5603	6403	7203
24	Nantung 62	4004	4804	5604	6404	7204
	Check	4005	4805	5605	6405	7205
		.	.	.	.	.
		.	.	.	.	.
		.	.	.	.	.
		4800	5600	6400	7200	8000

This plan of planting assumes that one would have enough strains to make up, together with the checks, eight hundred rows for the first series, repeating the series until all five are sown.

The methods for the field work, so far as planting and the like are concerned, will be the same as for the previous year, taking care to see that the seed are all properly planted in accordance with the plan of planting and making sure to have a field map indicating the location of each series. The usual field notes will be taken, and the picking and care of the samples and the like will be just the same as in other years. The usual laboratory studies of the lint characters will be made as before, and the selections which are to be saved for further testing will be made in accordance with the data from the laboratory studies and the yield comparisons.

For this third year the probable errors will be calculated to serve as a guide for making the selections (on the basis of yield) that are to be continued in the test. There are different ways of making these probable error calculations. One may obtain a probable error for each strain and the checks or it is possible to obtain a probable error based on all the strains and checks or one may obtain a general probable error based on the performance of the checks only. The last probable error is only an approximate value but, since one needs such a value only to serve as a guide in making selections, it is satisfactory for practical purposes and is the method that will be suggested here. It should be kept in mind that it is not the method that one would recommend for drawing final conclusions or for making definite comparisons between different strains. The method that is suggested is that of obtaining the probable error from the checks by using Bessel's formula.

For these calculations the yields of seed cotton will be used, and the probable error for each set of five checks will be determined. That is, for the first set of checks or for the check rows growing next to rows 4001, 4801, 5601, 6401, 7201 we shall have the check rows 0, 4800, 5600, 6400, 7200. Taking the yields of these as indicated in Table 6 we have: 212, 280, 234, 310, and 274.

Bessel's method is used for calculating the probable error of the mean of the checks. This method and the formula are given in detail in Table 6 A. The probable error for each set of five checks is determined and then from these a general probable error is calculated and applied as in Table 6. As indicated, this probable error may be obtained by different methods. The one that is satisfactory and requires the least amount of work is that of summing the yields of the checks and summing the probable errors and then dividing the sum of the probable errors by the sum of the yields. This will give a probable error in per cent which may be used as a guide in selecting the different strains to be kept in the test the following year.

In using this probable error, one would first determine the calculated or theoretical check yields and the gain or loss as compared with the check, which was explained earlier. Then the average yield may be multiplied by twice the value of the probable error in per cent which will give a selection factor as indicated in the Table under the column *2X × Average Yield*. The steps for making the calculations are illustrated in Table 6 A. Those strains that show a gain more than the value in this column may then be kept for further testing. In order to make a more rigid selection, one may multiply the average yield by three times the probable error in per cent, obtaining the values given in the column headed *3X × Average Yield*.

It should be kept in mind that these values are used only as a guide in making selections and that they are not the exact values that would be obtained if the probable errors for each strain were obtained; but, since they are to serve only as a guide, it will be satisfactory to make use of the

Table 6 — Plan for Planting Five Row Cotton Test with Method for Calculating Results

表六 — 棉花五行試驗種植計劃書及產量計算法

Last Year's Row Number 去年播植行號	Variety or Strain 品種或品系	Row Number* and Yield 行號與產量 Series 區別 I	II	III	IV	V	Total Yield 產量總數	Average Yield in Catties per Mow (Total × .08) 每畝平均產量（斤）（總數乘.08）	Theoretical Check 推算標準	Gain or Loss 產量比較	2X×Average Yield 2X×平均產量	3X×Average Yield 3X×平均產量	Percentage of Lint 衣分
	Check 標準	*0* 212	280	234	310	274	1310	104.8±4.69(4.48%)					35%
3	Nantung 11 南通	*4001* 226	*4801* 278	*5601* 210	*6401* 292	*7201* 260	1266	101.3	105.3	-4.0			36%
8	Nantung 41 南通	*4002* 240	*4802* 292	*5602* 226	*6402* 313	*7202* 284	1355	108.4	105.8	2.6	10.64		33%
16	Nantung 54 南通	*4003* 230	*4803* 300	*5603* 251	*6403* 305	*7203* 279	1365	109.2	106.2	3.0	10.72		37%
24	Nantung 62 南通	*4004* 282	*4804* 341	*5604* 296	*6404* 362	*7204* 334	1615	129.2	106.7	22.5	12.69	19.07	35%
	Check 標準	*4005* 221	*4805* 302	*5605* 214	*6405* 319	*7205* 284	1340	107.2±5.77(5.38%)					
32	Shanghai 17 上海	*4006* 232	*4806* 299	*5606* 240	*6406* 292	*7206* 282	1345	107.6	105.3	2.3	10.57		36%
38	Shanghai 24 上海	*4007* 255	*4807* 310	*5607* 232	*6407* 284	*7207* 299	1380	110.4	103.4	7.0	10.84		34%
44	Shanghai 33 上海	*4008* 202	*4808* 210	*5608* 240	*6408* 176	*7208* 162	1040	83.2	101.4	-18.2			33%
58	Shanghai 54 上海	*4009* 210	*4809* 272	*5609* 243	*6409* 181	*7209* 212	1118	89.4	99.5	-10.1			35%
	Check 標準	*4010* 226	*4810* 291	*5610* 213	*6410* 284	*7210* 206	1220	97.6±4.88(5.00%)					
62	Kiangying 7 江陰	*4011* 282	*4811* 331	*5611* 274	*6411* 335	*7211* 323	1545	123.6	96.4	27.2	12.14	18.21	36%
77	Kiangying 16 江陰	*4012* 232	*4812* 290	*5612* 222	*6412* 278	*7212* 268	1290	103.2	95.2	8.0	10.13		37%
79	Kiangying 34 江陰	*4013* 184	*4813* 232	*5613* 216	*6413* 162	*7213* 190	984	78.7	94.0	-15.3			34%
81	Kiangying 42 江陰	*4014* 218	*4814* 160	*5614* 156	*6414* 204	*7214* 192	930	74.4	92.8	-18.4			33%
	Check 標準	*4015* 212	*4815* 260	*5615* 192	*6415* 206	*7215* 275	1145	91.6±1.38(4.78%)					
		⋮	⋮	⋮	⋮	⋮							
		4800	*5600*	*6400*	*7200*	*8000*							

* The row number is printed in italics

* 行號數均係用斜體字印

Note: The strain number and the last year's row number in this and the following Tables are merely illustrative, and the same strain numbers are not carried through all the Tables.

附註：表中所用品系號數及去年播植行號數於後各表並不連續僅用作說明而已。

Table 6 A

表六A

Method for Calculating the Probable Error of the Mean of Each Check

每組標準區平均或差之計算法

Calculated from Yield per Row in Grams

由每行產量克數計算

First Check Series 第一組標準區	D	D^2
212	-50	2500
280	18	324
234	-28	784
310	48	2304
274	12	144
5 | 1310		6056

Mean 平均數 = 262±11.74 (to change from yield per row in grams to catties per mow, multiply by .4 which gives 104.8±4.70) (由每行產量克數算成每畝斤數即以平均數乘.4得104.8±4.70)

$$P.E._M = \pm .6745 \sqrt{\frac{D^2}{n(n-1)}}$$

平均或差

D^2 = sum of squares of deviations from the mean
與平均數之相差平方之和

n = number of individuals
個體數

$$P.E._M = \pm .6745 \sqrt{\frac{6056}{5(5-1)}}$$

$$= \pm .6745 \sqrt{\frac{6056}{20}}$$

$$= \pm .6745 \sqrt{302.8}$$

$$= \pm .6745 \times 17.40$$

$$= \pm 11.74$$

Calculated by First Changing Yield per Row in Grams to Catties per Mow (by multiplying the yield per row by .4)

先將每行產量算成每畝斤數即以每行產量乘.4而後計算平均或差

First Check Series 第一組標準區	D	D^2
84.8	20.0	400.00
112.0	7.2	51.84
93.6	11.2	125.44
124.0	19.2	368.64
109.6	4.8	23.04
5 | 524.0		968.96

Mean 平均數 = 104.8±4.69 (the slight difference between this and 4.70 is due to recording to only two decimal places) (兩法計算結果微有出入因小數點以下祇用兩位之故)

$$P.E._M = \pm .6745 \sqrt{\frac{968.96}{20}}$$

$$= \pm .6745 \times 6.96$$

$$= \pm 4.69$$

Method for Calculating the Average Probable Error of the Mean of the Checks in Per Cent

標準區平均數之平均或差百分數之計算法

First Method
第一法

	Average Yield and Probable Error 平均產量與或差
1st check 標準一	104.8 ± 4.69
2nd check 標準二	107.2 ± 5.77
3rd check 標準三	97.6 ± 4.88
4th check 標準四	91.6 ± 4.38
	401.2 ± 19.72

Divide the sum of the errors by the sum of the yields to obtain the probable error in per cent

或差之和被產量之和除以求或差之百分數

$$\frac{19.72}{401.2} \times 100 = 4.92\%$$

Second Method
第二法

P.E.$_M$ of Each Check in Percentage 每個標準區之平均或差百分數
4.48%
5.38%
5.00%
4.78%
4 | 19.64%
4.91%

The second method has been used for the preparation of the data in Table 6, but for a large series of tests the first method is to be preferred. It requires less work to calculate the general probable error in per cent and avoids the necessity of averaging per cents.

第六表之結果乃用第二法計算而得,但於大多數試驗用第一法較為適當.計算平均或差百分率較為簡便且可避免平均百分率之弊.

$$2X = 4.91\% \times 2 = 9.82\%$$
$$3X = 4.91\% \times 3 = 14.73\%$$

Method for Calculating 2X × Average Yield

2X乘平均產量之計算法

The average yield for variety 41 is 108.4 catties per mow 品種41之平均產量為每畝108.4斤

2X × 108.4 = 9.82% × 108.4 = 10.64 catties per mow 每畝斤數

The other values in the column entitled *2X × Average Yield* or *3X × Average Yield* are calculated in a similar manner. 2X乘平均產量或3X乘平均產量欄下之其他各數亦由同樣方法計算而得

probable error in this way. It may be that one will find that few, if any, of the strains yield more than the values obtained by using three times, or even two times, the probable error, and the question will arise as to whether all of them should be discarded. This will depend on the actual gains obtained and on characters other than yielding ability. If the gains are all very low, being only slightly better than the check, it is possible that one may not have any useful strains in his test. If a number of strains are found which show a gain over, or are just equal to, the value obtained when using two times the probable error, these should be given a chance for one more year's testing at least. This is equivalent to saying that the probable error is used in selecting the more superior strains.

After the calculations are all completed, one would use the field records together with the record from the laboratory examination and the yield performance to select the strains that are to be continued in the test for the fourth year.

Methods for the Fourth Year —The methods for the fourth year will be the same as those for the third year except that it will be desirable to have ten rows of each strain with the check rows arranged every fifth row as usual. If a large number of strains have been under test, it may be that - on account of the shortage of land or labor - it will not be possible to test all of those saved from the five row series in the ten row series. If this is true, one would move the best selections from the five row series to the ten row series, keeping the poorer ones in the five row series. A plan of planting will be made which will indicate the strains to be planted and the rows in which they grew the preceding year, taking care to provide for the necessary check and guard rows. If one chooses, he may assign permanent pedigree numbers to the strains kept, as is indicated in the planting plan, Table 7.

The planting in the field as well as the usual details that have already been described must be carefully executed and checked to see that no errors occur in the plan of planting or in planting the material in the field. During the growing season, the usual notes will be taken; and, after picking, the usual laboratory studies will be made. The field records together with the laboratory records and the yield data will be used in selecting the strains for further testing.

The calculation of the yields will be made in a manner similar to that described for the five row series. The theoretical check yields will be obtained by grading between the two nearest checks, and the probable errors for the different groups of checks will be determined as in the five row series. With the ten row series, however, there will be ten checks in each group. After the probable errors for each group of ten checks have been obtained, a general probable error for the whole experiment will be obtained based on the yield of the checks and the probable errors calculated in a manner similar to that for the five row series.

A change is made in the application of this error in the ten row series in that we shall use what is known as the probable error of the difference. By this we mean that, when one is comparing two series of results - each of which may have a probable error - we obtain the difference between the two results and a probable error, which is called the probable error of the difference. Then indicating the probable error of the difference by P. E. $_D$, it is calculated by the following formula: P. E. $_D = \sqrt{E_1^2+E_2^2}$. Since we are using this probable error merely as a guide in selecting the strains that are to be kept in our tests, we use the shorter formula for the probable error of the difference rather than the full formula.

In applying this formula to our results in which we have the probable errors calculated for the check plots only, we assume that the probable error of any variety will be equal to that of the check. This is only an approximation since, in some instances, the probable error of a variety may be higher or again it may be lower than the probable error obtained from the checks. Assuming then that the probable error of any variety is equal to that of the check, we may obtain the probable error of the difference between any variety and its calculated check yield in the following manner: From Table 7 we find that the average probable error for the checks is 3.15. Assuming now that any variety would have this same probable error, we have by substitution in our formula $P. E._D = \sqrt{(3.15)^2 + (3.15)^2} = 4.45$. This probable error of the difference may also be obtained by multiplying our general probable error, 3.15, by the $\sqrt{2}$ or $3.15 \times \sqrt{2} = 3.15 \times 1.414 = 4.45$.

In making our selections from the ten row series, we shall take three times the probable error of the difference or 3 x 4.45, giving 13.35. This value is then used to multiply the yield in catties per mow in order to obtain a selection factor to be used for selecting the superior strains. In using three times the probable error of the difference in the ten row series, we shall make a higher requirement to be met by those varieties or strains that are kept in the test. In the five row series we suggested using only two times or three times the probable error. If one chooses, he may use the probable error of the difference even for the five row series but, as this series is based on the yield of five rows only and as the different strains have been under test for yield only two years, it does not seem that it is necessary to make such a high requirement. It may be pointed out that, when taking three times the probable error as was done in the five row series, one is using a value which is near that which would be obtained by taking twice the probable error of the difference. For example, the probable error for the five row test is 4.91, and when this is multiplied by the $\sqrt{2}$ and then by 2 we obtain the value 13.88. Three times the probable error, 4.91, is 14.73, which is a little higher than the value obtained for the probable error of the difference. For rough approximations, therefore, three times the probable error will give a value approximating twice the probable error of the difference.

In making an application of the general probable error for the ten row series, we may now proceed to multiply each yield in turn by 13.35, which is three times the probable error of the difference. It is not necessary to multiply the yield of every strain by this factor since, by inspection, some of them may yield less than the check; and, unless they possess some unusually good characteristics, they would be dropped from further tests.

Table 7 — Plan for Planting Ten Row Cotton Test with Method for Calculating Results

表七 — 棉花十行試驗種植計劃書及產量計算法

Last Year's Row Number 去年種植行數	Variety or Strain 品種或品系	Row Number† and Yield 行數†與產量 — Series 區別: I	II	III	IV	V	VI	VII	VIII	IX	X	Total 產量總數	Average Yield in Catties Per Mow (total†×.04) 每畝平均產量(斤)(總數乘0.4)	Theoretical Check 推算標準	Gain or Loss 產量比較	X* × Average Yield X*×平均產量	Percentage of Lint 衣分
	Check 標準	*0* 232	291	284	236	201	292	322	287	253	222	2620	104.8±3.30 (3.15%)				35%
1004	1-3	*8001* 278	*8061* 280	*8121* 285	*8181* 252	*8241* 254	*8301* 270	*8361* 298	*8421* 289	*8481* 284	*8541* 270	2760	110.4	102.0	8.4	14.75	33%
1011	3-1	*8002* 294	*8062* 312	*8122* 307	*8182* 287	*8242* 290	*8302* 302	*8362* 325	*8422* 314	*8482* 317	*8542* 322	3070	122.8	99.2	23.6	16.41	37%
1024	3-2	*8003* 210	*8063* 225	*8123* 215	*8183* 196	*8243* 243	*8303* 226	*8363* 245	*8423* 212	*8483* 204	*8543* 214	2220	88.8	96.4	-7.6		36%
1032	3-4	*8004* 261	*8064* 210	*8124* 212	*8184* 205	*8244* 203	*8304* 242	*8364* 246	*8424* 214	*8484* 212	*8544* 195	2200	88.0	93.6	-5.6		35%
	Check 標準	*8005* 220	*8065* 282	*8125* 244	*8185* 192	*8245* 238	*8305* 210	*8365* 281	*8425* 203	*8485* 178	*8545* 222	2270	90.8±2.97 (3.27%)				
1043	4-1	*8006* 265	*8066* 233	*8126* 216	*8186* 224	*8246* 242	*8306* 216	*8366* 283	*8426* 204	*8486* 192	*8546* 195	2270	90.8	90.2	.6	12.13	37%
1057	4-2	*8007* 192	*8067* 203	*8127* 186	*8187* 206	*8247* 223	*8307* 184	*8367* 232	*8427* 186	*8487* 172	*8547* 165	1950	78.0	89.5	-11.5		36%
1074	4-4	*8008* 282	*8068* 276	*8128* 242	*8188* 285	*8248* 263	*8308* 252	*8368* 301	*8428* 277	*8488* 252	*8548* 276	2710	108.4	88.9	19.5	14.48	39%
1082	4-7	*8009* 238	*8069* 274	*8129* 243	*8189* 216	*8249* 198	*8309* 206	*8369* 239	*8429* 208	*8489* 236	*8549* 214	2272	90.9	88.2	2.7	12.14	32%
	Check 標準	*8010* 216	*8070* 278	*8130* 241	*8190* 185	*8250* 184	*8310* 232	*8370* 256	*8430* 196	*8490* 211	*8550* 187	2190	87.6±2.77 (3.16%)				
1096	5-1	*8011* 196	*8071* 212	*8131* 210	*8191* 176	*8251* 208	*8311* 187	*8371* 209	*8431* 196	*8491* 174	*8551* 152	1920	76.8	87.0	-10.2		34%
1123	5-4	*8012* 269	*8072* 305	*8132* 261	*8192* 239	*8252* 276	*8312* 284	*8372* 296	*8432* 272	*8492* 250	*8552* 205	2660	106.4	86.3	20.1	14.22	36%
1146	6-2	*8013* 220	*8073* 260	*8133* 212	*8193* 209	*8253* 198	*8313* 184	*8373* 189	*8433* 176	*8493* 202	*8553* 184	2034	81.4	85.7	-4.3		37%
1174	6-4	*8014* 240	*8074* 252	*8134* 242	*8194* 206	*8254* 196	*8314* 192	*8374* 212	*8434* 220	*8494* 216	*8554* 224	2200	88.0	85.0	3.0	11.76	34%
	Check 標準	*8015* 194	*8075* 252	*8135* 238	*8195* 178	*8255* 245	*8315* 189	*8375* 236	*8435* 184	*8495* 176	*8555* 218	2110	84.4±2.55 (3.02%)				
		⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮						
		8060	*8120*	*8180*	*8240*	*8300*	*8360*	*8420*	*8480*	*8540*	*8600*						

† The row number is printed in italics

† 行數數均係用斜體字印

* X = 3 (average probable error of the mean in % × $\sqrt{2}$)

(平均數之平均或差百分數 × $\sqrt{2}$)

= 3 (3.15% × $\sqrt{2}$)

= 3 (3.15% × 1.414)

= 13.36%

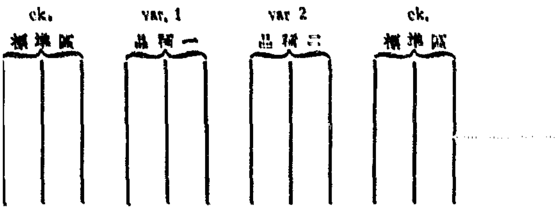
It is possible to facilitate the work by preparing a table which may be used in making the selections. One may prepare such a table by inspecting the yields for any particular year. Suppose that they vary from ninety to one hundred and forty catties, it is sufficient for practical purposes to make up the table for yields differing by five catties rather than to make all of the individual multiplications. As an illustration of what is meant, we may take a yield of ninety catties. Multiplying this by our factor, 13.35 per cent we obtain 12.01; taking another yield of ninety-five catties and multiplying this by our factor, we find a value of 12.68. This indicates that the difference between the selection factor for a five catty difference in yield is very slight and, therefore, to save labor it would not be necessary to multiply by all the small differences that may occur between ninety and ninety-five.

By using this table as a guide together with the field notes that have been taken, one will be able to select the more promising strains. After completing the laboratory study on the lint characteristics, one would select the better ones to be continued in the test.

Methods for the Fifth Year or the Advanced Test — For the fifth year's yield comparisons, it is desirable to use plots of a larger size; therefore, for the Chinese varieties a four-row block is recommended and for the foreign varieties a three-row block. That is, instead of having single rows, each strain will be planted in three-row blocks. The more promising strains from the fourth year test will be included in this fifth year test. Some of the less promising ones may be continued another year in the ten row test. For the fifth year it is recommended that two types of test be conducted. One test will be that of having three rows of each variety planted with a check plot, consisting also of three rows, planted every third block instead of every fifth as before. It is desirable to repeat these blocks five or, better, nine times if seed and land are available.

Figure 3 — Diagram Showing the Method of Arranging the Rows in an Advanced Test. A Check Plot of Three Rows Is Sown Every Third Plot.

圖 三—高級試驗行排列方法，每第三區為標準區，標準區亦為三行。



The varieties in this test will be arranged in systematic order; thus one plot of each variety will be planted with the checks every third. When one plot of each variety has been planted, the second series will begin and the varieties will be arranged in the same order as before. This method is shown in Figure 3.

The method for calculating the yields for this advanced test will be similar to the one just described for the ten row test with certain modifications. The theoretical check yields will be obtained as before and then the probable errors for the checks will be calculated but, instead of having ten checks for each group, we would now have forty for the Chinese cotton and thirty for the foreign. The probable error therefore will be calculated on the entire number as indicated in Table 8. The average probable error for the whole advanced test will be obtained as for the other tests, and three times the probable error of the difference will be used for selecting the strains to be continued in the test, as indicated in the Table. Using three times the probable error of the difference, we find the value to be 7.23. Multiplying the yield by this gives us the selection factor as indicated under the column X × *Average Yield*. Variety 3-1 yields an average of 116.7 catties per mow and gives a gain of thirteen catties over the theoretical check. This is several catties more than the selection factor and, therefore, this variety would be continued for further testing.

The other test that is recommended for the fifth year is that of planting either four-row or three-row blocks of each variety, depending on whether Chinese or foreign cotton is being tested, but the varieties will be arranged at random. The variety that has been used as check will be included as one of the varieties to be tested, and there will be only the same number of check plots as there are plots of each of the different varieties. By random arrangement is meant that the location of any one variety in the field will be determined by chance and not by any systematic arrangement. Suppose that twelve strains are being compared in systematic order in the first series then, by including the check, there will be thirteen varieties for testing by random arrangement.

The location of these varieties in the field will be restricted in that, in the first series of thirteen plots, only one plot of each variety may appear and so on for the second series of plots. The location of any one of the thirteen varieties will be determined purely at random which may be done in any one of several ways. One may have the numbers from one to thirteen (representing the variety numbers) written on cards and another series of cards with the thirteen plot numbers written on them.

Table 8 — Plan for Planting Advanced Cotton Test with Method for Calculating Results

表八 一 棉花高級試驗種植計劃書及產量計算法

Last Year's Row Number 去年種植行號	Variety or Strain 品種或品系	Row Number† and Yield 行號†與產量 — Series 區別: I	II	III	IV	V	VI	VII	VIII	IX	X	Total Yield 產量總數	Average Yield in Catties per Mow (Total × .01) 每畝平均產量(斤)(總數乘.01)	Theoretical Check 推算標準	Gain or Loss 產量比較	X*× Average Yield X*×平均產量	Percentage of Lint 衣分
	Check 標準	*9001* 280	*9061* 205	*9121* 252	*9181* 301	*9241* 296	*9301* 246	*9361* 294	*9421* 216	*9481* 195	*9541* 230						
		9002 274	*9062* 206	*9122* 234	*9182* 318	*9242* 332	*9302* 287	*9362* 316	*9422* 232	*9482* 251	*9542* 205						
		9003 258	*9063* 214	*9123* 278	*9183* 316	*9243* 324	*9303* 278	*9363* 306	*9423* 238	*9483* 283	*9543* 245						
		9004 242	*9064* 282	*9124* 225	*9184* 305	*9244* 312	*9304* 226	*9364* 292	*9424* 224	*9484* 290	*9544* 212	10520	105.2±1.69(1.61%)				33%
5002	3-1	*9005* 245	*9065* 276	*9125* 284	*9185* 318	*9245* 322	*9305* 276	*9365* 332	*9425* 256	*9485* 293	*9545* 271						
		9006 252	*9066* 278	*9126* 292	*9186* 320	*9246* 344	*9306* 352	*9366* 304	*9426* 296	*9486* 254	*9546* 262						
		9007 260	*9067* 272	*9127* 302	*9187* 312	*9247* 335	*9307* 302	*9367* 314	*9427* 258	*9487* 328	*9547* 285						
		9008 272	*9068* 304	*9128* 246	*9188* 298	*9248* 324	*9308* 316	*9368* 299	*9428* 284	*9488* 292	*9548* 240	11670	116.7	103.7	13.0	8.44	32%
5008	4-4	*9009* 237	*9069* 224	*9129* 264	*9189* 298	*9249* 274	*9309* 256	*9369* 294	*9429* 232	*9489* 216	*9549* 223						
		9010 264	*9070* 232	*9130* 244	*9190* 278	*9250* 294	*9310* 282	*9370* 287	*9430* 242	*9490* 220	*9550* 233						
		9011 242	*9071* 240	*9131* 282	*9191* 306	*9251* 326	*9311* 312	*9371* 322	*9431* 292	*9491* 254	*9551* 244						
		9012 202	*9072* 234	*9132* 215	*9192* 294	*9252* 286	*9312* 274	*9372* 284	*9432* 256	*9492* 220	*9552* 231	10410	104.1	102.3	1.8	7.53	38%
	Check 標準	*9013* 245	*9073* 208	*9133* 226	*9193* 292	*9253* 287	*9313* 238	*9373* 312	*9433* 220	*9493* 198	*9553* 202						
		9014 286	*9074* 221	*9134* 216	*9194* 278	*9254* 312	*9314* 223	*9374* 297	*9434* 218	*9494* 209	*9554* 230						
		9015 233	*9075* 202	*9135* 294	*9195* 298	*9255* 222	*9315* 306	*9375* 322	*9435* 294	*9495* 221	*9555* 283						
		9016 203	*9076* 212	*9136* 302	*9196* 312	*9256* 216	*9316* 220	*9376* 315	*9436* 284	*9496* 201	*9556* 222	10080	100.8±1.81(1.80%)				33%
		⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮						
		9060	*9120*	*9180*	*9240*	*9300*	*9360*	*9420*	*9489*	*9540*	*9600*						

† The row number is printed in italics

†行號數均係用斜體字印

* X = 3 (Average probable error of the mean in % × $\sqrt{2}$)

(平均數之平均誤差百分數 × $\sqrt{2}$)

= 3 (1.705% × $\sqrt{2}$)

= 3 (1.705% × 1.414)

= 7.23%

The two series of cards will be kept separate and, after thorough shuffling, one card will be drawn from those having the plot number and one card from the variety group. The card drawn from the group of plot cards will indicate the number of the plot and the card drawn from the other group will indicate the variety number that is to be planted in that plot. There are other ways of determining purely by chance, such as using the pages of a book and adopting the first number turned to. The point to be observed is that the location of any strain is determined by chance and that only one plot of a variety may appear in any series.

After the thirteen varieties have been located in the first thirteen plots, the process may be repeated until the desired number of replications has been reached. For this random series, it is desirable to have at least ten blocks of each variety if land is available. If land is not available, a smaller number of replications may be used, but the larger number is to be preferred. This random arrangement is illustrated in Table 9.

Table 9 — A Diagram Indicating the Arrangement That May Be Followed for Testing Thirteen Varieties with Ten Replications. The Varieties Are Distributed in Each Block by Random Arrangement as Illustrated by the Numbers

表　九一圖中表示有十三品種,每品種用十區試驗之排列方法.
每集團中各品種之排列,並無秩序,如號數所示者.

Block 集團數	Plot Number 品種區號												
	1	2	3	4	5	6	7	8	9	10	11	12	13
1	5	8	9	11	4	7	12	2	10	13	3	1	6
2	3	13	2	6	12	10	4	1	8	11	5	7	9
3	1	7	12	3	13	11	9	5	6	4	2	8	10
4	9	10	5	1	7	8	6	3	2	12	11	13	4
5	11	2	3	7	6	5	10	12	13	1	4	9	8
6	4	6	8	10	2	1	7	11	9	3	13	5	12
7	7	9	13	12	5	3	8	4	1	6	10	2	11
8	10	1	4	5	8	9	11	13	12	2	6	3	7
9	8	3	7	9	10	4	5	6	11	13	1	12	2
10	6	4	10	2	1	12	3	9	5	7	8	11	13

The method of calculating the results from a randomized series of plots will differ from the methods that have been discussed for the systematic methods of planting. This new method is known as the analysis of variance.

In order that this may be clearly understood, the method is given in detail using the data from Table 10.

Table 10 — Data Used for the Analysis of Variance
(the data are assumed yields for five varieties with ten replications)
Yield of Cotton - Catties per Mow

表十——差異分析之記錄(五品種十區試驗之假定產量)
棉花產量—每畝斤數

Variety 品種	Number of Replications 重複次數										Total 總數	Mean 平均數
	1	2	3	4	5	6	7	8	9	10		
A	122	124	136	142	126	148	132	136	140	124	1330	133
B	106	116	121	134	124	125	124	112	126	102	1190	119
C	110	118	124	105	114	118	116	116	122	117	1160	116
D	104	100	108	94	112	102	106	101	114	99	1040	104
E	118	112	111	115	114	127	112	115	108	118	1150	115
Total 總數	560	570	600	590	590	620	590	580	610	560	5870	587
Mean 平均數	112	114	120	118	118	124	118	116	122	112		117.4 General Mean 總平均

The first steps in the analysis of variance are to obtain the total for the variety yields, the mean of each variety, the total for each replication, and the mean for each series of replications or each block. The total yields for the varieties are obtained by summing the values in the rows, and the yields for the replications or blocks are obtained by adding the columns. The analysis of variance consists of finding the amount of variation due to the difference between varieties and the amount of variation due to differences between the blocks or the different replications. By obtaining the variation due to these two causes, it is possible to obtain a net error which will be the error of experiment.

It is necessary now to determine the total sum of the squares of the deviations of each plot from the mean of the whole series. This may be done by obtaining the mean first and then taking the difference between each plot and the mean for each plot in turn. Unless the yields dealt with are very large, it is just as convenient to assume the mean as zero and to square the yield of each plot directly. Thus we obtain the square for the first plot of variety A, 122, and for the second plot of variety A and so on for all of the fifty plots. The total sum of these squares is 695910. Since these have been obtained from an assumed mean of zero, it is necessary to correct for the true mean. This may be done by squaring the mean, 117.4, and multiplying by 50, the number of plots. This gives 689138. The mean is squared because we are dealing with squares. This correction factor may also be obtained by multiplying the grand total, 5870, by the mean, 117.4. This correction factor is now subtracted from the total sums of the squares of the individual plot yields as follows:

Total sums of the squares of individual plot yields	695910
Correction factor	-689138
Remainder	6772

This remainder is the total sum of the squares of the deviations of the individual plots from the mean. In order to complete the analysis, we now arrange the following Table:

Table 11 — Giving the Values for the Analysis of Variance
表十一—差異分析之數值

Variation due to 差異之因	Degrees of Freedom 自由變異個數	Sum of Squares 平方之和	Mean Square 平均方	1/2 Loge (平均方) (mean square)
Replications (columns) 重複 (縱行)	9	722	80.22	1.0411
Varieties (rows) 品種 (橫行)	4	4332	1083.00	2.3424
Error 差數	36	1718	47.72	.7814
Total 總數	49	6772		

The total sum of the squares which we have just obtained appears at the bottom of Table 11. At the bottom, under the heading *Degrees of Freedom*, also appears the number 49. For our purpose it is sufficient to state that in examples of this sort the degrees of freedom are one less than the number of plots. The total variation given by the total sum may now be divided into the variation due to replications, the variation due to varieties, and the remainder or the variation due to the error of the experiment.

We may first determine the variation due to blocks or due to replications. This is obtained by squaring the total yield of each block as, for example, 560 which is the total for block 1 and 570, the total for block 2. These values are squared and the calculation completed as indicated below:

Replications (columns)

Total Yield of Each Block		Square of Total Yield of Each Block
560		313600
570		324900
600		360000
590		348100
590		348100
620		384400
590		348100
580		336400
610		372100
560		313600
	Sum	3449300
	Divide by 5 since there are 5 varieties in each block	689860
	Subtract the correction factor	-689138
	Remainder	722

This appears in the first line of Table 11, and there are nine degrees of freedom since there are ten blocks in all.

The variation due to varieties is obtained by squaring the total yield of each variety. The details of the calculation will now be given:

Varieties (rows)

Yield		Square
1330		1768900
1190		1416100
1160		1345600
1040		1081600
1150		1322500
	Sum	6934700
	Divide by 10 since there are 10 replications	693470
	Subtract the correction factor	-689138
	Remainder	4332

By summing the variation due to blocks and that due to varieties and subtracting this sum from the total variation, we have the remainder, 1718, which is the total sum of the squares from which we obtain the error of the experiment. The degrees of freedom are also obtained by summing the degrees of freedom of the blocks and varieties and subtracting from the total degrees of freedom. This leaves thirty-six degrees of freedom for the calculation of the error. The several sums of squares are now divided by the appropriate degrees of freedom, giving the mean square.

The test of the significance of the differences in yield of the varieties depends on whether there is any important difference between the mean square due to varieties and the mean square due to error. If the mean square due to varieties is considerably larger than the mean square due to error, then one may assume that there is some significant difference between the yields of the different varieties.

A more exact way of determining this fact is given by Fisher, the author of this method. This consists of determining one - half of the natural logarithms for the mean square values. This appears in the last column of the Table as $\frac{1}{2} \cdot Log_e$. If the mean squares are large numbers, the mean square may be divided by ten or one hundred before the logarithm is obtained. The difference between the logarithm due to varieties and that due to errors is then obtained; and, by looking up in appropriate Tables which Fisher has prepared, we determine how large a difference may be expected between varieties and error if all the plots had been sown to the same variety or, in other words, how large a difference may be expected due to chance alone. When this difference, as shown by the tables, is larger than would be expected from chance we may say there is a significant difference between varieties.

We may now complete the analysis of the variety yields. One way of doing this is first to determine the error of our experiment which we now call the standard error. This is obtained by taking the square root of the mean square for error, 47.72, which is 6.91. This is the error in catties for any one plot. The total yields may be used for comparing the different varieties, and in this case we need the standard error for a total of ten plots. This may be obtained directly as follows: the standard error of the total of ten plots equals $\sqrt{47.72 \times 10} = 21.84$. This is now converted to percentage by dividing by the mean of all the plots, 1174: $\frac{21.84}{1174} \times 100 = 1.86$ per cent. The total yields of each variety are also obtained in per cent as indicated below. In order to test the significance of any variety we use the standard error of the total in per cent, 1.86 per cent; and, since we want to obtain the standard error of differences, we multiply this by the $\sqrt{2}$ or 1.86 per cent $\times$ 1.414 = 2.63 per cent. Twice this value, or 5.26, is then obtained and it is assumed that any variety that differs by more than this amount in per cent from the mean of all varieties is significantly different. The total yields and the yields expressed as a percentage of the mean and the standard error are

	A	B	C	D	E	M	S. E.
Total	1330	1190	1160	1040	1150	1174	21.84
Percentage	113.29	101.36	98.81	88.59	97.96	100	1.86

Thus we conclude that variety A is significantly better than the mean of all varieties and variety D is significantly poorer.

The method just outlined would be extended for any number of varieties one has under test, and it is desirable to obtain the appropriate tables for the interpretation of these results, which are given in Fisher's book (*Statistical Methods for Research Workers*, Fourth Edition, R. A. Fisher; publisher, Oliver and Boyd) If one has a large number of varieties, it is more convenient to make up different groups for testing. Suppose one had forty varieties for such a test, it would be better to divide them into four groups of ten varieties each or into two groups of twenty varieties each.

Having these two kinds of tests for the fifth year will give very definite information as to the field performance of the several strains. The usual field practice, such as note-taking and the like, will be followed as before. It is desirable to do more selfing so that a greater quantity of seed may be had for the multiplication of that strain which should be multiplied for general use. In order to obtain sufficient seed it is best to have several seed rows or a small seed block for the fifth year. These seed rows should be long enough so that they will furnish plenty of seed for the following year's work and some for multiplication. Earlier it was suggested that seed rows may be started with the beginning of the improvement work but, if selfing has not been practiced, seed rows should be planted beginning with the fourth year test.

While the plan just outlined is called the plan for the fifth year, the same plan should be followed for two or three years. That is, those strains that have been continued in the test from the boll rows to the advanced test have shown promise so far as their commercial value is concerned and should be tested thoroughly until the best one or two are found. One would not have a large number of such strains in an advanced test and, in order to determine definitely which one or ones should be multiplied and eventually distributed to farmers, it is desirable that they be continued in the advanced test two or three years. Naturally, any that prove undesirable will be dropped even after one year in the advanced test. The points that should be considered in keeping a strain in the advanced test or dropping it are not only the yield but the length and fineness of the lint, disease resistance, and other such characters that are of practical importance.

If, at the end of the first year in the advanced test, a few strains seem to be much more promising than the others it will be desirable to begin to multiply them so that by the time the test has continued one or two years more a large quantity of seed of the better sorts is available. This may mean that, at times, one may begin to multiply strains that may later be discontinued; but, even so, it is better to begin to multiply early than to wait until the test has been completed before beginning the seed multiplication. Since the station will have some land given to the growing of general cotton and any one of the strains from the advanced test will undoubtedly be an improvement over common cotton, the land given to the multiplication of a strain that may later be dropped will not be wasted; and, as stated, it is best to start the multiplication early so that the seed of the improved strains may reach the farmers as quickly as possible. When, as the result of the test, it is possible to select one strain or possibly two, these should be multiplied as rapidly as possible and arrangements made to distribute the seed to the farmers.

After the results of the first-year-advanced-test have indicated some of the more promising varieties, it will be desirable for the station to arrange for a number of regional tests. That is, arrangement should be made with schools, hsien stations, or other organizations having land for experimental purposes in cotton-growing regions to handle a small field test in which the improved varieties together with some of the local varieties may be compared. The same improved varieties and, to a certain extent, the same local varieties should be grown in all of the regional tests if possible. This will enable the station to determine what type or types may be more generally adapted, and this information will be useful in determining what strain or strains should be multiplied for general distribution.

It should be stated that it is not desirable for a station to multiply and distribute several strains of the same type of cotton. It is much better to select one strain and distribute it as rapidly as possible. If it is necessary for the station to work with more than one type, then the number of strains of each type distributed should be kept low. If the conditions for which the station is working are such that in certain regions an early variety or some other special strain is desirable while in another region a different type is wanted, the station should endeavor to meet these needs; but it is improtant to keep in mind the fact that one good strain multiplied and distributed to the farmers is much better than several mediocre ones.

Hybridization —The previous discussion of and directions for cotton improvement and testing are based on selection. As the work of cotton improvement in China continues, it will be desirable to resort to hybridization. At present, it is better to place emphasis on selection than to start work in hybridization.

Hybridization should be undertaken only by those persons who are sufficiently trained in genetics as to be able to handle the work in a satisfactory manner. To meet certain cultural or environmental conditions and with the possibility of improving the quality and amount of lint, it will be desirable to do some work with hybridization. It is possible that certain varieties of Chinese cotton may be found that possess desirable characteristics which, if possible to combine in a new type of plant, would give a better plant either from the standpoint of yield, length and quality of lint, disease resistance, or something of that sort.

In those regions where foreign varieties prove to be superior to the Chinese varieties, certain types of foreign varieties may be found which possess desirable characteristics that may be combined through hybridization. Since crosses between the Chinese types of cotton and the foreign types are sterile, the crossing of these types should not be undertaken except by expert geneticists who may be able to develop a technique that may make possible the production of fertile hybrids between the Chinese and foreign types.

When crossing between Chinese types or between foreign types is to be undertaken, the work must be very carefully done. The flowers to be crossed should be emasculated early before any pollen is shed and, as a precaution, it is desirable to wash the pistil which can be done by means of the type of wash bottle used in chemical laboratories. After emasculation, the flowers should be covered by means of thin paper bags and properly tagged. It is also desirable to bag the flowers on plants of the variety that has been chosen as the male parent. Usually emasculation is done one day and the pollinations made the day after.

The crossing will be done by collecting the pollen from the flowers of the plant chosen as the male parent and dusting it on the pistil of the flower that has been emasculated. It is best to use pollen from only one plant in making any one cross. That is, the pollen of several plants of the same variety should not be mixed together. Different plants of the same variety may be crossed, but it is best to use the pollen from only the one plant for any one cross. After the pollination is completed, the paper bags should be replaced over the flower and a record made on the tag showing the cross that has been made. Either this should be done or the tag given a number and a record kept of the number of each cross and the varieties crossed.

For example, if one is crossing Chicken Foot with Million Dollar, the tag on the pollinated flower of Chicken Foot may bear merely the number 1; and then a record in the proper notebook will be made as follows: Cross No. 1, Chicken Foot × Million Dollar. As already stated, it is best to use the pollen from one plant for each cross and therefore the record may read Cross No. 1, Chicken Foot 1 × Million Dollar 3. This would show that plant number one of Chicken Foot has been crossed with a plant of Million Dollar that has been given the number three. One may simplify the work by using one plant as the pollen plant for several crosses. For example, Million Dollar 3 may be used as the male plant for making several crosses. As shedding occurs to such a large extent, it is desirable to make a large number of pollinations for each cross that it is planned to make.

After the boll has begun to develop, the bag may be removed, but it is very important to keep the boll properly tagged so that the seed will be saved when the cotton is mature. The seed will be collected, making sure that the seed from each boll is kept in separate bags. The lint will be removed from the seed when preparing the seed for planting the following year.

It is important to have a satisfactory system for numbering the hybrid seed. One method that may be used will be described: If crosses have been made between Chicken Foot and Million Dollar, the seed from the cross in which the same plant of Chicken Foot has been crossed with the same plant of Million Dollar may be given the number 1a. Where different plants of Chicken Foot and Million Dollar have been used, the cross may be given the number 1b and so on for as many crosses as one may have made where different plants of the same varieties have been used. The number 1 will indicate that the same varieties have been crossed, and the letter will indicate that different plants have been used in making the cross.

If reciprocal hybrids have been made - that is, if Million Dollar has been pollinated by Chicken Foot - it is a simple matter to indicate this by numbering the cross 1ar, the *r* denoting that this is a reciprocal cross.

The seed from each cross will be planted separately in the field, and it is desirable to practice thin seeding so that it will be possible to have only one plant in a place. The flowers on these plants should all be selfed and the seed from each plant saved separately, and the seed from each plant will be numbered 1a1, 1a2, 1a3, and so on. This means that the first plant of the cross that is saved is given the number 1, the second the number 2, and so on. If another cross has been made between the same varieties but with different plants, the number would be 1b1, 1b2, 1b3, and so on.

It may happen that the seed for a particular cross were not actually crossed due to faulty technique. This can often be told readily by observing the plants in the field; where it seems that certain of the plants are not hybrids, the series can be discarded.

Since the plants of the immediate cross, or the first generation plants as they are termed, are all hybrid, it is desirable to save a large quantity of seed of this generation. The selfed seed from any one plant may be bulked together, and it should be stored carefully to avoid dangers of loss. In preparation for planting the following year, the lint will be removed; and, since it is desirable to have a large number of plants - or a large population as it is termed - it will be desirable to delint the seed by means of sulphuric acid. This will insure a more rapid germination and should produce a better stand than if the seed are not delinted.

It is desirable to practice thin seeding so that only one plant will be left in a place. The seed from each F_1 plant will be sown separately. That is, all the seed from 1a1 will be sown by itself, and then this may be followed by the seed from 1a2 and so on. Since this generation, known as the second generation, will be the one in which segregation occurs, it is important that the plants be carefully observed throughout the early growing season and that a large number of the different types be selfed. Since it takes two years to reach the segregating generation (one year for the cross and one year for the first generation) it is important that a large quantity of seed from a large number of plants be saved. The selfing, therefore, should be conducted on a very large scale.

The plants from the different crosses may be numbered in the following way: those that are saved from the first series 1a1 will be numbered 1a1-1, 1a1-2, and so on for as many individual plants as have been saved from this cross; those that are saved from another cross as, for example, 2a1 will be given the number 2a1-1 and so on for as many plants as are saved from this cross. Since certain of the plants that are saved will segregate the following generation and since others may breed true, it is desirable to plant a large number of seed from each of the second generation plants that have been selfed.

The seed for the third generation will be prepared for planting and handled in the same way as for the second generation. The plants will be studied in the field and notes taken. The notes that are taken will indicate which series should be continued for further testing, and the individual plants in these series should be selfed. One should keep in mind at all times that it is desirable to have a large quantity of seed, and therefore selfing should be done on a large scale. Certain of the third generation series may have bred true. If some are found that possess desirable lint characteristics and seem to be promising, the individual plants would be planted the following year in a plant-to-row series; and from then on they would be handled in the same manner as described for the handling and testing of selections.

Those series that are still segregating would be continued in the fourth generation in the same manner as was followed for the third generation. Selfing will be continued, and any promising strains that are found in the fourth generation will be placed in a plant-to-row series and the method of testing continued as already stated.

As a general rule one will obtain enough true-breeding segregates from the third and fourth generation to give sufficient material for testing. However, if the cross is a very important one, it may be desirable to continue the individual pedigrees for one or more generations further, that is, for the fifth or sixth generations. Whether one does this or not will depend on the amount of material obtained from the third and fourth generations and on whether other, more promising material is being obtained from new and different hybrid combinations.

As indicated, any of the hybrid strains that seem to be promising from the standpoint of lint characteristics will be placed in the regular test and handled just the same as the plan for testing selections. After the comparisons of the hybrids or selections have been continued for a sufficient length of time to enable one to select the more promising strain, this promising strain should be multiplied on the station grounds so as to obtain a large quantity of pure seed. Since cotton crosses so readily and as there are many chances for mixtures to occur, the multiplication fields should be carefully observed and all plants that do not conform to the type that is being multiplied should be discarded. This should be done before the cotton begins to bloom. This means that, as soon as the plants are well developed so that the characters may be readily distinguished, well-trained men should go through the field and any off-types (those that do not conform to the type being multiplied) should be pulled out. This should be done every year with all multiplication fields.

After the station has a large quantity of seed of the new variety, efforts should be made with farmers or with cooperative societies to grow the new variety of cotton, saving the seed for further distribution. In arranging with the farmers or with the cooperative society, it is important that they grow the new variety of cotton only; for, if two varieties are grown on the same farm, there is danger of the mixing of seed and thus all of the labor and cost of producing the new seed may be lost.

In order to insure the purity of the seed for further distribution, the fields of these individual farmers or fields of those farmers belonging to the cooperative society must be observed and the off-types pulled out as before. The multiplication and distribution of seed are just as important a part of cotton improvement as that of producing a better strain. Unless it is possible to cooperate with individual farmers or with well-organized cooperative societies for the multiplication of the improved seed, there is little need to spend time and money in developing better varieties since it will be impossible for any one station to own or control enough land to produce all the seed of the improved variety that may be desired.

In those cases where it is possible to work with farmers who cooperate well and with well-organized cooperative societies, it is best for the station to supply these good farmers or cooperative societies each year with pure seed from the station farm. This will aid in maintaining the purity of the seed. Thus the station staff members should keep in as close touch with the multiplication and distribution of the improved varieties as they have with the work of producing the improved variety.

Conclusion

The need for improved varieties of cotton for the different cotton-growing regions of China is very great, and it is necessary that steps be taken to obtain good varieties for all the different regions. The importance of testing the Chinese and foreign varieties that are already in existence has been emphasized since, in this way, it is hoped that it will be possible to obtain varieties already in existence that may be used with satisfaction in the different regions of China until breeding and selection have produced better sorts.

Even though this is possible, it is recognized that it is necessary to undertake thorough-going cotton improvement work; and for this reason the methods of selection and hybridization have been outlined together with satisfactory methods for field testing. It will take several years to develop an improved strain of cotton and therefore it is very important that, when an improved strain is obtained, it be given a thorough test in a number of different localities to determine its range of adaptability.

After the results of these regional tests indicate where the improved strain will give satisfactory results, steps must be taken to insure a rapid multiplication and distribution of this seed to the farmers. The same care over multiplication and distribution must be exercised by the station officials as has been given to the experimental work leading to the production of a new variety. The methods that have been outlined for testing the different selections or hybrids may be summarized as follows:

First Year — Boll or plant rows

Second Year — Two or three rows of each strain distributed in the field with a check row every fifth row. The length of row to be twenty or twenty-four feet depending on whether Chinese or foreign cotton is being grown. The rows may be longer but it is better to have more replications of shorter rows.

Third Year — Five rows of each strain distributed in the field with a check row every fifth row. The length of row to be the same as in the second year.

Fourth Year— Ten rows of each strain distributed in the field with a check row every fifth. The length of row to be the same as before.

Fifth and Succeeding Years - Two separate tests are recommended for the fifth year. In one test three-row blocks of each strain will be grown with a check block of three rows placed every third block. The length of row to be the same as before. Each strain is to be replicated nine times if seed and land are available, giving ten blocks of each strain.

The other test consists of having three-row blocks of each strain replicated nine times, but the arrangement of the strains in the field will be determined by chance or will be arranged at random. The variety that has been used for the check will be included in this test as one of the varieties, and there will be the same number of check plots as there will be of the strains.

If land is limited, the number of replications for the two fifth year tests may be reduced; but for more accurate results it is better to use the larger number of replications.

Seed Rows It is best to have special seed rows for the selfing so that the regular planting for yield comparisons will not be interfered with due to the tramping of the field and the selfing of the flowers. If selfing has not been practiced in the early years, the seed rows should begin with the fourth year test.

中國棉花改良法

洛夫 著　陳燕山譯

一、引　言

棉爲中國主要農作物之一,南北各省,皆有種植,惟因其栽培方法,故步自封,不知改善,致生產數量,尙不足以供紡織界之需要,每年仰給於海外者,爲數甚鉅,利權外溢,頗足驚人;故對於中國棉產之增加及品質之改良,實爲當務之急。至於棉產之增加,固可利用已耕地或開闢新地,以資推廣,然以棉作替代其他作物,而使糧食之生產減少,亦非妥策;更當權衡事勢,雙方兼顧,以使其作平均之發展。利用已耕地或開闢新地,從事植棉,固能增加產量;如就已經耕種之棉田,亟圖改良,以增加每畝之產量,亦爲必要之舉也。

改進棉作,當注意於雙方面:首爲總產量之增加;其他即爲改良品質,以應市場之需要。增加產量之方法,又有數種:如栽培法之改進,土壤之改良等是,然於中國重要產棉區域,如能獲得優良棉種細心種植,其產量之增加,亦頗可觀也。

欲得優良棉種,可按以下兩種方法行之:第一,由大規模之品種或區域試驗,在某一區域中,可以得到較原有品種更能適合而優良之新品種;第二,用育種方法,以育成優良品種。

用育種方法產生新品種,其主要方法亦有二種:即選種與雜交是也。由栽培法之改進與土壤之改良,雖亦能增加產量,但對於品質改良上,如增加纖維長度及其他各優良品質等,功效甚小。因此欲求品質之改良,仍非從改良品種之根本方法上着手不可。至於品種之改良,可由品種試驗或育種方法爲之。如能以育種方法謹愼進行,則對於任何作

物之產量與品質等,俱有增進之可能。此篇之論述,其目標乃在討論如何應用作物育種方法,以使棉作得能改進也。

所謂較良品種者,乃尋覓現有品種能在某區域中,較之該區域原來種植之品種,更能適合優良之意也。棉花在中國栽培,面積頗廣,因環境之不同,而土壤與氣候之差異亦大,故各處需要之品種又隨之而不同矣。

近二三十年來,中國為謀棉種之改良,特由外國引進各種品種甚多,其歷史,有數處已在三十年以上;但對於某處產棉區域,究以何項品種最為適宜,尚無充分之試驗結果。雖有數處已決定宜於中棉或美棉,然此種決定所基之證據,仍有未充,尚未足解決中國各部之中美棉適應問題。即於某區域中已知其適應中棉或美棉。但究以何種品種最為優良,仍難作真實之判明也。

此種問題,既是事實,故棉作在任何區域內,其改良之步驟:第一,須視該區域內之風土情況,決定其宜於中棉抑美棉;第二,在適宜棉種中,又以何項品種最為優良。故凡棉作試驗場之研究棉作者,當搜集各種中外棉種,舉行精密之品種試驗。此種試驗規模不宜小,對於試驗之時期,更須延長,以期得到最確實最美滿之結果。何種品種,最為優良,又當視纖維之品質——包括長度韌力與其他優良性狀——及每畝之產量而定。此等條件,不能僅憑個人之觀察,更必另有詳細之記載及精密之研究,方能據以為實。各品種行試驗時,一切操作,均須一致,且種植之重複次數尤不能少,俾資可靠。依精密長期試驗之結果,可以決定該區域內何種品種最為優良,然後推廣於農民,而令其種植。迨以後用育種方法,育成更優良之新品種再設法置換之。

二、選種

改良棉作品種以求產量及品質之增進,當應用育種方法育成在

某產棉區域較爲適合之優良品種。欲應用此法以改進棉作,按中國目前之情形,且較爲有望者,厥爲前述第一種之選種方法。姑先討論此方法於下:

選種對於棉花產量與品質之增進,極爲有望,已如上述。所謂選種者,乃由適合該處種植之品種中,選擇單株或單莂(鈴)以尋求優良純系之謂也。如在研究棉作改良之區域中,見有某種適合之品種,而尚未純粹者,則將該項品種,種植於較大之區域內,以資選擇單株或單鈴,作爲繼續試驗之用。

選種之最好方法,當在較早時期,到多數棉田中,考察棉作生長之狀態,而後選擇之;認爲最優良之棉株加以記號,以作識別。選種時,對於何者爲良株,必當加意辨認,蓋棉作之生長習性不同,有多數品種,其生長木枝較果枝爲多,木枝發育雖茂盛,結果實少,或結果稍多而太遲。此種現象各品種均有之,不過有多少之差別耳。在中棉中,有數種品種,木枝之發生較果枝爲多,棉株生長雖高,而結果甚少。在無經驗之選種者,有時被此種現象所迷惑,以爲選擇此項發育強盛高大之棉株,較之矮小者必能得良好之結果,其實不然也。

在棉田中考察棉株生長之狀態,遇有必選之良株,即插一竹桿以爲標幟,或代以其他取價較廉之材料,或繫布條於株端,亦可。惟中國農民所耕種之面積甚小,如於其田中選擇多數棉株,則農民定受損失,是可預先與之接洽,出資以償其所失也。

至於在較早時期,往田間選擇良株之原因,乃因棉花爲常異交之作物,在田間天然雜交之機會甚多,故必預先設法,將欲選之棉株,妥爲防範,實行自交之工作。如是,則所得之種籽,較之任其在田內行自由之雜交者,必見純粹也。

棉花施行自交,能結實如常。據一般研究之結果,棉花自交數年,對於生長能力及產量,既無損減,又不退化。平日雜交,大半皆藉蜂類及其

他昆蟲以為媒介,故對於棉作欲行自交,其方法當在未開花以前,用紙袋罩花,或用薄布將全株罩住,此種薄布須使空氣流通,然不如用紙袋較為適當;其他用鐵絲繞於花朵之尖端,或用紙夾(即迴形針)挾住花瓣之尖端亦可使之不能開放,以避免雜交之發生。普通用迴形針挾花,結果頗稱良好。尚有用紙牌套花者,因自交棉花須掛一紙牌,以資識別,在紙牌之中間,開一小縫,套於花之尖端,如此掛牌與套花,一物可兼二用,極為便利。

在田間選擇單株,能使其自花受精,其利益有二:用單株之種籽,作育種之起始,較之用單鈴之種籽,對於時間上,大概可節省一年,一也;用自交之種籽,較之任其在田內行異花受精之種籽,更能純粹,二也。

作物之選種工作,其起始選擇單株之數目,本愈多愈好,然因須先在田內選擇單株,而後再行自交,對於第一年所選之數,往往被其限制。第一年選擇,多數固屬重要。他如種籽之純潔及每株上應有較多之種籽數等,亦關重要。是以育種者,對於獲得多數自交之單株種籽,乃為最緊要之事。

上述各方法,未必盡能依照進行,如事實上不能辦到,則用單株選種,不加自交;若并單株選種亦不能行,則選單鈴,根據以往之經驗及智識,就該處適宜之品種中,作儘量之選擇可也。

為求各種相異品種,備作試驗材料起見,第一年須往各區域內,先行選種。所選擇之區域,其氣候及環境,當與所欲行育種工作之地互相彷彿,不可相差太遠。採選之數目,可按照經費與試驗地之多少,儘量搜集之,愈多愈好。如於起始作此種育種工作時,所選數目,祇有四十或五十個上下,則對於棉作之改良,恐無裨益焉。

選種工作人員,以曾受訓練,經驗豐富者行之為最宜。若無此種人才,須先行訓練而後派遣之,決不可令其昧然從事。選種時,最當明悉者,即何種宜選優良品質之標徵何在。此種情形,非有經驗及熟練者,絕難

辨認,最好由主持此種育種工作者,自行出外選擇,或與助理者同往田間,詳細考察。如是對於各產棉區域之情形,及所種之種類,必能明瞭,同時對於棉作改良上之一切問題,亦可加以實地之研究,則將來之改進方法,自應更見妥實矣。

如第一種所建議之方法能實行,卽於較早時期,到田間選擇單株,加以標記,而行自花受精。作大規模之試驗,是爲上策。如該種方法,不能實行,只可選擇棉鈴。當選種時,紙牌紙袋,須充分預備,以便在某處選得棉鈴或單株之籽棉後,隨時可以裝套安插之。在某一村莊所選擇之材料,裝在一處,詳記村名,以明其地域之所在。此種記載,有二種意義:一,能使研究者,得知由某處所種之棉花,種類如何;其次,卽在某處選擇之材料中,如遇有優良品種發現時,則能回到原處,再作第二次選擇之工作。

在每一田中,選擇棉種,當選若干棉株或棉鈴,並無確實之數目,只須品種良好,足以代表該品種之標準形質者,皆可儘量搜集,以作試驗之材料。遇有特異新奇之棉種,亦當留之。選種時間如見寬餘,對於纖維,尙可加以考察,用小梳將纖維梳齊,以觀其實質究如何,至少亦須用手指將其拉出,考查其長度與品質;若果粗劣,則無須選擇,立時將其淘汰可已。在一田中選種時,須顧及田之各部分,決不可單就最良好之一部施行選擇。據一般之觀察,均以爲在肥沃田中,棉株之生長狀況,皆稱茂盛,一株上之棉花,較瘠薄地上之棉株所生者,有加倍之收量;然以遺傳性狀而論,生於瘠土內,而生長平常之株,其生產能力未必卽次於肥土中而生長極佳者。故不良田地中,有時亦有較良之棉株。總之,此項棉株選得後,卽爲將來新品種之根原。欲圖結果之良好,對於採選上,自不可不特別注意也。

選擇時,對於棉株之形態,如分枝習性,纖維品質,以及抗病能力等,尤當留意。卽棉鈴成熟吐絮時,棉絮是否易於脫落,頗爲重要。但此種習性,各品種均不相同,其中差異極大。大概棉絮成熟易於脫落者,乃爲不

良之性狀,因棉絮落在地上,極易污染潮濕,往往減損色澤,在價值上能受極大之影響故也。

三、種籽之處理

選得之棉鈴,隨時晒乾,如於試驗場附近,選擇一批單株,則每株上之棉鈴,可分別裝於紙袋或信封中,如係鈴選,亦如是辦,袋上附以記號以資分別。最緊要者,即所有棉鈴,均須充分晒乾,不能稍帶潮濕,否則易於生霉,必減少其發芽力。

如在遠處選擇棉種,將所選之材料,由郵局寄到試驗場,或自行攜回均可。此項材料,亦須晒乾以防生霉,蓋中國農民在田間採取棉花,非常勤速,甫經開放,即行採取,完全開放之棉花,存留於田間者甚少,內中包含水分甚多。故採選後,當隨即晒乾,而後妥爲封裝,方不致於損壞也。

選得之棉鈴,送到試驗室以前,固已完全乾燥,爲穩妥計。日後仍須常常放在太陽中曝晒,及其眞正乾燥,再行貯藏。每株上之棉花,如用紙袋裝存,曝晒時,有將棉花取出者,俟其晒畢,每袋棉花,仍必歸回原袋以免混雜,如用小布袋,則不須將棉花取出,即袋口亦無須開放,故混雜之機會極少。

四、試驗室之考查與種籽之預備

在田間選種,對於纖維之品質,在可能範圍內,當詳爲考察。惟因田間忽促,不能精密,故必攜回試驗室中,再經考查一次。有數處試驗場,對於室內考查,非常精細,致費時太多。要知此種選得之種子,在第一年並無須精密考查,蓋各品系之生產能力,尚未得知,若僅以纖維之長短,專作取捨之標準,則纖維稍短之品系,勢必被其淘汰。此淘汰之品系其生產能力,或較纖維稍長者遠爲優越,徒以纖維稍短,遂加淘汰,豈不可惜。且纖維之長短,亦與環境之適否有關,土壤中之水分,尤能影響於纖維

之長短,至某種限度。故選擇新種,對於纖維長短,不必過於苛求,此非謂各種短纖維之品系均應保留之,乃謂考察纖維,在第一年無須特別精詳,以致費時太多,對於選種之取捨,不可祇憑室內之考種也。如籽重花衣百分數等,無須詳細考查,對於纖維之細長度,及品質僅須作一大概之攷察,將適合纖維之品系,儘量保留,以作試驗之用可也。

選擇棉種,應保留之數目,乃視試驗地之大小與其他設備如試驗室及人工等而定。然試驗材料仍以多留爲宜,蓋作物育種之成敗,對於起始試驗時,所選單株之多少,有莫大之關係。其能得到產量較高品種與否,全由所遇之機會而斷定之,所選材料愈多,則獲得良好品種之機會亦愈大,故留作試驗用之材料,決不可少也。

供試種籽,經室內考查之後,即加以實地試驗,以觀其生長狀況及其生產能力如何,隨後再判別其優劣,而定取捨。室內考種,對於何種品種,具有高大生產力,無從得知。實地試驗之年限,至少亦須在二年以上。纖維較短之品種,有時尙能合用,其生產能力較纖維長者爲大,對於農民種植或稍有益。至環境在其生長緊要時,因水分供給之多少,最能影響於其纖維之長度,且各種種籽之來源不同,環境更有差異,故第一年之種籽,在室內考查,不可太嚴,以免良種被其淘汰。

種籽處理時,乃將經試驗室考查以後,預備播種之種籽,先行除去種籽上之花衣,隨後擇其健全者,作爲試驗之用。纖維一經除去,卽將種籽放在一小紙袋內,而每一袋上,記以號碼,以資辨識,而免紊亂。

編號方法,首貴簡單,號碼愈小愈好,在紙袋及簿子上,記號時,須要便利。其最簡方法,頗有多種,有將各地所選擇之材料,分成各組,而不給號碼者;又有將各地選得之種籽分組後,卽附以地名續編號碼者;譬如由南通所選之品種,以南通名之,各個品種,再分別與以號碼,如南通一,南通二,南通三等,以至種號完畢爲止。由其他各處所選擇之材料,亦復如是。如此則所用號碼,比較爲小。此外尙有用各地分組,而號碼依次繼

續而下者;如南通所選單本共計爲一百,若繼之以西安選種時,則其排列西安第一種,卽用一百零一號,如西安一零一,西安一零二號是也。

總之編號之方法,採用各有不同,互有利弊;如以各地分組編號,則有數種具有同樣之號碼,如某組第一號或第二號是。如於號碼之前,不加以地名,定必錯誤。第一年所選擇之材料,可無須給以特別號碼,只須記載各項選種之來源及給以種植之行號而已。其第一年各品系不給系號之最大原因,乃因此項材料,經一年試驗之後,恐有四分之三以上之數,卽被淘汰,則大多數之系號,被淘汰後,仍然無用,所謂一品系,卽指由單本而來之植株而言也。

在尋常情形,籽棉必須先經軋花機軋去纖維,而後將種籽作爲播種之用,若種籽爲數甚少,如鈴選或株選,則往往用手,先將纖維由籽上剝去。籽上絨毛,如不用手剝,改用濃硫酸浸種法,亦可除棄之。在濃硫酸中浸十五分或至三十分鐘,卽可將絨毛完全除盡。浸種時,須將種籽在硫酸中,時時攪動,如是絨毛脫落更能完善。硫酸對於種籽,並無損傷,不過絨毛除盡後,種籽必用清水洗淨,不能容有硫酸氣味存於籽上。爲穩妥計,水中可以加用石灰或安摩尼亞水以使之中和。此種浸種法,能促進種籽發芽,並有消毒作用,種籽上附有之一切病菌,藉此可以除去。或以爲硫酸浸種,太費金錢,殊不經濟,但此種除絨之種籽發芽較速,將來生於行中,棉株亦較爲整齊,結果當必良好,縱有若干費用,亦足以償其所失矣。(浸種後,發芽效力如何見第一表)

種籽上之絨毛,用手或用硫酸除去後,卽可預備播種。惟所選之品種,當擇一標準品種,以資比較。此項作標準或對照之品種,必用一最適於當地者。如該場尙未有優良品種,能作標準之用時,則於選種時預先與農民接洽,就當地最普通最適宜之品種中,預留一批種籽,專作標準品種之用;否則設法另取一品種,認爲在該處能有希望者,以作標準品種亦可。此項種籽預備數量宜多,應在一擔以上,除作標準用外,猶可繁

殖若干,以待來日之用。

五、種植計劃

在播種之前,須有種植計劃書之擬定,表明種子來源,各地所選品系數目以及種植方法等。其他播種應注意事項,亦均要預先規劃。種籽亦須依其種類之不同,分成中棉或美棉各組。若於中棉或美棉中,尚有不同之品種,可再另行分成小組。此種分組,對於某一處所有之選種,在種植計劃書中,未必能排在一處,勢必因品種之不同又須分成若干組。若以田間技術而論,可依品種之形態而歸類分組,較之以地方分組更能適合也。

育種工作在某處起始時,尚不知中棉美棉何者爲適,常於大多數之選系中,中美棉均有,斯時於預備種植計劃書時,中美棉應各做一份,較爲便利。所有種植材料須預爲措備。其種植計劃書中,對於安插標準品種,不可忽略,每第十行之地位,應爲標準品種。如試驗地寬裕,每五行可設一標準行,試驗中棉,用中棉品種爲標準;試驗美棉,卽以美棉品種爲標準。

預備播種之種籽,最好裝於不同顏色之封袋內,以便查考;供試驗用之品種,用一種顏色,標準品種,另用一色,如是於田間播種分配種籽時,一看便知。

種籽之以株爲單位者,卽預備株行種植計劃書,若以鈴爲單位,則預備鈴行種植計劃書。如二者均有,因鈴行與株行試驗,所用行長不同,必當各備一份。其鈴行種植計劃書之格式如下:

鈴行種植計劃書(民國二十四年)

選種號數或種籽來源		行號
	標準	0
南通或定縣等	1	1
	2	2

3	3
4	4
準 標	5
5	6
6	7
7	8
8	9
標 準	10
9	11
10	12
11	13
12	14
標 準	15
13	16
14	17
15	18
16	19
標 準	20

依次繼續而下,將一地所有之同樣品種,完全包括在內,隨後繼之以另一地方選擇之同類品種,至所有之鈴,皆有適當行號爲止。如試驗地狹小,每十行設一標準行,固如前述,如爲事勢所許,仍以每五行設一標準行,較爲良好也。

種籽之編號方法,於前節中曾已述及;但種植計劃書中,種籽之編號方法又視各人所要繼續之方法如何而定。此法有下列三種:(一)供試品種祇給一地名以作區別,不給任何選號;(二)記選種地名及給一號碼,此號碼自一號起至某一處所有種籽完畢爲止,其他另一處之種籽,亦由一號起至其完畢爲止;(三)除記以地名外,又給以號碼,此種號碼,並不中斷,即各地種號繼續而下,某一處種號完畢後,第二處之種號,仍繼第一處之末號繼續而下。

上述各法,可以隨其便利上採用一種。前已說明,號碼愈小愈好,故以第一種方法較爲合宜。據上例觀之,對於第一年種植計劃,乃用地名

及選種號碼,若祇以地名記之,亦可適用,將各地之種籽依次排列,給以種植之行號,如用此種方法,則於種植計劃書上,祇有行號而已。在任何作物育種工作,所需要之方法,須正確,同時亦要簡單,故對於記載任何種籽之系號,當設法使其所記號碼減小,若所寫之號碼較少則錯誤之機會亦少。

種植計劃書預備完畢,所有標準行亦依照所計劃者安置妥當,在播種以前校對一次,以免錯誤。此項糾正工作,最好由二人共同行之,一人觀察種植計劃書,其他一人卽誦讀紙袋上之選擇地名及行號,以便互相校對。

種植計劃書完全糾正後,將所有備妥之材料,安置於適當處所,各紙袋之種籽,不使其紛亂,待播種時,復將其攜往田間,彼時各紙袋中之種籽,亦不能任意搖動,以免播種時,混亂不淸也。

六、 第一年田間試驗之方法

田間任何試驗,未經開始以前,對於試驗地之選擇,最爲重要。一種田地之表面,縱屬平坦,但其肥力未必均一。選擇時,當然依照過去之經驗,選擇肥力均一者,以作試驗之用。其肥力雖絕對不能一致,要亦不能相差過多也。試驗區之排列,及播種之方法,乃依各地氣候情形之不同,常有所變更:如在乾燥區域,水患不多之地,可行平作,無須作畦;若排水不良,則必仍行畦作,於畦間另設排水溝以便排水。畦之闊度,亦由排水情形不同,難得一致,平時闊度,皆比所要播種之行長爲寬,不宜太狹,以免距離水溝過近,有被水冲洗之虞。

鈴行試驗地,每畦之闊度,以能種二鈴行之長度爲限,如水面頗高,或易於淹沒,可多開水溝,使每畦闊度,祇能種一鈴行之長度。但鈴行之長度,又視種籽之多少而定,每鈴之種籽,至少可種四五穴,所用行長,宜於一致,如是將來比較時便利多多中棉株距,新制用八寸,如種五穴,則

每行長四十寸,如須排水,其畦更當加寬,使種籽不至種於溝邊而有冲淵之患。其行間距離,約在一尺五寸左右。美棉株距一尺,五穴行長須五尺,行距在二尺至二尺五寸之間,如試驗地充足,最好用二尺五寸之行距。或謂行距無須太寬,因棉株不能充分利用寬闊之面積,頗不經濟,要知行距寬闊,棉株能以暢行發育,其生長狀態,旣稱良好,而觀察各種品性時,更能易於辨認,實較狹窄行距爲愈也。

第一年起始試驗時,如欲以株選爲育種之單位,則所有種籽之數較多,行長亦可增加。株距及行距,可以與鈴行試驗相同。如種籽數多,行長可用二十尺至二十四尺。採用行長,必須一律,不能稍有參差也。若用長行以作試驗,對於排水問題,亦不能不有所顧慮,如排水問題重要,又不能作寬十尺至二十尺之畦時,可改作狹畦,而令試驗行之長,與畦長平行,則排水問題,亦可以解決,照舊得以預備播種。

試驗區之周圍,當加以保護行,因試驗種籽不可種於田之邊際,應有相當保護,故須種保護行,藉以保護之。俟行長與行距決定後,排水問題亦已解決,即可開始播種,行中之穴距,依規定之距離,將其配好,先行劃溝,隨後開穴,再就其穴中施行點播。或以鋤開溝,而在溝中按相當之距離點播。

棉花試驗所用之播種量,必須充分,播種時先行密播,而後再行間苗,規定每行株數,務使每行棉株排列整齊,不致缺苗。有數種黏土,棉苗不易破土而出,播種後即遇暴雨,出苗更感困難,如每穴播下之種籽較多,則可共同頂土出苗,得免此弊。

播種行備妥後,即可將試驗種籽與標準品種,依種植計劃書,順次播下,每畦之起始,先種一二行保護行,試驗行之前,先種一標準行,而後再依所計劃者排列之,順序而下。畦之末端,須止於標準行,同時又須種一二行保護行。試驗行之排列方法,表明於第一圖中,可參閱焉。試驗行之前,插以鐵牌,竹製或木製均可,每十行或二十行插一個。如木牌充足,

每十行插一個,如第十號二十號等。第一個標準行前,亦插一木牌,以示試驗行之起始。保護行仍須插木牌,並註明保護行之行數,一行或二行,以作區別。

凡播種至每畦末端,必要依種植計劃,順序止於標準行,已如上述。若標準行後,所存之地不能再種試驗品種,以至其次之標準行時,即可不種試驗品種,以免標準行之次序,有所紊亂。例如鈴行試驗,若以每十行為標準行,則每一畦之末端,必須止於標準行十之倍數;如以每五行為標準行,則止於五之倍數。若至畦之末端,在標準行後,祇能種一二行試驗行,可不種試驗行,代以保護行可也。第二畦起始時,先種保護行,繼之以特別標準行,而後再續種試驗品種。此種特別標準行,亦須插一木牌,注明特別標準及下一行之行號。每畦或排之起始處,或對於試驗行,如遇墳墓或其他障礙物,受阻礙時,均須添設特別標準行。

各袋種籽,依其順序在各行前排列妥當,必校對一次,方能播種,以免錯誤,每十行有一木牌表明之,予以校對上之便利不少。播種時先自一端起始,至畦之末端為止,照順序轉至第二畦,繼續而下。如每畦種二排鈴行,則鈴行之間,當有一小路,如係狹畦,則畦間小溝,即作為小路。若用寬畦,每畦上可容二鈴行之長度,其播種之方法如下:

鈴行之第一排,先種畦寬之半,樹一木牌於畦溝之邊側,俟種到畦之末端,即在同畦上回頭,繼續播種其餘之一半,在畦之溝邊,亦立一木牌,鈴行之間,留一間隔,以資分別。其排列方法見圖二。

如試驗地因排水關係,必須作成狹畦,而畦之闊度,祇能有種一鈴行之長度;或其地無排水關係,無須作畦,則可平作,不設排水溝,其種植方法如圖一,鈴行與鈴行之間,可留一走道,以便觀察。

各行試驗種袋,已安置無誤,並已校對清楚,即可開始播種,在相當距離內施行點播,每穴種同等種籽數,使其得同等之機會。播種後復行校對一次,以觀每種播植是否整齊,或有無遺漏。校對後覆土,不宜太深,

以免種苗難以出土。點播之穴,亦不必加深,種籽種於一點上,尤所切忌,最好稍爲分散於穴中,否則覆土後,種籽在土中深淺不等,若遇暴雨將土面壓實,覆土較淺者,尚可不致生礙,而覆土較深之種籽,則不易頂土而出矣。覆土後又當巡視一次,以觀其有無未經覆蓋之處。

播種完畢,卽就田間之情形,繪一地圖,將試驗行之田間排列狀況,記於圖中,註明每畦起始及末端之行號,以及保護行之行數等等。俟棉苗出土後,攜圖到田間校對一次,糾正有無錯誤之處,以及視察各行是否遺漏。

播種後其生長時期,發育狀況,抗病力,早熟,及其他重要性狀等,皆須有適當之記載,以備將來選種時作一臂助。對於折倒病 (Damping off) 之抵抗性如何,更須注意,蓋其爲害幼苗甚烈,不得不力爲防除也。如在試驗區中,任何一行內,發現惡劣之病害,而認爲易於傳播者,則當將該行之棉株,盡行拔去,以免蔓延。

棉爲常異交作物,不行人工淘汰,品系必雜而不純;先將田間記載,細爲考察一次,然後將優良鈴行選出,在當選行中,再選擇更優良者數株施行自交。其自交之方法,前已詳及,卽用紙袋或用鉄絲,繫於花之頂端,或用紙夾,或用紙牌開一小縫,套住花之頂端,自交種籽,必要分別清楚,故以紙牌掛於花上,將來可於收花時,分開採收之。因其天然落花之數頗多,所以自花受精之數目,亦當增加,俾得充分之種籽,不致因落花而使自交種籽有感缺乏也。

自花受精之需要與否,又依各地情形而不同,若需要絕對純粹之種籽,則非行自交不可。自花受精之工作,耗費時間與金錢甚大,但由自交獲得之種籽,品系確稱純粹。各處棉花受天然雜交之機會如何,須自行試驗,方可決定;蓋天然雜交之機會,各處不同,蜜蜂及其他昆蟲媒介物之多寡無定,而花粉傳佈之機會亦異,此項媒介昆蟲若少,天然雜交之機會卽小。但此種情形,或有改變,某時期內天然雜交之機會本小,以

後或因鄰近養蜂事業增加,則天然雜交機會,又必隨而增加。觀第二表,可以察知各處對於天然雜交之差異情形。

在某處試驗場,如當地天然雜交之機會甚少,所有試驗種類亦僅一種,則此項棉花在初試數年內,可不行自交,俟優良品系發現後,然後進行自花受精。如欲種籽絕對純潔可靠,則自花受精仍爲必要之手續。

用完全自交之種籽,以作試驗,固屬需要,但求多數之自交種籽,作爲每年試驗之用,則頗爲困難,例如欲在鈴行試驗中,選擇一二株,施行自交,俟獲得純潔種籽,作爲下年試驗之用,此事即不容易。如該試驗場,人工衆多,則大規模之自交工作,可以舉行。如天然雜交頗爲普通,而試驗場人工缺乏,則欲得多量自交種籽以供一切試驗之用,實爲不可能之事。欲用完全自交種籽,以作試驗用,旣爲事勢上所不許,則以後之試驗,可照下列數種方法舉行之:

如試驗場種植之種類,祇有一種,且當地天然雜交之機會甚少,即照前節所述辦理,在初試數年內,可以不舉行自交,俟以後得到優良品系再爲行之。此項工作,可以另設種籽區,較爲妥當。在天然雜交之機會甚大之地,欲求純粹之種籽,仍非行自交不可。

如不能得到充分之自交種籽,以供試驗之用,於鈴行試驗中,選優良棉株一二株,先行自交,將自交種籽種於種籽行內,以後再繼續行之,鈴行中之未行自交者,改作下年試驗行內種籽之用。第二年之自交工作,可在種籽行內,選擇最優良者二三株,繼續自交,而種籽行內之未行自交者,亦作爲下年比較試驗種籽之用;如此每年繼續進行,將種籽行區域,逐漸擴大,增加種量,以作繼續試驗用之種籽,最爲合宜。

此種每年試驗之種籽,乃由種籽行而來,種籽行之種籽,前一年皆曾行自交者,故種籽行內之未行自交者,爲期祇有一年,此雖不能供作最純粹種籽之用,然在人工有限,不能供給充分之自交種籽,作爲試驗時,亦可採用矣。若此種辦法繼續數年,以後缺點較少,因種籽區之種籽,

所能繼續存在者,皆係每年選擇之最優良品系,在種籽區內,雖尙未行自交,然對於試驗之產量影響頗小,在田間縱有天然雜交之機會,爲害亦不大,且經數年之繼續選擇,所存之品系,均稱優良也。

其他各種之改變方法,亦可應用,究不如前法較爲適宜,此項改變方法,卽在初試二年時,不舉行產量比較,僅行自花受精,在第一年鈴行中,將優良棉株,先行自交,留待下年種植,第二年仍繼續自交,應用評判能力,選擇優良品系,以作充分之自交種籽,爲下年比較試驗之用。

在某處試驗場內,如當地天然雜交之機會甚大,當注意一品種趨嚮之所至;其時期以愈早愈好,如行育種所用之品種,爲同一品種,天然雜交之機會,亦不少,而人工不多時在初試三四年內,先可不用自交之種籽,及第三四年以後,再另設種籽區,施行自交,亦可。

優良行選出後,可作爲繼續研究之用。先行預備口袋,採收棉花。此種口袋,用紙製或布製均可,仍以後者較爲合用,因棉花採收以後,須時常曝晒,如用稀薄布,作成口袋,則曝晒時,不必開口,祗須放在乾燥之平臺上卽可;若用紙袋,曝晒時,必將袋口開放,以使水分蒸發,使其易於乾燥,如此則不免有混雜之機會發生。再紙袋被風吹倒時,袋中棉花亦必隨之而傾於外側,如不注意,或有工人不知緣由,將棉花任意裝入袋中,則種籽又混雜而不能純粹。不過用紙袋,於登記號碼時,如行號及選號等,較之布袋爲容易耳。若用布袋,祗有另貼紙牌,用以表明之。

採收之鈴行或株行試驗之棉花,其中附有自交之棉株,則每株上有自交之種籽,當必分別裝入袋中,每株一袋。棉爲天然雜交作物,當初在田間選種時,或已受天然雜交影響,一行中之棉株,未必純粹,所以對於各株自交種籽,亦須分別收藏,用紙牌表明各選株之號碼;例如第四行爲當選之行,則其中之自交棉株,可以4(1), 4(2)或4-1, 4-2等之記號表明之。如以後各棉株可以合併,則以用第一法較爲適當,若仍須繼續分別試驗,實以用第二法爲宜。

中國棉花改良法

如將各株作分開之收穫,各品系較爲純粹。所謂品系者,卽指棉株由單本而來,如此項種籽,係由天然雜交甚少之處所選得,且行中之棉株,無論鈴行或株行,自外表觀察之,知各棉株均視爲相同,則可混合收穫,各株無須分別採收。

每次收花時,各選行之口袋,須攜至田內,按各袋上之號碼,放在各該行之一端,當注意其行號,不可錯誤。當選行中之自交棉株,分別收花,若行中之棉花,採收時,每次總有一端起始,則第一株自交棉株爲第一號,第二株爲第二號,以此類推,如是則株上之號碼,可無須特別記載,卽無標籤,亦能明瞭。

每次收花後,應放在日光中曝晒,而令其乾燥,然後妥爲保存,以待室內攷種。鈴行或株行中各選株之考種,較之第一年初選者,應當詳細。所須攷驗之性狀,卽纖維之長度,衣分(衣花百分率)籽指(百粒籽量)及品質等。取樣攷驗時,將各粒籽棉混和之,隨意採取,不可選擇,至於取樣之數目,可參閱第三表。此表之材料,乃由金陵大學彭壽邦先生所供給。其結果似取任何大小之棉樣,均無若何差異。若以試驗正確程度而論,以或差大小計算之,則以較大之棉樣爲好,其差異亦不顯著。茲因在初試時試驗材料甚多,所須考種之棉樣亦夥,故第一年之考種,每株或一系之種籽,卽取十粒或二十粒,均稱適當。

所有種籽經考查完畢以後,卽可用作參考,以選繼續試驗之材料。根據各項記載結果,將不良材料,作一部份之淘汰,惟改良棉作,除須注意品質外,對於田間生長情形及其產量,亦極關重要;室內考種,祇能注意於其品質之一部,如長度與衣分等而已,他如田間生長狀況,與其生產能力,亦須兼顧,所以保留種籽,仍須注重多數條件,淘汰手續,不可拘於一例,以免材料欠缺,

選種完畢,將種籽上之纖維除去,依其種類之不同,分成數組,中棉歸於中棉一類,美棉歸於美棉一類,如中棉或美棉中尙有不同之品種,

再將同品種之相異者,分成數組,日後在田間試驗時,得將同樣品種,或形態相似者,排在一處,以作比較;且對於行間或區間之生長競爭,亦可避免也。

七、 第二年田間試驗方法

第二年之田間試驗法,其行長較之第一年應增加若干尺,中棉至少須二十尺,而美棉爲二十四尺。如試驗地與種籽較爲充足,則行長仍可再行增加。然與其種一行較長之行,不如種二行或二行以上較短之行,較爲適宜也。上述之行長,對於計算結果時,較爲便利,如種籽充足,則各個選種,至少種植二行,然一品系之二行,不能種在一處,應俟各品種種植完畢後,再重複種植一次。

每第五行定爲標準行,所用品種,亦須與第一年鈴行所用者相同,除有特別緣因外。標準品種,不宜時常更動,以資統一。如第一年經試驗後,而知所用標準品種,爲不適當,固可另擇一適宜品種,以備代替,不過比較試驗,有廣續性,欲得各年之眞確比較成績,最好於數年繼續試驗之中,仍用同一品種,較爲妥實也。

根據各品種之形態,及由其所考查之情形,將同樣之種類歸成數組,以備擬定種植計劃書;此項種植計劃書中,註明品系或選號種籽之來源,各品種種植之行號,及去年種植之行號,均應列入,其排列方法,先將各品系自始至終,排列一次,隨後重複一次,自首至尾,再排列一次。

第二年之種植計劃書,其排列方法如下:

第二年或二行試驗種植計劃書

去年行號	品種或品系	種植行號 區別 I	種植行號 區別 II
	標準	0	
8	南通 7	1	1001
11	南通 9	2	1002

13	南通 11	3	1003
26	南通 21	4	1004
	標準	5	1005
133	定縣 133	6	1006
139	定縣 139	7	1007
146	定縣 146	8	1008
151	定縣 151	9	1009
	標準	10	1010

以此類推,繼續而下,至完畢而止。在此列中表示有八百品系,每第五行爲標準品種,第一列共有一千行,再重複一次時,則由一〇〇一行起以至於二〇〇〇行爲止。如種籽充足,試驗地有餘,每品系可種三行若用自交種籽,試驗時,非特種於第三列,已感不足,即第二列亦恐難有充足之種籽,因欲於每行能得充足之棉株,種籽仍非多備不可也。

種植計劃書備妥後,各品系之種籽,裝於小封袋內,各袋上之種植,行號,亦一一記明。袋上之種植行號及選種號,與種植計劃書校對一次,俟符合無誤,即將種籽妥爲保存於適當處所,以待播種。

播種方法之詳細情形,大概與鈴行試驗相似,不過種植行較長耳。如試驗場位於雨水較多處,爲圖排水之便利,則須作畦,此畦之闊度,最好按照能種試驗行之長度開之,即中棉之行長,至少二十尺,美棉至少二十四尺,如不能作成此種長度之寬畦,因排水不良,可作成狹畦,將試驗行之長度,與畦之長度相平行。

每第十行插一木牌,試驗行先用開溝器開溝,然後定穴,照鈴行種植法施行點播。又有數處試驗場,於開溝後採用條播者,點播與條播均可,依各地環境之不同,採用適當方法用之;最緊要者,務使其能得充足之幼苗,不致有感缺乏也。每畦之始末兩端,均須種保護行。凡一排之起始播種試驗行以前,又須種一特別標準行;例如三〇一行前之特別標準,即可在木牌上寫明特別標準三〇一行前以表示之。

播種之前,先將各袋種籽按號排列於行端,加以校對,視其無誤,再

行點播。每穴所用種籽數量要歸一律;棉作試驗常有缺苗之弊,播種宜密,並須預留種籽若干,以備補種之用。若種籽無餘,而仍有缺苗時,則可設法補種黃豆,或其他作物,藉以減少缺苗之影響。

棉種發芽後,對於初期生長之情形,即須記載;先繪田間地圖,攜去校對一次,以觀圖中所記載之行號等,有無錯誤。他如抗病,早熟,分枝習性等,關於良種選擇上,各種重要性狀,同時亦須檢查。不種種籽行者,是必選擇行中之優良棉株數株,留作自交之用,採用試驗區之第一列,盡作自交之用亦可。自交種籽務要充足,特設種籽區,專作收種之用,較爲便利。

收花時各行中之自交棉株,當分別採收,各株自交種籽,各裝一袋。一行中之棉株,確已認爲純潔時,則同行中各株之自交種籽,即可收在一處。若能於一株上,得到多數之種籽,則以後試驗,每系祇用一株之種籽,較爲純粹。其他關於曝晒,收藏各種手續,與鈴行試驗者同,姑從略;不過每行產量,當有記載,而行中之選株,亦應與其他各株分別收穫。

棉花採收完畢,及曝晒乾燥後,即舉行室內考種,檢其纖維之長度,衣分,籽指及其他有關選種之重要性狀,以作選擇優良品種之參考。比較產量,甚爲重要,產量與標準品種比較時,爲求其正確計,可將花衣百分數乘每行籽花之重量,求出花衣之重量,再以之比較。凡品系較標準區產量爲高,而有優良性狀者,方可選擇,留作繼續試驗之用。

選擇品系,恆視標準品種之程度如何而定;若標準區之品種,爲當地最優良之品種,且結果甚好,品系具有優良之品質,其產量稍比標準品種增多,即可當選而繼續試驗之。如標準品種,爲平常品種,品系產量,能較標準品種超過甚多時,方能入選。

在第二年試驗時,各品系之或差,無須計算,用標準行之產量,計算全試驗之或差數,可以得知該試驗變異大小之大概情形。祇以各品系之產量與標準品種作爲比較,對於各品系之選擇,頗稱便利。其比較之

方法,詳於第四表,卽種植計劃書及假定產量之表中。先將二行之平均產量算出,及標準區與各品系之平均產量,均求得後,再用標準區之產量,推算理論標準。

理論標準之計算法,亦有數種採取任何方法均可應用。第一種,乃將二行試驗全試驗標準行之產量總平均之,此項標準產量之總平均,卽以之作爲其他品系產量比較之標準。第二種方法,卽以最近二標準區之產量平均之,作爲中間四區之理論對照。第三法,卽所謂等級法,用等級法推算之,應用該法較爲適當。

等級法之計算方法;例如第一組二標準行之平均產量,每畝爲八十斤;其次之二標準行每畝爲七十六斤;若以二者相減卽得差數四斤。今因第二組標準區與第一組標準區相隔,距離爲五區,故以爲土壤肥力改變漸進,今第二對標準區之產量,少於第一對標準區之產量,則土壤之肥力,由第一對至第二對漸減,而其中間相隔共有五區,故以五除之,卽 $\frac{76-80}{5}=-.8$。今所得之數,既爲減號,則假定第一行與一〇〇一行,亦種標準品種,則較零行與第一〇〇〇行之產量,應減少十分之八斤,所以第一行與一〇〇一行之理論產量,爲七十九十分之二(79.2)斤,再次下一行爲七十八十分之四(78.4)斤。餘類推。

爲求得等級法之理論對照,最好將第二個標準區之產量,放於前面,與第一個標準區之產量相減,以示結果爲正號(加)或負號(減)。上例76-80,其結果爲負號數,故自第一個標準區80斤至第一個理論標準區當減少 8斤,其餘各個理論標準區,亦復如是,直至五行爲止。在第五行與一零零五(1005)行之下,其他一對標準區卽第十與一〇一〇行之標準區產量少於七十六斤;故其結果亦爲負號。其他理論對照,亦用上述方法推算而得,以至所有全試驗之理論標準,全行算出,以便比較。現今所述之計算數,皆就籽棉產量而論者,若各品系經室內考種,已知其衣分,則應用花衣百分數,乘各品系之籽棉產量,卽得每畝花衣重量,再

作最後之比較,亦屬可能也。

各品系之產量與標準品種相比較,得出之差數,可記於產量增減比較行內。凡產量較低之品系,即可淘汰。然有時有因特種原因,須保留以作繼續試驗之用者;例如有一品種,其產量雖較標準品種爲低,然纖維之品質甚優,或有抗病能力,須行保留,以觀其在較長時期內之結果。其品系之產量較高者,當然留作繼續試驗之用。總之此項當選之品系,應以具特殊之優良性狀者爲貴,產量稍低之品系,如遇有特種性狀,如纖維品質,與抗病能力等皆稱優良者,仍當留之。

在尋常環境之下,如一品系之產量,較之標準品種,每畝能增加花衣一二斤,不能作爲確實優於標準品種之品系;其產量有數斤以上之差異者,或可認爲以後能有多產之望,然此猶不能視爲定例,蓋一品種在第一年之結果,雖有較高之產量,以後未必仍不見減少也。凡品系具有較高之產量,纖維品質優良,已經當選爲試驗種籽者,即可除去纖維,妥爲封藏,預記於播種計劃中。

八、第三年田間試驗之方法

第三年試驗工作,較之第二年更爲擴充,各品系之種植行數亦須增加,如各品系有多數種籽,至少須種五行,即須預備五袋種籽,行長與行距,可與前年相同,如須增加行長,亦無不可。

爲圖產量計算便利起見,計算行長以行距相乘,能得一畝之適當分數,欲將每行產量,化成每畝斤數,則以簡單之因數相乘即得。例如中棉試驗,用行長二十尺,行距一尺五寸,如行長與行距相乘,可得每行之面積三十平方尺。而每畝面積爲六千方尺,則每行之面積,等於每畝面積二百分之一。美棉行長爲二十四尺,行距爲二尺五寸,每行面積爲六十方尺,等於百分之一畝。如中棉行長,尚須增加,最好先斟酌行長,使其適當,以合便利之改算因子。爲求比較試驗之正確,玆將各種行長之或

差詳列於第五表。

單行區之或差,雖依行長之增加而減少,然其減少之速度並不大。若行長由二十尺增加至三十尺,則所須地積亦必增加。吾人若將重複次數加多,則其結果更能正確,在有限制之試驗地,更屬重要。若試驗場之試驗地充足,人工亦多,可應用較長之行;但增加行長,實不如增加重複次數較爲適當,較長之行,種植仍須重複數次。因增加重複次數,所用之行長較短,較之用同等面積之較長行,而減少重複次數者,更爲可靠也。

第三年試驗或五行試驗之種植計劃書,亦須預備,此種種植計劃書,每五行爲標準行,每品系種五行列表如下:

第三年或五行試驗種植計劃書

去年種植行號	品種或品系	種植行號 區別 I	II	III	IV	V
	標準	0				
3	南通 11	4001	4801	5601	6401	7201
8	南通 41	4002	4802	5602	6402	7202
16	南通 54	4003	4803	5603	6403	7203
24	南通 62	4004	4804	5604	6104	7204
	標準	4005	4805	5605	6405	7205
	⋮	⋮	⋮	⋮	⋮	⋮
	⋮	4800	5600	6400	7200	8000

此項種植計劃書,假定所有品系及標準行,共計每列爲八百行,而每系重複種植五次,總計爲四千行。

播種方法與前年相同,每行之種籽,依種植計劃程序,按次排列。播種以後,於田間地圖上,詳註各種材料及播種之所在地,以便檢查;往後田間生長狀況隨時當有記載,收花時應注意之事及室內考種之各種研究,皆與前年者同,仍以室內考種之結果與產量之比較,作爲選擇之參考,以作繼續試驗之材料。

第三年之試驗,成積獲得後,卽計算或差數,作爲選種上之標準;其

計算方法,向有數種,試驗中之各品系及標準區逐一計算其或差數一也;計算所有試驗品系及標準區之平均或差數二也;祇用標準區之產量計算一大概之或差數三也。根據標準區所計算之或差數,雖是一概數,然用作選種之標準,亦稱適合,故將此項之計算方法建議於後,備供採用。惟此種或差數不能作爲評判品系優劣之最後標準,對於品系間之比較,亦不能作爲確實之數,蓋此數之計算,祇用標準區之產量,以貝塞爾氏公式 (Bessel's formula) 計算者也。

計算時,卽應用標準區之籽棉產量,而將每組五行標準區之或差求出之;例如第一組標準區在4001,4801,5601,6401,7201,行前之標準行0,4800,5600,6400,7200,其各行之產量在第六表上爲212,280,234,310,與274。

標準區之平均數及其或差,卽用貝氏公式計算之,此項公式與計算方法,詳說於第六A表中,每組五行標準區或差算出後,再將標準區或差計算一平均或差,應用此數於第六表中。此項或差數,能用數種之方法計算,如六A表所示,其適當而計算便利之方法,乃將標準區之平均產量總加之,其或差數亦總加之,而後將標準區或差之總數,被標準區平均產量之總數除之,再乘以一百,卽得平均或差之百分數,作爲選擇繼續試驗品系之標準矣。

應用此項或差數時,須先將理論標準或推算標準算出,而後將各品系之產量,與理論標準相比較,以求產量之增減數,亦已於前節說明,以此或差百分數之二倍數,乘各品系之平均產量,卽得一種選擇之因子數,註明於第六表中2X乘平均產量格內,其計算之步驟,亦詳細說明於第六A表中,可參閱之。凡品系之產量之增加較此標準,有超過者,可留作繼續試驗之品系,如選擇條件須從嚴格,仍可將其標準提高,卽增加因子數,而用三倍或差百分數,乘各品系之平均產量,此項因子數,可在3X乘平均產量行中註明之。

該種概數,僅能作爲指導選擇繼續試驗之材料,不能作爲確實之

數;如將各品系之或差數,各個分別計算,當較爲確實,今旣用之以爲選種指導,得一概數,亦屬相宜,若各品系之產量,能得大於標準品種三倍或差數,或二倍或差數者甚少,或完全無有,是否必將所有品系完全淘汰,當須觀察實際之產量,增加若干,更須注意該種品系品質究如何,或其他性狀系似而後决定之。如所有品系之產量增加,均屬低微,或較標準品種稍好,如是可認爲無良好品系之存在。若各品系之產量,較之標準品種爲大,或等於二倍或差數,則至少可繼續試驗一年,以觀究竟,故此項或差百分數之應用,不過作優良品系選擇上之取材已耳。

各項計算,一俟完畢,卽可將田間記錄,室內考種結果及產量比較,作爲選擇品系之考察,預備第四年試驗之材料。

九、 第四年田間試驗之方法

第四年之試驗方法,與第三年相同。本年試驗中,各品系之試驗行數,勢必增加,每品系種十行,仍以每五行爲標準行。如驗試品系甚多,或因試驗地有限,或因人工分配不足,不能將全部較優良之品系,由五行試驗皆升入十行試驗時,可將最優良之品系,升到十行試驗,較次者,仍留在五行內續試一年。種植計劃書亦須擬定,註明應種之品系行號及其去年種植之行號等。對於應有之標準行及保護行,皆須隨時注意。於此時期中,將在十行試驗之品系,可以給一永久系號。其情形於第七表種植計劃書中,業已註明,可資參照。

無論種植計劃書,或播種時之各行種籽,宜詳加校對。生長期內之田間記載,棉花採收後考種工作,皆如前舉行,仍依其結果之不同,以作選擇品種之參考。

本年產量之計算方法,與行五行試驗者無異;先求理論標準,以最近二個標準區之產量,用等級法推算之,隨後再將各組標準區之或差數算出,所不同者,在此十行試驗內,每組標準區有十行,每組標準區之

或差數算出後,即求全試驗之普通或差數,其方法同於五行試驗。

應用此項或差數,與前稍有不同,即增加所謂偏差之或差數是也。凡比較二項試驗結果,每項皆有一個或差數,如二項結果比較相減,得一偏差數,偏差或差數,用 P,E,D, 記號表示之;計算公式為

$P.E._D = \sqrt{E_1^2+E_2^2}$, 此項或差數,亦僅作為採選品系之引導,以資繼續試驗而已;故所用之公式,亦稱短簡,並非應用偏差或差之全部公式也。

此種公式,以標準區之或差數,應用於試驗之結果,吾人以為其他各品系之或差數乃與標準品種相同。然在事實上或非如是品系之或差數有較高於標準品種者,亦有較其為低者。今以此數作為概數,假定各品系與標準品種相比較,其偏差之或差數,即可以下法計算之:由第七表所算得之標準區平均或差為三・一五,假定任何品系之或差亦與此數相同,以數字代入於此公式後,可以算出之即

$P.E._D = \sqrt{(3.15)^2+(3.15)^2} = 4.45$, 此種偏差或差數,又可由普通或差數三.一五乘 $\sqrt{2}$ 或 $3.15 \times \sqrt{2} = 3.15 \times 1.414 = 4.45$ 求出之。

十行試驗之選擇方法,可應用三倍偏差或差數,或 $3\times4.45 = 13.35$, 此數再乘品系產量之每畝斤數,得出選種因子數,作為選擇優良品系之標準。今用三倍偏差或差數,乃為提高選擇標準,選擇較優良之品種或品系,以作繼續試驗之用。在五行試驗中,所用之選擇數,祇用二倍或三倍或差數,雖亦能應用偏差之或差數,然五行試驗所有產量,僅有五行之結果,而各品系之試驗時期亦僅二年,故無須求其較高之標準。五行試驗用三倍或差數,與二倍偏差或差數相近似,例如五行試驗之或差數等於4.91, 如以方根二 ($\sqrt{2}$) 乘以二倍數即 $4.91\times\sqrt{2}\times 2$ 即得 13.38 數;若以三倍或差數 4.91×3 即等於 14.73, 較之二倍或差數稍高;就其大概論之,由三倍或差數所得之價值,約與二倍偏差或差數相近。

十行試驗應用此或差數時,即以此數13.35乘各品系之每畝產量,所乘之數,即三倍偏差或差數。然每個品系不必均乘之,因其中有產量

不及標準品種者,此種品系,非遇有特別之品性,即可直接淘汰之。

為選擇便利起見,亦可預製一表,先觀察當年各品系產量之差異情形,假定有由九十斤至一百四十斤之差異,即以每差五斤之數,與或差數相乘,無須用每個單位之差數相乘。為明瞭計,再申述之:若以九十斤產量乘或差數13.35%,則得12.01斤,今以九十五斤之產量,乘以此或差數得12.68,由此可以證明,相差五斤之產量,與此或差數相乘,其所得之選種因子數,相差甚少。故為節省時間,在九十與九十五差異之間者,各個數即無須皆乘矣。

就此種選種因子數表,與田間生長狀況之記錄,可選出較優良之品系,俟室內考種手續完畢,即可決定去留,作以後試驗之材料。

十、第五年高級試驗法

第五年之產量比較試驗,須用較大之小區試驗,對於中棉可用四行區,美棉則用三行區。在第四年試驗中,所有較優良之品系,皆可升入此項試驗,其餘較次者,在十行試驗內,續試一年。第五年之試驗,同以下方法試驗,較為適當:即每品系用三行區,而以每第三區為標準區,標準區亦以三行為一區,每品種重複五次,如種籽及試驗地充足,最好重複九次。

此項試驗,每品種之排列方法均有定序;每品種種植一區,每第三區為標準區,品種種植完畢,再順照原有次序重複種植,以至重複次數終了為止;其排列方法見第三圖。

高級試驗之計算方法,除略有改變外,大致與十行試驗者相彷彿,理論對照之計算多與前法相同。各標準區之或差數,亦須算出,然所用行數與十行試驗不同,此種試驗,中棉有四十行,美棉有三十行,或差數之計算,即用全部行數,詳於第八表中。全試驗之年均或差數,如以前法計算之,用三倍偏差或差數,作為選種之因子數,以選擇優良品系,在表

中亦可以見之。今以三倍偏差或差數即 7.23 乘品系之平均產量,即得選種因子數,在表八 X 乘平均產量行中記錄之。今品種 3—1 之平均產量爲每畝 116.7 斤,較之理論對照超出十二斤,而比選種因子數亦超出數斤,所以此種可以當選。

第五年試驗之另一方法,即每品種仍用四行或三行區試驗,由中棉或美棉而異,但各品種之排列,不依秩序,標準亦無一定之地位,不過將標準品種加入,作爲試驗品種之一,故試驗中之標準區,等於其他各品種之數。所謂無秩序之排列,即每一品種,在試驗區內,所佔地位,無一定之秩序,其排列之地位次序,完全憑機會決定之。若在有秩序排列試驗時,有十二品種,則在無秩序排列爲十三品種,因加入標準品種一種故也。

此項試驗區之排列,雖無秩序,然亦有相當之限制,第一組之十三品種,每種祇有一區,以後每次重複之十三區,每一品種亦爲一區,每一組中十三品種排列之地位,並無一定,完全憑機會而定。此種方法頗有數種:有用紙片十三個,每片記一號碼,自一至十三寫爲品種號,再另用紙片十三個,上寫區號,次將十三個,品種號,與十三個區號,各分一堆,俟完全抖亂後,每次向各堆各抽一個每次所抽出之品種,即種在所抽出之區號內。他如應用書中頁數之第一字,或用其他方法均可。然每一組品種中,每品種祇種一區。

十三品種第一組隨機排列定後,另須重複抽籤,以定各品種在第二組中之地位,至所要之重複次數完畢爲止。在此種無秩序排列試驗中,至少每品種須有十區,若因試驗地有限制,則重複次數,亦可減少,總以較多之重複次數爲良。無秩序之排列方法,說明於第九表中。

無秩序試驗區產量之計算方法,與前所述之有秩序排列方法不同,此項計算方法,即所謂差異之分析 (Analysis of Variance) 是也。茲爲明其計算方法計,特將第十表中之產量記錄,作爲此法分析之材料,

詳第十表。

差異分析之第一步,先求出各品種產量之總數及其平均數,重複區之總數及其平均數。各品種之總產量,乃將横行之產量相加;而重複區之總產量,係將縱行相加。所謂差異之分析,乃將品種間及重複間之差異數,先行求出,由此差異數之大小,再求出淨差數,卽爲試驗差。

其次之計算,卽求各區之產量,與總平均相差之平方和。此數由每區產量與總平均數相差,及各差數平方相加之和卽是。如所用數字不大,可假定總平均數爲零,以各區自身產量平方之,例如品種A第一區之產量爲一二二,卽以此數平方之,隨後再以第二區者平方之,以至五十區爲止,此五十區之總平方數爲六九五九一〇。今旣以假定平均數爲零,故當糾正,以求離平均差之眞數。其法可用總平均數一一七·四自方,而乘以五十;卽五十區所得之數爲六八九一三八。其總平均自方,因其他各數,亦由平方而來。此項糾正數可用總數之和五八七〇,再與平均數一一七·四相乘,亦得此數。卽自各區平方差之和數減去如下:

各區產量平方之和	695910
糾正數	—689138
	6772

由此相減之餘數,卽爲各區離平均數差數之平方之和數。全試驗詳第十一表。

平方之總和,卽在表十一之最末一行內,在自由變異個數之最後一行之數字,爲四九。所謂自由變異個數,卽總區數減一之數。今將所有總差數可以分成重複之差,品種之差與其存餘之差數爲試驗差。

求得重複區之差數,將各組重複區總數平方;例如五六〇乃是第一組之總數,而五七〇爲第二組之總數,此總數各個平方而後相加如下:

重複(縱行)

每組重複區之總產量	各組總產量之平方
560	313600
570	324900
600	360000

590		348100
590		348100
620		384400
590		348100
580		336400
610		272100
560		313600
	總 數	3449300
	因每組內有五品種，以五除之。	689860
	減去糾正數	689138
	賸 餘	722

此數在第十一表中第一行見之,因重複區共有十次,故能自由變異個數爲十減一,等於九。至於品種之差異數;乃將各品種之總產量平方之;其計算方法如下:

品 種(橫行)

產量		平方
1330		1768900
1190		1416100
1160		1345600
1040		1081600
1150		1322500
	總 數	6934700
	因每品種重複十次，以十除之。	693470
	減去糾正數	—689138
	賸 餘	4332

若以重複與品種之差異相加,而與總差異數相減,其賸餘之數一七一八,卽爲試驗差平方之和,由此可得試驗差數。至於能自由變異之個數,亦以重複與品種之自由變異個數相加,而與總數相減,其賸餘之數,爲三六,以此計算其試驗差,用能自由變異個數,與各個平方之和相除,卽得平均方。

各品種產量是否有顯著之差異,其試驗法乃視品種之平均方,與試驗差平均方之差異大小如何而定。若品種之平均方大於試驗差之平均方甚多,則吾人必以為品種間之產量有顯著之差別在焉。

對於此種試驗,欲求較為確實之數,以定差異是否顯著,可應用費氏(Fisher)方法,即由平均方之數,先行尋出其自然對數之半數($\frac{1}{2}\log_e$)此數即在表中末行見之。若此項平均方數甚大,可先除十或一百,而後再尋對數。由此求出品種之對數與試驗差對數之差,再藉費氏所備妥之表格,檢查之,若種同一品種時,其間相差當有若干,或因機會之不同,其相差之程度如何。如品種與試驗差之差數,大於表中所列之數,或大於機會所遇到之數,則吾人可認為品種間,當有顯著之差異也。

為完成品種產量之完全分析,須繼續計算,以求試驗之差數,即所謂標準差是也。將試驗差之平均方開方,即以四七·七二開方,得六·九一,此為每區之試驗差斤數若以每品種之總產量為試驗比較產量之差異時,則此種標準差,亦當用十乘之,以求十區之總差為標準。用以下之方法,可以求得之:即 $\sqrt{47.72\times10}$ 開方後,得二一·八四,是為十區之總標準差,以此數改算成百分數,先用各品種十區之平均數一一七四除之,再乘以一百,即 $\frac{21.84}{1174}\times100=1.86\%$。各品種之總產量,亦算成百分數,如下表所示。試驗各品種是否有顯著之差異,可應用標準百分數 1.86% 算之。為求得標準差之偏差,以便比較二品種之偏差,故將標準差先乘方根二,即 $1.86\times\sqrt{2}=1.86\times1.414,=2.63\%$ 以此數之二倍五·二六,為試驗差異是否顯著之標準,品種之產量,百分數與總平均數之相差,若大於此數時,則為有顯著之差異也。

各品種之總產量,及其百分數,與標準差列表如下:

	A	B	C	D	E	M	S,E.
總數	1330	1190	1160	1040	1150	1174	21.84
百分數	113.29	101.36	98.81	88.59	97.96	100	1.86

由上表可以察知品種A之1330總平均數,爲優之最顯著者,而他品種D 1040,則爲劣之最顯著者也。

上述之方法,可以擴充至試驗中之任何品種數,惟此種試驗,須要適當之應用表,以便解釋試驗之結果。該種應用表盡載於費氏書中,即(Statistical Methods for Research Workers, Fourth Edition, R.A. Fisher 出版者 Oliver and Boyd) 可參照之。

如試驗品種數較多,試驗時,最好將之分成數組,較爲便利;例如有四十品種,即可分成四組,每組十品種,或分成二組,每組二十品種亦可。

在第五年經上述二種試驗之後。對於試驗各品種或品系之生產能力如何,頗能得到確實之認識。其田間生長狀況,亦按以前方法記載之。自交工作,更須精密進行,冀得多量種籽,以作繁殖之用及將來推廣之準備,故宜多設種籽行,爲得到多量種籽起見,在第五年可植種子行數行或一小區。如前所述,當改良工作開始時,即可種植種籽行若開始時,不舉行自交工作,則種籽行之種植,留待第四年試驗時,再行增設亦可。

第五年之試驗方法,如前節所述,當繼續試驗二三年。該項品系,自鈴行試驗能繼續以至於高級試驗,必有商業上之價值。故仍當繼續精密試驗,以期得到最優良之一二品系。在高級試驗時,所有品系,固不甚多,但欲求可靠之優良品系,作爲繁殖及推廣於農民,則對於高級試驗,非繼續舉行二三年,絕難認爲確實也。

在第一年高級試驗中,如有較次之品種,隨時即加淘汰。是時對於品系採用淘汰或保留之標準,不但專注重於產量,其他品質如纖維之長度,抗病力以及各重要之性狀,亦不可漠視也。

第一年高級試驗終了,確知有數種品系,較之其他各種更爲優良,可將此項品系,先行繁殖,以後試驗再繼續一二年,即已有大量種籽,可以應用;不過此時進行繁殖,以後仍須重行淘汰。以實際論之,此時先行

繁殖,比諸以後俟其試驗完畢,再爲起始繁殖者,較爲適當。蓋試驗場除試驗地以外總有田地可種普通棉花。已經達於高級試驗之品系,無論如何,較之普通棉花,當爲優良,以經過高級試驗之品系,種植於普通棉田內,較之普通棉花當然有利。以後雖必加以淘汰,然目前對於田而旣不致廢棄,而先行令其繁殖,將改良種籽,推廣於農民又稱迅速。及其試驗完成,決定某一品系,認爲確實優良後,再使其儘量繁殖。分配於農民,以達育種之目的。

由第一年高級試驗之結果,發見數品種確有優良性狀表現者,則該試驗場卽須與其他試驗場或農事機關,從事接洽,舉行區域試驗,以作比較。改良品種適應試驗中可以數種改良品種;與當地之數種品種作爲比較,以觀其在此改良品種中究以何種最爲適當。若屬可行,最好除改良品種外,再用數種當地品種,在各地同時舉行。此種區域試驗,可以得知某品系或某品種,在某處較爲適宜,可資繁殖及推廣之用。

當推廣良種時,一試驗場對於同類之數品系,卽無須全行繁殖與推廣,最好僅就一品系,盡力繁殖推廣之。如於必要時,一試驗場須進行此種數品系繁殖與推廣之工作,則對於各種之品系分配,以愈少愈好。該試驗場所處之地位,如爲培植一種早熟品種,藉以適合某一區域之環境,而在另一區域,則須其他品種,又必設法供給其所要者而妥爲培植之。若能就一種最優良之品系繁殖之而推廣之,則以後進行容易,效果顯著,較之同時推廣數種品系,當必優勝多矣。

十一、雜交

以上所論之棉作改良及試驗方法,乃以選種爲根據,當中國棉作改良事業繼續進行,則雜交育種,自亦不可少,但以目前情形而論,仍當注重於選種。

雜交育種工作,必須於遺傳學上有充分之訓練者行之,方能勝任。

爲適合某種栽培及環境情形之需要,能得到優良及多量之花衣,則雜交工作,甚關緊要。中棉品種中,有具有某種優良性狀者,將數種品種所有之優良性狀,如花之產量,纖維之長度與品質,抗病及其他優良性狀等,以雜交方法,使其集合於一種品種上,則成爲一種優良完全之品種。

在適於美棉之地,有數種美棉,各具特種優點而不完全,亦可應用雜交方法,使其合併。但中棉與美棉雜交,不能結實,故常人無須進行。此項雜交工作須待遺傳學專家用一種技術,方能將不結實之中美棉雜交種,成爲結實之雜種也。

當舉行中棉或美棉品種雜交時,必須特別注意於手續之完備:對於預備雜交之花,非先去勢不可;去勢後,最好以化學試驗室所用之洗滌瓶,將雌蕊洗滌,以免遺留花粉;隨用薄紙袋套好,附掛紙牌以表明之。所用雄花,亦須用紙袋套住,藉以避免異粉之傳入。去勢時間,大概在下午,翌日上午卽可進行交配工作。

交配時,可將預先選擇之品種花粉,加在已去雄蕊之雌蕊柱頭上;同品種而不同株之花粉,當分開不可混雜;同品種之數棉株,可行雜交,然每次交配所用花粉,最好祇由一株而來。授粉以後,紙袋仍要套好,於紙牌上記明之;或在紙牌上,祇寫一個號數,而在記載簿上另寫號碼,雜交之種類,及其數目等。

例如雞脚棉與百萬棉交配,則於雞脚棉被雜交花上所掛之紙牌,可僅記雜交一,而於記載簿上則記載如下,雜交一:雞脚棉一×百萬棉三,此卽表示雞脚棉之第一株被第三株之百萬棉所雜交。至於一株上之花粉,亦可用之於數株上而行雜交,例如百萬棉三,可以作爲父本,作數株之雜交。棉花落花之機會甚大,各種之交配數目,須要增多,超過於預定之數目。

棉鈴起始發育後,可將紙袋除去,保留紙牌,以便棉花成熟時,可以分別採收,各鈴之籽棉,分別裝於各紙袋內,將來及將播種時,卽可將纖

維除去,以備種植。

雜交種籽之記號,應有適當之方法。假如雞脚棉與百萬棉行雜交,則其雜交之種籽,可以 1a 記之,此卽指同一株雞脚棉與同一株百萬棉而言;若以同品種而另一株雜交,則可記以 Ib 號數;如此類推,至此一類雜交完畢爲止。所用一號,係指同一對品種之雜交,而 ab 等字樣,乃表示不同株之交配。

如有反交;卽百萬棉被雞脚棉雜交時,則用另一記號分別之,如 1ar 所用 r 一字,乃表示反交之意。

每一種交配之種籽,必須分別種植。播種時亦須疏植,每一穴僅留一株。每株上之花,必須自交。以後收花時,每株裝一袋,每株之號碼,可記以 1a1, 1a2, 1a3, 等。在此種雜交 1a 中,所選之第一株,爲 1a1, 第二株爲1a2, 在同品種而不同株之雜交內選擇者,則記以 1b1,1b2 等。

有時因交配技術上之錯誤,得出非眞確之雜種。此項假雜種之棉株,在田間可以分別之。如眞非雜交之棉株,可將此系取消之。

第一代之棉株,旣爲雜交種,故必保留多數之種籽,每一株上之自交種籽,可以收在一處,妥爲保存,不至有所損失,以待下年種植之用。種植時先將纖維除去。爲謀得多數之棉株,希望種籽均能發芽,可用硫酸浸種,除去纖維,則種籽發芽較易,且稈整齊,較之未去絨毛者,頗爲良好也。

播種時,各籽須行疏播,每穴祇有一株,已如上述。由第一年各棉株所得之種籽,各株亦須分別播種, 1a1 之種籽先種在一處,以後再種1a2 等。此爲第二代之種籽,又爲分離時代,故於田間生長情形,當詳加觀察,選擇大多數不同形態之良好棉株,加以自交。自雜交以至分離時代,須要二年,卽第一年雜交,第二年爲第一代雜種,故必須自多數之棉株,保留多數之種籽。是以自花授粉工作須大規模行之也。

各種雜交選株之記號方法,可照下法行之,由第一種雜交中 1a1 所選之棉株,可記 1a1-1, 1a1-2 等,以至此種雜交中,所選之棉株完畢爲

止。若在其他一種雜交中，選留棉株如2a1，則可記以2a1-1等，亦至所選之數完畢為止。此次選留之棉株，在下代有復行分離者，亦有不分離而保存固有之性狀者，故第二代之自交種籽，種植愈多愈好，如是選擇優良棉株之機會亦愈大也。

第三代之種籽，其處理方法，與第二代同，各株在田間生長狀況，亦須記載并詳加研究，註明何項系統，須繼續試驗。各單株仍必繼續自交，又宜時常注意留多數種籽，以求多數棉株，故自交工作須大規模舉行之。第三代雜種中有能保存純粹而不分離者，在此種棉株中，有適合之纖維及優良之性狀者選擇之。此所選之各單株，下年卽行株行試驗，以後按照以前之選種試驗方法進行之。

第三代之選種中，如仍有分離作用，則於第四代繼續舉行如第三代試驗之自交工作。第四代若發見有優良品系，來年可加入於株行試驗，其方法亦如前。

就大概而論，在第三代或第四代，可得充分已分離之純種，以作試驗材料，然如有一種極重要之雜交，則單本選種，可復繼續一二年，延至第五代第六代，再供試驗材料。究應如何，當視第三與第四兩代所得之材料而定之。

如有優良雜交品系，卽有良好纖維品質者，可以加入正式試驗，所用方法，仍與選種試驗者相同。俟雜交種，或其他選種，經長期之比較試驗後卽可選定較良品系。由此育成之新品系先令其在試驗場上，進行繁殖，以求多獲純潔之種籽量。棉花頗易雜交，混雜之機會極多，故此項繁殖區之棉株，必須嚴密考察，如有不合該新品系之形態者，卽拔棄之。此項工作須在開花前舉行之，卽當棉株生育，至已表顯其性狀而能分別時，可到田間巡視，將不合形態之棉株，立卽拔去。此種去僞去劣之工作，每年均須在各繁殖區中繼續行之。

迨試驗場一有充分新品種之種籽，卽須與農民或合作機關接洽

種植新種辦法,留種以資推廣。接洽時須言明凡種植此項新品種者,不可再種植其他品種,是當注意。否則異品種相混雜,新品種仍劣變,虛耗育種之勞力與金錢矣。

爲保持新品種種籽之純潔,以作較遠之推廣,對於各農民及合作機關之棉田,當作嚴密之考查,凡有與該品種不合之棉株,須要拔去。新品種之繁殖與分配,對於棉種之改良,與新品種之育成,有同等之重要。故非與農民妥爲接洽,或組織完善之採種合作社,辦理改良種子之繁殖,則育成此優良品種所需之時間與金錢,殆爲徒費;因任何試驗場不能有如是廣大之地,自繁殖所要改良品種種子之全量也。

此種繁殖與推廣事業,接洽如已妥協,每年卽由試驗場供給最優良之純潔種籽於農民與合作社,試驗場之職員,並須隨時指導農民,親臨其事,如是則新品種之繁殖與推廣,定必良好,而改良品種之眞價值及改良品種工作之重要,庶能表現也。

十二、結　論

中國各產棉區域,品種優劣不齊,每年種植,因不加選擇,致品系雜而不純,產量日趨退化,是以對於改良品種需要甚殷。而設法改良品種,使產棉區域得有良好品種,增加產量,改進纖維,實爲必要之圖。試驗已有之中美棉品種,選拔當地適應之良種,在目前亦甚重要,蓋在更優良之新品種未經育成以前,大可就品種比較試驗所選拔者,設法先行推廣之。一面對棉作之改進,作精密之研究,於上述之選種,雜交及試驗方法,逐一實行,費數年之光陰,當可獲得優良之品系。優良之品系一經育成,當在各處舉行區域試驗,以定此新品系適應範圍之大小。

由區域試驗得到眞確之結果後,卽知改良品系在何種區域,生長適宜,而成績優良。然後設法使其迅速繁殖,發給農民種植。良種之繁殖與推廣,其重要與育成新種相等。試驗場之職員從事推廣,其謹愼縝密,

當一如從事試驗也。育種上所關之選種及雜交各重要方法,已詳述如上,玆復將其大綱揭錄於下,備供採擇。

第一年　舉行鈴行或株行試驗。

第二年　每品系作二行或三行之試驗,每第五行爲標準行,行長二十尺或二十四尺,視中棉或美棉種類而定。行之長度或可增加,然與其取用長行,不若用較短之行,增加重複次數之爲愈也。

第三年　每品系用五行試驗,各行均勻分配於田內每第五行爲標準行,行長如第二年。

第四年　每品系種十行,每第五行爲標準行,行長亦如前。

第五年及以後試驗　第五年用二種方法試驗:第一種方法,每品系,用三行區,每第三區爲標準區,亦採用三行區,行長如前,如種籽與試驗地充足,每品系可重複種植九次,即每系各種十區;其他一種方法,亦用三行區,重複九次,即每品系種十區,惟試驗區之排列,並無一定之次序,依機遇而定,所用之標準品種,亦須加入,作爲試驗品種之一,故每組之試驗品種中,有標準品種一區。

如試驗地有限,則第五年二種試驗方法,均可減少重複次數,但爲試驗結果正確計,仍以用較多之重複次數爲佳。

種籽行　爲保存品種之純潔,最好另設種籽行以行自交工作,如是在正式試驗地中,所有試驗材料,不至因包花及踐踏而影響其產量比較。如在初期試驗時,不舉行自交,則第四年試驗時,必須起始設種籽行。

附　　註

(一)此稿中一部份之圖表,承陳燕山先生襄助而成,特誌之以伸謝忱。

(二)中文之圖表,係與英文圖表合併排列,請閱者注意。

(三)本篇譯文曾經吳東淦先生潤辭,馮澤芳盧守耕二先生校閱,特此誌謝。

實價國幣五角郵費在內

Price $0.50 Mex. including postage

(For sale in foreign countries $0.50 Gold)