ABSTRACT BIBLIOGRAPHY OF COTTON BREEDING AND GENETICS
1900—1950

by

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PREFACE

In compiling this bibliographical abstract of cotton breeding and genetics an attempt has been made to include every major scientific paper on the subject published between 1900 and 1950. Annual reports have not in general been included, as this would have entailed considerable duplication.

The gene list given in Appendix II follows the system originally suggested by Hutchinson and Silow (1939). In compiling this list and the table of genoms (Appendix III), data from papers published after 1950 have been included to make the information as up to date as possible.

Considerable difficulty was experienced with the transliteration of Russian material. The system finally adopted does not always agree with that used by the Commonwealth Bureau of Plant Breeding and Genetics, and for this the writer takes full responsibility.

The writer is indebted to Mr. L. C. Hughes and to the late J. E. W. Sadd, both of the Empire Cotton Growing Corporation, for their help in the preparation of the Index, and to Mr. R. L. Cuany, formerly of the Empire Cotton Growing Corporation, for his help in compiling Appendix III. Grateful acknowledgement is made of the facilities afforded by the libraries of the Research Division of the Sudan Ministry of Agriculture and of the Empire Cotton Growing Corporation at Shambat, Sudan, and also to the Staff of the Commonwealth Bureau of Plant Breeding and Genetics for the work entailed in the preparation of the manuscript for press.

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1900—1950


   Pollen from flowers kept at more than 41-42°C failed to germinate on a receptive stigma. The best germination was obtained with flowers kept at 35-37°C.


   Deals with Bahtim Abiad.


   ABBAS, M. 1943. *See Afzal, M., Manda, D. N. and Abbas, M. 1943.*

   ABBAS, M. 1944. *See Afzal, M. and Abbas, M.*

   ABDUL GHANI, M. 1946. *See Afzal, M. and Abdul Ghani, M.*


   Aims, and especially methods, in American plant breeding are described in this review.


   Certain forms, e.g. Karunganni (G. indicum), show incomplete dehiscence of the boll loculi. In crosses with types having normal full opening, 3:1 ratios of fully open : incomplete were obtained in the F₂.


   In a hybrid of *G. arboreum x G. stocksii*, chromosome pairing was incomplete, the number of bivalents in a nucleus varying from five to nine with an average of 7-13. The mean number of chiasmata per bivalent at diplotene was only 1-3 compared with about 1-7 in the parents and the reduction of the mean per bivalent due to terminalization was gradual.

   The anaphase movements of the chromosomes and the development of the first division spindle in the hybrid were highly irregular, and tripolar and bent spindles occurred.

   In all crosses between *G. stocksii* and other Old World cottons, not more than about seven chromosomes of the two species were found to be homologous. This suggests that the
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remaining six chromosomes of G. stocksii have a different origin from that of the corresponding set in other Old World cottons.


A detailed study of the morphology of the somatic chromosomes of G. stocksii, G. arboreum (Strain K1) and G. herbaceum (Strain 2919). The chromosomes of G. stocksii and G. arboreum were found to be almost identical in their frequency distribution for length, whereas those of G. herbaceum differed markedly. Five metaphase plates of each species gave average chromosome lengths per plate as follows: G. herbaceum, 78·3 microns; G. stocksii, 68·4; and G. arboreum, 68·0; differences of 1·77 were significant at the P = 0·05 level.


It is noted, inter alia, that in Brazil a number of commercial varieties with adequate resistance to ramulososis (Colletotrichum gossypii var. cephalosporioides) are at present available.


G. cernuum has shallow broad-lobed leaves, long bracts, petals and bolls, very short lint and very high lint index and seed weight. Burma Silky (G. indicum) has shallow broad-lobed leaves, short bracts, petals and bolls, long lint and low lint index and seed weight. In hybrids between these two, the depth of laciniation was inherited simply. The length and breadth of bracts showed little segregation in the F₃, while the rest of the characters were inherited in a complex manner. Length of lint was inherited independently of lint index and seed index, and lint index was very highly correlated with seed index.


A lintless mutant of Mollisoni has been grown for four generations. The plant body is glabrous and the stigmas protrude through the flower buds. In the F₃ of Mollisoni lintless × ordinary Mollisoni this floral abnormality was completely linked with the lintless condition.


Two types of lintlessness occurring in G. arboreum are described. Hairy lintless is shown to be due to a single gene, H², which is lethal when homozygous and gives somewhat weak heterozygotes. Glabrous lintless is governed by a recessive gene, h⁰, giving a glabrous plant with only a few short hairs on the seed. H² gives a normal plant.


Four F₁ plants of G. stocksii × G. indicum were raised. Three of these resembled the G. stocksii parent and the fourth was intermediate between G. stocksii and G. indicum. All four were sterile.

Describes a supposed mutant found in the Mollisoni variety of *G. indicum*; each locule had 6-7 ovules but only developed one mature seed.


The most important cause of motes appears to be defective nutrition; defective fertilization plays a very minor part and lethal factors do not appear to be present.


The degree of hairiness increases from the bottom of the plant to the top in all varieties. In genetic studies on hairiness of cotton, it is therefore necessary to determine the location of the leaf and its age before counting the hairs.


Motes are less numerous in *desi* than in Upland cotton but their disposition within the locule is similar. Motes were commonest in early and late pickings and defective nutrition is suggested as the most important cause.


Petalody in *G. arboreum* (double-flowered but fertile) constitutes a single factor difference with respect to normal, with an intermediate heterozygote. The expression of the gene weakened as the plants aged.

AFZAL, M. 1940. See VERMA, P. M. and AFZAL, M.


This paper outlines the progress to date.


The jassid population on different varieties was estimated by three methods, sweeping, counting and fumigation; for five years (1937-41). Since the order of susceptibility of all the varieties remained practically the same for the three methods, breeders are advised to use sweeping, which is cheapest and simplest. 4F, LSS and 289F/43 were equally resistant, and 289F/K25 was the most susceptible variety. Jubilee cotton, a *desi* variety, was the most resistant strain of all.

AFZAL, M. 1944. See SIKKA, S. M., IHSAN-UK-RAHMAN KHAN and AFZAL, M.

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the characters of the plant associated with jassid resistance. *Indian J. Ent.*, 5, pp. 41–51.

Moisture content of leaf veins, toughness of leaf cuticle, pH value of cell sap and hairiness of leaf veins were examined in detail. It was found that amongst these characters hairiness was the only easily recognisable morphological character of the plant which was closely associated with jassid resistance.


The course of meiosis in the F₁ of three *arboreum-anomalum* crosses, namely, Arboreum-red x *G. anomalum*, K₁ x *G. anomalum* and Jubilee x *G. anomalum*, has been traced.

The conjugation of chromosomes at metaphase I in the three hybrids was variable, Arboreum-red x *G. anomalum* giving a mean pairing of 10₁ + 6₁, K₁ x *G. anomalum* 9₁ + 7₁ + 8₁ and Jubilee x *G. anomalum* 11₁ + 7₁ + 2₁. Due to anomalous behaviour of the univalents and the formation of single and double chromatin bridges both during heterotypic and homotypic divisions, the distribution of chromatin material to the daughter nuclei was unequal and all the three hybrids consequently exhibited a high degree of sterility. Most of the seeds set in these hybrids were non-viable, but a few of them (about 1.8%) germinated and showed only 26 chromosomes in their somatic cells. One root tip, belonging to the F₂ of Jubilee x *G. anomalum*, however, gave a count of 2n = 27 chromosomes.

By backcrossing the F₁ of Jubilee x *G. anomalum* twice with Jubilee and selecting plants with high boll number and seed setting in subsequent generations, new fully fertile strains, possessing perfectly white lint and excelling even the cultivated parent in yield of seed cotton, ginning outturn, staple length and fineness of lint have been produced.

The scope of utilizing the wild Nigerian species *G. anomalum* as a parent for improving the staple length and fineness, etc. of the cultivated *arboreum* and *herbaceum* cottons has been discussed.


An account of research at Lyallpur to improve yield, ginning outturn and staple of *desi* cottons.

A number of strains, collectively called Jubilee, have been isolated, and of these DC 37 and DC 40 have given the best results in yield, fibre strength, ginning outturn and highest standard warp counts in tests with Mollisoni cotton. Jubilee cotton has also received satisfactory reports from the technological laboratories and the mills. The staple of this cotton has been further improved by crossing with *G. anomalum*.


Covers the history of Upland cotton in the Punjab and an account of selection work during the last 20 years.

26. AFZAL, M. 1946 c. American cottons in India—their introduction and development. *Indian
American cotton seed was first introduced into India in 1818, but early efforts to acclimatize it were, in the main, failures. In 1840 experiments in the Bombay Presidency were successful in establishing the New Orleans cotton, and the area under it increased rapidly. The beginning of the present century saw the spread of Upland cotton on a wide scale. Improved strains are now grown over millions of acres in India. A list is given of the most important varieties at present under cultivation, and their technological properties are described.


A high genetic linkage between hairiness and resistance was found in hybrid progenies. A few crossovers were found, however.


The production and breeding of arboreum and hisutum cottons for the Punjab are discussed with reference to yield, ginning outturn, staple improvement, and resistance to root rot and angular leaf spot, spotted and pink bollworms, jassids and white fly.


Improved yields during the past 30 years are mainly attributable to higher yielding varieties. Still better results will be obtained if Punjab farmers modernize their methods.


Covers: frequency arrays of ginning percentage before and after selection; ginning percentage of reselections in 289F/43; yield of Jubilee strains as compared to 39-Mollisoni; ginning outturn, spinning counts and cash return per acre of Jubilee strains; yield, technological properties and cash return per acre of Jubilee-anomalum derivatives.


This survey covers development, lint and seed characters, genetical and cytological investigations, agronomic studies, and the breeding of improved varieties.


A variety with marked hairiness and tough leaf veins, such as 4F, has greater jassid resistance than the more succulent Victory. Hairiness and toughness increase with close spacing. AFZAL, M. 1950 a and b. Sae KHAN, A. H. and AFZAL, M.

33. AFZAL, M. and KHAN, A. H. 1950 a. Natural crossing in
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About 2% of outcrossing occurred between contiguous plants of either *G. arboreum* or Upland cotton.


The amount of natural crossing in Upland was very small beyond 12.5 ft.; 100 ft. was found to give perfect isolation. It was shown, however, that self pollen was more effective than foreign pollen in securing fertilization.


Three types of barrier were tested at Lyallpur as a means of preventing natural crossing under ordinary field conditions: allied varieties, open space and sorghum. The growing of allied varieties side by side provided the most effective barrier in the case of both local and American cottons.

AHMAD, N. 1940. See KOSHAL, R. S., GULATI, A. N. and AHMAD, N.

AHSAN-UL-RAHMAN. See IHSAN-UR-RAHMAN KHAN.


The author discusses the arrangement of parent types to determine natural crossing. About 20% of the bolls from a mixed planting of Keenan and Okra were crosses, but he believes that there is strong probability that 40% of the blossoms may be crossed and that crossing is beneficial in selected strains, but detrimental in unselected cotton. Cross pollination by various insects is discussed.


AMIN, K. C. 1936. See THAKAR, B. J. and AMIN, K. C.


Ten American-Asiatic hybrids were grown and successfully backcrossed to the Upland parent. No success attended efforts to induce polyploidy by means of callus.


Hybrids between New World and Old World cultivated cottons were backcrossed to the New World parents, though the seed set on the *F*₁ plants was very small. The backcross plants ranged from sterile to completely fertile. Their progeny showed marked fertility in some cases and a predominance of New World characters.

A number of cotton species and hybrids were treated with colchicine. *G. herbaceum*, *G.
arboreum and G. hirsutum when doubled were sterile, showing very defective bursting of the anthers. Fertile types were however obtained by treating the sterile hybrids G. arboreum x G. anomalum, G. davidsonii x G. anomalum, and G. hirsutum x G. herbaceum with colchicine.


Twenty-three F1 hybrids have been obtained from very many attempts to cross diploid Asiatic cottons with tetraploid New World cottons. Of these hybrids, 19 are triploids (2n = 39), one is tetraploid (2n = 52) and another is pentaploid (2n = 65). All the hybrids showed hybrid vigour, were almost completely sterile and in most characters were intermediate between the two parents. Backcrossing to New World cottons has been successful, particularly when the tetraploid hybrid was used as one parent. One plant in the first backcross population was found to be fully fertile.


Discusses the mechanism of reproduction and growth and describes the application of colchicine to cotton, its action, and results achieved.


The results of ten generations of pedigree selection for high and low oil content and protein content of the seed show that protein and oil content are closely and negatively correlated.


It is noted, inter alia, that there was no noticeable decrease in vigour of hybrid cotton plants after six years of inbreeding. Inheritance of lint percentage, lint colour, plant colour and 'cluster' appeared to be monofactorial, whereas seed fuzz, pubescence and petal spot all appeared to depend on two or more factors. Linkage was recorded between fuzziness and ginning outturn. Normal green was fully dominant to virescence yellow leaf, red leaf was dominant to virescence yellow, and normal green leaf was dominant to chlorophyll deficiency.


It is noted, inter alia, that tests of a large number of cotton varieties for resistance to cold in the seedling stage, revealed several capable of withstanding low temperature, suggesting the possibility of breeding strains to withstand cold wet weather.

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Covers tying the buds, wiring, stitching and bagging or netting.


The inheritance of various characters is illustrated by analysing crosses of forms differing in boll size, lint length, earliness, ginning outturn, fuzz, type of inflorescence, and length of sympodial branches in G. hirsutum, and for certain characters also in G. herbaceum. The inheritance of certain qualitative characters is also described, such as dehiscence, and non-dehiscence of bolls, brown colour of lint, petal spot and form of leaf.

The F₁ of Upland x Egyptian excelled both parents in lint qualities and yield and also in important agronomic characters such as drought and frost resistance. Families have been obtained in the F₃ that are superior to both parents in earliness, yield and size of bolls. In lint length these more nearly approach Upland.

Hybrids have now been obtained between the 26 and 52-chromosome cotton species in nearly all combinations and several complex hybrids have also been produced. Thus in 1928 a quadruple hybrid was obtained at Tashkent by crossing the hybrid G. hirsutum x G. barbadense with the hybrid G. nanking x G. herbaceum. In 1930 this hybrid produced one boll with four normally developed seeds, giving rise to an F₂ which proved fertile in 1932.

Hybrids between the two chromosome groups occur even naturally, and contrary to Zaitsev’s opinion the reciprocal hybrids are equally successful and are alike in characters. Success varies from 0.01 to 2–2.5%. The pollen is largely sterile, though a few good pollen grains are formed; in almost all combinations, however, seed is set when the hybrids are pollinated with the parental species, especially when the 52-chromosome species is used. In the F₂ so produced great variations in form and characters appear which are not known in either parental species, some indeed which are unknown in Gossypium, such as small flattened bolls. Fertility varies from very low to almost 100%. One particularly interesting hybrid has been obtained of (G. barbadense x G. herbaceum) x G. barbadense, distinguished by great fertility and capable of crossing also with G. barbadense, G. arborum and G. hirsutum. It affords a means therefore of combining the characters of G. herbaceum with all these species.

Only one F₃ has been studied, namely (G. barbadense x G. arborum) x G. barbadense. Here again there is a great variety of form including certain plants of the Egyptian type possessed of great fertility and earliness, others combining the characters of the Egyptian and Indian cottons, forms intermediate between the parents and some with quite new combinations of characters.

Mutations, produced by X-rays, affected nearly all possible organs of the plant. Among the mutations observed were various floral anormities, unusual size or dwarfishness of the plant, or of certain organs, and forms with increased productivity and with earlier maturity. One mutant from the variety 1306 Schroeder was distinguished by an increased
number of shortened nodes on the sympodial branches resulting in a larger number of bolls per branch, associated with a more compact growth and greater number of sympodial branches, the combined effect of which was to produce a yield 3-4 times above the normal. Unusual forms have also been obtained by the action of narcotics on the growing point.

A brief history is given of the development of cotton breeding in the Soviet Union, followed by an outline of the present practical breeding work.

Descriptions are given of all the varieties of cotton grown in the Soviet Union. The volume closes with chapters on seed production and control and on methods of cultivation.

A popular account, with special reference to cotton.

Deals with Sind Sudhar, Sind 4F–98, Sind Boss III, Sind Sea Island and Sind NR.

A historical account which also covers breeding methods used for cotton.

A botanical study of Chaco cottons (mostly G. hirsutum) of Argentina and an outline of selection work aimed at improving yield, earliness, quality and ease of harvesting.

54. ANONYMOUS. 1941. (Results of work of the Plant Protection Station of the Cotton Research Institute on pests and diseases of cotton and lucerne). Soyuznikhi, Tashkent, 72 pp. [Russian].
(Condensed from Plant Breed. Abstr., 13, p. 56).
Egyptian cottons and G. herbaceum were the most resistant to red spider. The hybrid F₆ 46, which is characterized by very hairy leaf surface, is practically immune. This hybrid will be used as parent for further breeding. The Egyptian x Peruvian hybrid 40/5063 also proved very resistant.

55. ANONYMOUS. 1941. Two new Cambodia strains. Indian Fmg., 2, p. 83.
Deals with the varieties Co.3 and Co.4.

The genetical relationships of the various genes determining lintless seeds have been investigated. A cross between 1027 lintless (lₐ) and Wagad lintless (lₐ) segregated normal, lₐ types, l₈ types and double recessives in the F₂, the proportions being 9 : 3 : 3 : 1 respectively; the double recessives had small shrivelled seeds. Punjab hairy lintless (l₈) was also crossed with 1027 lintless (lₐ) and the F₂ comprised F₃, lₐ and normal phenotypes in the ratio of 35 : 16 : 13. It is concluded
that $l_{a}$ and $l_{b}$ are distinct genes with $l_{b}$ epistatic to $l_{a}$; a modifying gene is postulated to determine lint production in the presence of either $L_{a}$ or $L_{b}$.

No linkage could be found between $l_{a}$ and either petal colour ($Y$) or anthocyanin ($R_{b}$) genes.

A satisfactory explanation of the $F_{2}$ segregation of Wagad lintless ($l_{b}$) x Punjab hairy lintless ($h_{a}$) has not yet been devised; $F_{2}$, $u_{c}$ and normal phenotypes were produced. Crosses between Wagad lintless ($l_{b}$) and G. arboreum varieties segregated either in 3:1 or 13:3 ratios; the difference between these two modes of segregation is attributed to modifying genes. Neither anthocyanin, flower colour or leaf shape genes exhibited linkage with $l_{b}$.

Nandyal lintless appears to be another gene determining lintless seeds. Its phenotype differs from $h_{a}$, $h_{b}$ and $l_{c}$ and it can be distinguished from $l_{b}$ by its breeding behaviour when crossed with Narrow Kokati. As a result of crossing Punjab hairy lintless ($l_{c}$) and Punjab glabrous lintless ($h_{c}$), an $F_{2}$ was obtained containing hairy linted, $F_{2}$ hairy lintless, $l_{c}$ hairy lintless and glabrous lintless types in the ratio of 3:6:3:4; it is concluded that $h_{c}$ and $l_{c}$ are distinct genes. An X-ray-induced mutant, determining dilute petal spot was produced in the variety Banilla and on crossing the homozygote with normal plants, a monohybrid segregation was obtained; the mutant is almost completely dominant. The gene $R_{2}^{0s}$ has been shown to be different from gene $R_{2}^{18}$; the latter being distinguished from the former by the anther pigmentation of its phenotype.

Allelic intermutation is reported for the $R_{2}$ series, the following changes having been observed: $R_{2}^{0s}$ to $R_{2}^{18}$, $R_{2}^{0s}$ to $R_{2}^{18}$, and $R_{2}^{*}$ to green spotless. The latter gene is not the green spotless gene ($R_{2}^{no}$) of Silow which induces pigmentation along the exposed petal margins. The breeding behaviour of a single leaf mutant was difficult to interpret; it gave neither a mono-hybrid ratio when crossed with normal plants nor a dihybrid ratio when crossed with other leaf mutants.

A gene determining pale yellow petal ($Y^{n}_{b}$) occurring in a Chinese introduction is different from the Banilla pale yellow gene ($Y^{n}_{a}$). It is complementary, however, to Banilla pale yellow or white, in combination with which it gives rise to a yellow pigmentation.

It has also been found that a single recessive factor determines virescent yellow seedlings. The gene concerned, moreover, is independent of the anthocyanin ($R_{b}$) genes. A petaloid mutant was investigated and found to be unlinked either to anthocyanin or petal colour genes; the degree of dominance of the normal to the petaloid mutant depended on the genetical background of the cross.

Fuzz inheritance is apparently more complex than generally supposed. The ratios of $F_{2}$ progeny types and the discovery that lines of intermediate fuzziness breed true to this character suggest that several genes are probably involved.

X-ray treatment of the variety MU 4 induced a definite increase in ginning percentage; when, however, allowance was made for selection bias, this increase became less significant.

The genetics of wilt resistance has been studied in the varieties New Million Dollar and Jarila. Seed has been obtained from the
following interspecific hybrids: 
G. thurberi x G. arboreum, G. thurberi x G. hirsutum, G. raimondii x G. arboreum, G. raimondii x G. hirsutum, G. harvenessii x G. hirsutum, and 4n (G. arboreum x G. anomalum) x G. hirsutum. Bolls have set in colchicine-treated plants of G. gaiitense x G. hirsutum and G. armoricanum x G. hirsutum. Heterosis has been observed in G. arboreum crosses.

Statistical analysis has shown that little further improvement of ginning percentage or halo length is to be expected by continuous selection. The relative efficiencies of various sampling patterns have been investigated.

57. ANONYMOUS. 1942. What the scientists are doing. Breeding wilt resistance. Indian Fmg., 3, pp. 442-443. Describes the technique used at Poona for isolating cotton strains resistant to Fusarium vasinfectum.

58. ANONYMOUS. 1942. New type of American cotton B6. Cotton, M/c, 10/10/42. The new type B 6 was evolved from Rowden. It is specially adapted for mechanical picking and has a staple length of more than one inch.

59. ANONYMOUS. 1943. What the scientists are doing. New cotton for Broach. Indian Fmg., 4, p. 37. Records the production of wilt resistant types from the cross Goghari x BD 8.

60. ANONYMOUS. 1943. Progress report of the Cotton Genetics Research Scheme, Indore, 1942-43, 20 pp. (Condensed from Plant Breed. Abstr., 14, pp. 12-13). A few instances of simple dominance of naked seeds to fuzzy have been observed but crosses between these two types usually show continuous segregation for this character, several of the intermediate grades breeding true. It is assumed that fuzziness is determined by multiple factors. In crosses between 5-locular and 3-locular bolls, the former are simply recessive to the latter; 4-locular bolls occur occasionally in both these types. Results from crosses of single leaf mutant x normal confirmed that only 30% of the mutant gametes are functional.

The red leaf character, which exhibits a practically uniform red pigmentation on the upper leaf surface, when crossed with normal types gives an F₂ comprising red, intermediate, and normal green forms in a ratio of 1 : 2 : 1. Certain environmental factors may partially suppress the expression of this feature; it is associated with earliness and is not, on the whole, correlated with any disadvantageous character.

Green spotless (R₂₀₀) is the basic recessive allele of the R₂ series. It segregates according to a 3 : 1 ratio when crossed with R₂₀₅. The latter gene differs from the anthocyanin gene of Tellapathi which determines pigmentation in the anthers. R₂₀₅ is dominant to the Tellapathi gene in respect of anthocyanin characters.

A single plant of Upland cotton, whose seed had received X-ray treatment for 20 min., behaved outstandingly in progeny trials; it was superior to MU 4 in yield, ginning outturn and lint length.

Several wilt-resistant families have been found among the progeny of the following crosses; M 1 x Jarila, M-9-20 x Jarila
and Million Dollar x Jarila. *G. anomalum* is very susceptible to wilt and this defect was conveyed to all the progeny of the cross, 4n (*G. anomalum* × Kc) × *G. hirsutum*.

The correlation between earliness and various morphological features has been investigated and a statistical analysis made of the various components of yield. Regression coefficients were calculated between the number of bolls per plant, the number of seeds per boll, the weight of cotton per seed and the ginning outturn. It was concluded that the most important character to select is the weight of cotton per seed.

A large scale yield trial with bulks from X-ray progenies has confirmed their superiority over controls in respect of yield, ginning outturn and lint length.

The attempt to evolve a homozygous 5-locular boll type in *G. arboreum* has confirmed the simple recessive nature of this to the normal 3-4-lock condition. The gene responsible, is, however, unstable. Results indicate that small petal spot, dilute petal spot and full petal spot, *Sr<sup>n</sup>* and *Sr* respectively, constitute a multiple series. The *R<sub>2</sub>* and *Sr* genes were shown to assort independently.

The green spotless mutant reported previously is recessive to ghost spot, but with the spotted alleles higher in the series it gives hybrids with high grade pigment of the plant body, almost of the level of the intense red allele.

Red leaf, as distinct from jassid red, appearing in *hirsutum* cottons, has been found to be genetically determined, most varieties bearing the character in a heterozygous condition, but its expression is considerably influenced by environmental factors.

Further progress has been made in breeding for wilt resistance.

In the study of the potentialities of different ecotypes of *G. hirsutum* with regard to combination of economic characters, the completed analysis of *F<sub>1</sub>* data has indicated that every character examined shows a clear heterosis. The parents used were the strains K 546, Jarila, Gao 115, EB 31, Sh. 764 and nine Bengal strains. Examination of *F<sub>2</sub>* halo length shows that as in the *F<sub>1</sub>* generation, the *F<sub>2</sub>* means are consistently higher than the parental averages but the excess over parents is considerably less.
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than in the F1. The F2 means are generally in the same order as those of the parents involved. Among all the strains used, F2 variability is generally less in those crosses where the F2 means are higher, and this should set a limit to improvement by selection. About 22 bolls have been obtained by crossing doubled (G. arboreum x G. thurberi) with G. hirsutum. The lint in these bolls is brown and short but silky and strong. It has been found that the G. thurberi crosses show some resistance to bollworm in the early stages, just when the flowers are opening. The hybrid G. hirsutum x G. raimondii was self-sterile but when doubled became partially self-fertile. The doubled hybrid does not, however, give fertile seeds when crossed with G. hirsutum. G. raimondii, though stated to be jassid resistant in Peru, is attacked under Indore conditions.


It was confirmed that the simple dominance of tufted over fuzzy seed in G. hirsutum is only shown in the progeny of parents from the same variety. A single major gene determines the tufted condition but a large number of modifiers exist.

In a cross between Bishnoor (G. arboreum) and Malvi 9 (G. hirsutum) large boll size was found to be nearly dominant. Boll size showed a close association with leaf shape. In the F2 of crosses between large-bolled varieties from the Punjab and a small-bolled Malvi Upland cotton from Indore, boll size was intermediate.

It was confirmed that a single recessive gene, designated vc, determines the presence of the 5-lock boll in G. arboreum. The gene vc is inherited independently of the genes L, Le1, Pb, Ne, Rn, Ya, and Yb. Selection to eliminate various degrees of fasciation, lateness and partial sterility is necessary before this economically valuable character can be exploited.

A type of broad leaf found in one of the Mallisoni cottons of the Punjab, possessing a long and pointed middle lobe, behaves as a simple recessive to the usual form of broad leaf.

A selection of Dhar 43, apparently homozygous for wilt resistance, showed an 8% mortality due to wilt infection under greenhouse conditions. An F2 of the cross Dhar 43 x Chinese red spotless gave 29% mortality; it was found that the wilt resistant red spotless group of F2 plants closely resembled the Chinese parent. In a trial of selected hybrid families several possessed as low a wilt mortality under field conditions as V 434 and Jarilla, and were superior to both Malvi and Dhar 43 in yield, ginning outturn and halo length.

Interspecific hybridization is mainly concerned with G. thurberi and G. raimondii. Some plants giving bolls and seed have been obtained from a cross between the doubled-hybrid G. arboreum x G. thurberi and G. hirsutum. The lint of these seeds is over 25 mm. long, fine, strong and slightly brown in colour; the seed is either fully fuzzy or naked, according to the G. hirsutum parent used. Selection for increased seed number
per boll is in progress. The triple hybrid has also been crossed reciprocally with the two parents. The cross with *G. hirsutum* was only successful when the triple hybrid was used as the female parent; the cross with the other parent was successful in both directions, but more successful when the doubled hybrid was used as the female parent. The original doubled hybrid, *G. arboreum* x *G. thurberi*, has exhibited seasonal rhythm in fertility. As the triple hybrid shows susceptibility to bollworm, work is in progress to determine whether the immunity of *G. thurberi* can be transferred to Asiatic cottons and thence to the cultivated tetraploids. So far crossings between *G. thurberi* and *G. herbaceum* and between the undoubled hybrid *G. arboreum* x *G. thurberi* and various *G. herbaceum* and *G. arboreum* types have failed. The undoubled hybrid *G. hirsutum* x *G. raimondii* was backcrossed to *G. hirsutum* without success. The doubled hybrid has given some bolls and seed. While backcrossing the C₁ reciprocally to *G. hirsutum* did not give any bolls, some of the C₂ plants produced bolls; crosses between these plants used as female parents and *G. hirsutum* were successful. The hybrids exhibited a susceptibility to jassid attack similar to that of the *G. raimondii* parent.

The seed of two American (MU 4 and X-4463) and two desi (Jarila and Dhar 43) cottons were subjected to different periods of cold treatment. Only the American varieties showed the effects of vernalization. In the case of X-4463 a yield increase of 30–50% over the control resulted from cold treatment of the seed for 10–15 days.

The strain developed from X-ray-treated seed of MU 4 showed superiority in both ginning outturn and halo length to the control. It was demonstrated that such superiority is not due to variation of MU 4, but to the mutational effect of the X-ray treatment.


Deals with the variety Piratinga and with a Delfos strain, both characterized by long lint.


The spiral structure in the central layers of the fibre largely determines its tensile strength. This structure and the average dimensions of the fibre are varietal characteristics, though affected by environment.

With the X-ray diffraction pattern it is possible to determine fibre structure even in badly weather-damaged cotton.

A binary dye mixture can be used to indicate the proportion of thin-walled fibres in a cotton sample.

The arealometer measures fibre fineness through a surface area determination that is much more rapid than the weight-per-inch method formerly used.

Accurate and rapid measurements of length and strength can be obtained on the fibrograph and the Pressley breaker.

Variety is of primary importance in determining fibre quality and spinning performance.

There is a definite trend for fibre limited in length by environmental influences to be compensated by enhanced strength and fineness, and conversely, for...
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environmentally increased fibre length to be accompanied by a loss in fibre strength.

Tests show the creation of strains with fibres of extraordinary quality and spinning performance is in sight. Other new cottons combine disease resistance with good yield and improved fibre quality. A short-limbed strain of cotton has been developed for use with the stripper harvester. Work is in progress to create strains of cotton better adapted for use with the spindle-type picker than those now grown.

Deals with Giza Nos. 47, 50 and 53.


A description of Arkot 2-1, a high-yielding, storm-resistant, early-maturing derivative of Stoneville 2B suitable for mechanical picking.

Resistance of cotton varieties to blackarm is being investigated, the plants being classified into (a) B2 absent, (b) medium resistance (B2 present), and (c) high resistance indicating the presence of other factors besides B2. The (b) type of resistance has been found in types not carrying B2.
Wilt resistance tests have also been made.

In Uzbekistan a new variety of cotton from which the leaves fall when the crop is mature has been produced by selection. This is an advantage for machine harvesting. Other characters include increased weight of the boll and higher fibre content. Sparse lateral growth allows an increase in the number of plants per acre.

A description of the variety Fox.

A description is given of the cotton breeding methods followed at the research stations of Sáenz Peña, Las Breñas and La Banda, Argentina. Information is given on the varieties they have produced. Wilt resistance is one of the principal breeding objectives.

ANSARI, M. A. A. 1938. See HUTCHINSON, J. B., GADKARI, P. D. and ANSARI, M. A. A.

ANSARI, M. A. A. 1943. See SETHI, B. L. and ANSARI, M. A. A.
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Ansari, M. A. A. 1947. See Seth, B. L., Ansari, M. A. A. and Samson, S.


This article sets out the aims and objects of the Cotton Breeding Section, giving at the same time a short description of the system by means of which it is hoped they will be achieved. A brief account is given of some of the breeding investigations carried out on Egyptian and American cottons.

The author concludes that, if G. hirsutum is an amphidiploid, it is made up of two very closely related species having chromosome sets morphologically similar to each other.

Pollen germination and seed set were improved by pollinating emasculated flowers with a mixture of pollen from different plants of the same variety; pollen from plants growing on fertile ground was more effective.

Causes of partial sterility of commercial cotton varieties were investigated and sterility was found to be largely due to unfavourable environment, causing uneven distribution of nutrients and moisture, and to Vorticillium and Fusarium wilt.

Experiments suggest that flowers in a central position on the plants are more vigorous than those on the lower or upper branches of the same plants. Pollen grains from these flowers are larger and more viable, and the pollen tubes grow better and result in better seed setting. The pollen tubes of cross-pollinated flowers develop better than those of selfed flowers.
The seed obtained from the central flowers gives more vigorous and productive plants than
that collected from other positions on the plant. These plants have shorter internodes and are early and develop uniformly. Pollination of the variety S-460 with a mixture comprising self pollen and the pollen of two other varieties gave a higher percentage of hybrid progeny when the operation was made soon after the flower opened than when it was delayed for a day.

There has been some evidence that mixed pollen intensifies the growth of the pollen tubes and results in more successful fertilizations and better embryo development than self pollen.

Moisture conditions affected fertilization processes, a curtailment in water supply resulting in the production of a smaller number of seeds in the boll and in the seed having inferior properties.

Experiments with variety 8517 suggest that intervarietal hybrids derived from the same parents but differing in respect of their origins make better crosses than material of identical origin.


The pollen tubes of variety 36M2 developed better after pollination with mixed pollen from whole flowers than with pollen from several anthers or a single anther. In variety S-460 more bolls developed and the seed weighed heavier when pollen from many plants was used than when pollen from a single flower or 40 to 100 pollen grains from a single plant were used. Pollination with large amounts of pollen gave healthier and more productive seed. For instance, F-137, a variety of G. barbadense resistant to gummosis, gave susceptible progenies, and S-460 gave progenies more susceptible to wilt, when pollinated with small amounts of pollen.

Embryos and endosperms of intervarietal hybrids developed more rapidly than those of self-pollinated plants.

ATTECK, O. M. 1941 a and b. See HARLAND, S. C. and ATTECK, O. M.

ATTECK, O. S. 1931. See HARLAND, S. C. and ATTECK, O. S.


Experiments were carried out to determine whether certain indigenous perennial cottons of Haiti were resistant to Anthomonus grandis as had been claimed for them. Annual cottons were used as controls. Though no definite conclusion is drawn about the point at issue, it appears that the indigenous cotton is much more resistant to pink bollworm and mosaic than the annual type and is more hardy. It is suggested that the indigenous cottons could be improved by selection for earliness.


Deals mainly with selection in Pima and Maarad which were among the Egyptian forms imported into the USSR.

To increase boll size crosses
were made between Egyptian cotton and *G. peruvianum*, which, however, being sterile under Russian conditions, had to be grown under short day illumination (9 hours) to obtain the cross and an F₂. In the F₁ the boll was of intermediate size, while in the F₂ 2-3% of the annual plants had larger bolls, the female parent in these cases being the perennial species. On sowing seeds from the plants with larger bolls separately, segregation occurred in the F₃ and 12-15% of the progeny had large bolls. In the F₅ lines with this characteristic as well as earliness have been obtained. It is hoped to produce a variety combining these features with other desirable characteristics of Egyptian cotton.


In the attempt to raise the boll size of Egyptian cotton, crosses were made between a number of varieties of *G. barbadense* and various large-bolled forms of *G. peruvianum*, which were induced to flower by means of short-day treatment. Only hybrids with the largest bolls were retained.

Seed was obtained from the hybrids by growing them under short-day conditions. The F₃ so obtained, consisting of 912 plants, was grown in the open and showed wide segregation. Altogether 196 of the plants were annuals and seven of them produced large bolls of the *peruvianum* type. Among 77 F₃ families only four were perennial. The progeny of the seven large-bolled plants segregated both for boll size and for morphological characters. The boll weight varied from 1.1 to 6 grm.; in some a larger quantity of lint was produced on account of the large number of seeds per boll, in others on account of the large size of the seeds, whilst in some these two features were combined. In time of maturity most of the F₃ plants were of the Egyptian type, the average being about the same as Pima or Maarad.

The length, elasticity and lustre of the Egyptian cottons were dominant in F₁ and segregated in F₂, the lint length varying from 28 to 45 mm. Lint length varied from 35 to 45 mm. in the F₃ and F₅ progeny of the large-bolled plants and the highest lint yields were obtained from the crosses involving Pima and a large-bolled Peruvian type.

Backcrossing the F₁ to Egyptian gave all annual progeny and to Peruvian all perennial; no large-bolled segregates appeared in either backcross.

From the above results, together with a preliminary examination of the F₄, it is concluded that in a few more years it should be possible to produce Egyptian cottons with bolls weighing 4.5-6 grm., characterized at the same time by productivity and high lint quality, and in earliness approximating to that of Pima.


In the section on cotton it is
noted that selection within Sannahatti (G. herbaceum) produced S.69, the present main commercial type. From crosses of G. arboreum x G. herbaceum, the types H 190 and Strain 19 were produced. The former has a ginning outturn of 30%, a staple of \( \frac{7}{8}-1'' \) and yields nearly as well as Sannahatti. MA II, now widely grown, was bred from Peruvian x acclimatized Upland (Doddahatti).

Work with X-rays has so far produced nothing of economic value.


A botanical and ecological description of T. thompsonoides.

BALASUBRAHMANIAN, R. See BALASUBRAHMYAN, R.


A large number of crosses were made between G. indicum \( \varphi \) and G. hirsutum \( \varphi \). Seeds of normal size were obtained although the embryos were imperfectly developed. A very small number of good seeds was produced. To test the possibility of their having arisen by parthenogenesis, 700 flowers of G. indicum were emasculated. Seven produced bolls and, of these, four gave good seeds with lint.

The author is of the opinion that the seeds previously formed were the result of parthenogenesis.

BALASUBRAHMANIAN, R. See also BALASUBRAHMYAN, R.


Deals with the two genes \( \text{ch}_{1} \) ('albino' from G. herbaceum) and \( \text{ch}_{2} \) ('xantha' from G. arboreum). The descriptions given by Hutchinson and Bhola Nath (1938) and Yu (1939) agree closely with the \( \text{ch}_{2} \) effect. The 'albino' type \( \text{ch}_{1} \) appears to be new and different from the chlorophyll deficient forms recorded by other workers in Asiatic cottons.


It is noted, \textit{inter alia}, that immature buds collected two days before opening were sent by post in cellophane rolls and the pollen was used successfully 44 hours later.

BALASUBRAHMANIAN, R. 1948, See DHARMARAJULU, K.
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Seshadri Ayyangar, G., Mudaliar, V. R. and Balasubrahmanyan, R.


Three primitive G. arboresum perennials are still cultivated in India to a limited extent: Nadam, Podupathi and Rozi. Nadam is resistant to drought and stem weevil (Pempherulus affinis) and has the lowest percentage of insect-damaged seed cotton in annual harvests. Podupathi is noted for hardiness and fibre strength and Rozi is more or less immune to root rot.


Reviews the literature on heterosis in cotton and describes experiments to find whether the hybrid vigour of G. hirsutum x G. barbadense crosses can be used commercially. Vegetative propagation by means of hormones has been successful and it may prove possible to replace the pest ridden perennial Nadam (G. arboresum) by suitable perennial hybrids.

Balasubrahmanyan, R. 1949. See Neelakantan, L. and Balasubrahmanyan, R.


MA II showed the lowest jassid blight and nymphal population. Both late sowing and wide spacing gave rise to greater damage than early sowing and close spacing. Susceptible types possessed a higher leaf moisture than resistant varieties.

There was a close agreement between hair density on lamina and midrib. Hairiness increased with rising nodal position of the leaf. Absence of fresh crops of leaf hairs and arrested development of leaf hairs after late planting indicate the need for testing all hairy varieties under late planted conditions before declaring them resistant.


A general discussion from the genetic standpoint.


The inheritance of three new G. arboresum genotypes from the Cocanada tract was studied: green stem ghost R2a, lint immature Im and incomplete boll dehiscence Deb.

R2a is homologous with burma ghost; Im is a simple recessive to Lm; and Deb is recessive to Deb. Wagad contains Deb, complementary to Deb, giving a normal F1 with a constitution of Deb Deb Deb Deb, and a modified
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dihybrid ratio of 9:3:4 due to the epistasis of deₐ over deₐ.

The possibility of the Coca-nada tract being a primary centre of origin of G. arboreum is advanced.

96. BALASUBRAHMANYAN, R. 1950 a.
The need for breeding crop varieties adapted to varying levels of soil fertility and for special conditions of soil and climate. Proc. 7th Meeting Crops Soils Wing Bl. Agric. Anim. husb. India, Madras, April 1948, pp. 141–142.

In cotton improvement in Madras, a wider hybridization programme involving varieties which have undergone long spatial or ecological isolation is likely to provide the variability required for selecting widely adapted strains.

97. BALASUBRAHMANYAN, R. 1950 b.

A recessive mutation (m) appeared in material grown from X-irradiated seed of G. arboreum race indicum. The gene m gives an increased mean number of bracts, petals and boll loculi.

In a cross between this 'meristic variant' and a female sterile type, a new mutant named no ovary (g) appeared. Factor m was epistatic to g.

98. BALASUBRAHMANYAN, R. 1950 c.

A narrow-leaved mutant, strain SX 507, has been induced by X-ray treatment of seeds of G. arboreum. SX 507 has been crossed and back-crossed with the parent strain. The F₁ was intermediate but the F₂ showed a segregation ratio such that the mutation may either have been in a dominant direction from i to I or, assuming the factor concerned to be of an inhibitory nature, in the recessive direction from I to i.


The white-linted Cocanadas pure line '43' was a simple recessive to Khaki A9 (Lc₂). Strain Cocanadas-1 carried the very light brown gene Lc₂ while the behaviour of the deeper coloured pure lines 123 and 129 suggested their probable genotypes as Lc₂. Nanking Khaki behaved as a simple dominant over Cocanadas-1 (Lc₂) indicating that it carried a darker allele at the same locus, while the parental and F₁ grading would admit of an Lc₂ postulate. G. 1037 and G. 1019 carry Lc₂.

The high colour variability in Lc₂ is probably environmental.

There was a reduction in the length of brown segregates in all the hybrid progenies.


A survey is given of resistance to Xanthomonas malvacearum in Madras American cottons and in a range of material from the Sudan. It is shown that cotton varieties known to be resistant in the Sudan are not necessarily resistant in Madras.

101. BALASUBRAHMANYAN, R. and SANTHANAM, V. 1950 a. The
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The inheritance of four dwarf mutants in race *indicum* was studied. Coimbatore dwarf behaves as a monogenic recessive to normal in both *G. arboreum* and *G. herbaceum* crosses. Anakapalle dwarf is a simple recessive to normal while it behaves as complementary to Cocanada dwarf. Lint colour and plant habit are inherited independently of one another. 1767 dwarf and Cocanada dwarf represent possibly independent mutations at the same locus, but carry a different complex of modifiers, and provide an interesting instance of heterosis when intercrossed. The gene symbols *d*, *d*, are given to Cocanada dwarf and Anakapalle dwarf respectively.


The character sparse lint found in a strain of *G. arboreum* race *indicum* is shown to be due to a single recessive gene *h*.

BALASUBRAMANIA AYYAR, R. 1938. See RAMANATHA AYYAR, V. and BALASUBRAMANIA AYYAR, R.


It is noted, *inter alia*, that Cambodia and Uppam are equally liable to attack by stem weevil, but that Karunganni is resistant.


Reviews selfing methods employed for cotton and describes the paper-cone method.


Deals with the variety Empire, an early cropping, thrips resistant type. Wilt resistant strains of Empire are now available.


This paper includes the history of the cotton flower and the early stages of the embryo. The cytology of the sex cells is described in detail and a brief account is given of the development of the cotton fibre. The development of the fibre is by simple linear extension of the epidermal cells, the cotton fibre thus being a simple epidermal hair.


Notes on heredity in cotton are given. The following crosses were made: Texas Wool x Abbassi, Hindi x Hindi hybrid, Afif x Truitt Big Boll, Hindi x Charara and Charara x Moqui.

The author considers that there are probably allelomorphic pairs of characters in cotton hybrids,
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which exhibit complete dominance and recession in the heterozygote. The alleomorphic pairs for the seed characters were as follows:

<table>
<thead>
<tr>
<th>Dominant</th>
<th>Recessive</th>
</tr>
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<tbody>
<tr>
<td>Long staple</td>
<td>Short staple</td>
</tr>
<tr>
<td>Regular</td>
<td>Irregular</td>
</tr>
<tr>
<td>distribution</td>
<td>distribution</td>
</tr>
<tr>
<td>Regular length</td>
<td>Irregular length</td>
</tr>
<tr>
<td>Coloured lint</td>
<td>White lint</td>
</tr>
<tr>
<td>Silky lint</td>
<td>Harsh lint</td>
</tr>
<tr>
<td>More fuzz</td>
<td>Less fuzz</td>
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</table>


A brief preliminary note on the subject; it foreshadows the breeding of early maturing types to check Earias insuliana damage since time of ripening is considered to be a Mendelian character.


All varieties, whether old or new, were found to comprise mixtures of strains. Cross fertilization between plants under field conditions was roughly 5–10%. A list of simply inherited character pairs is given:

- Leaf: red spot/no spot, glabrous (D)/hirsute (R), light green/dark green.
- Stem: tall/short, branched/unbranched, late secondary branches (D)/no late branches (R).
- Flower: yellow petal/white, spot/no spot, yellow anthers/buff, long filaments (D)/short.
- Flowering: early/late, continuous/interrupted in September.

- Maturity: early/late, continuous production/“early death.”
- Bell: many divisions/tew.
- Seed: more fuzz (D)/less fuzz (R), heavy (D)/light (R).
- Lint: long (D)/short (R), brown/white, regular length (D)/irregular (R), even distribution (D)/uneven (R), Egyptian quality (D)/Upland quality (R). In this list D signifies dominant and recessive, the absence of either indicates that the hybrid is intermediate.


The effect of changes in environment on a mixed cotton variety are considered, e.g. raising the water table would favour shallow rooting types and vice versa. The origin of Afifi is cited as an instance of natural selection. Ordinary brown Egyptian cotton, practically Ashmouni, was grown on a sandy stretch at Mit Afifi where it was regularly flooded at high Nile. The flood prevented the later bolls from opening so that natural selection produced an early type and this became Mit Afifi—distinguished by unusual earliness.

The origin of Egyptian cotton is covered in detail (pp. 253–259). Herodotus affirms (sc 569) that two corselets of cotton were sent from Egypt to the Lacede­manians. Shems el Din (b. 1596) gives details of cotton cultivation. Alpinus notes (1592) that the cultivated cotton was herbaceous but that a tree cotton was used as an ornamental shrub (illustrated in *De Plantis Aegypti*).

Hindi cotton though regarded as indigenous, was probably brought into cultivation first in Persia, whence specimens have
be obtained, and then in Egypt.

The Jumel tree was growing in Cairo gardens in about 1790.

Two areas of Sea Island cotton are mentioned, one of which shows admixture with Egyptian types; the other has been kept pure for 30 years.

Balls' hypothesis is that in the early years certain brown cottons were imported from Brazil. These intercrossed with Sea Island, and the present Egyptian cottons arose from these hybrid swarms, in some cases with "blood" from G. viifolium added.


It is concluded that Mendel's law applies to all characters of the cotton plant which have been critically investigated. No cases of coupling have been discovered likely to prevent the synthesis of desired forms. Most of the characters of the plant fluctuate, but far less than has been commonly assumed.

The cultivated varieties of cotton in Egypt consist of innumerable different strains, and the deterioration which these undergo after a few years is due to this heterogeneity brought about by natural and unconscious artificial selection. The amount of cross fertilization in Egyptian cotton fields is between 5% and 15%. The accumulated effect of this annual crossing maintains the cotton crop as a mass of natural hybrids, and accelerates the depreciation of varieties when inferior strains are introduced by seed mixture.


A general discussion of Mendelian cotton breeding is followed by experimental results from a single cross of Afifi and Truitt. Studies of unit characters include the observations made on red spot, hairiness, and shape of the leaf; height and branching of the stem; colour, form and formation of the flower; surface glandulation, shape, and number of divisions of the boll; weight, fuzz distribution, and fuzz colour of the seed; and length, colour, regularity, weight, and quality of the lint. Other chapters discuss natural crossing of cotton, output in ginning, and the history, present status, and future of the crop in Egypt.


Suggests that the growing of Upland cotton in Egypt should be stopped either by legislation or, preferably, by breeding early maturing, heavy yielding types of Egyptian cotton able to compete with Upland.

Lengths of style (long/short), column (long/short) and filaments (long/short) are established as unit characters. It should thus be possible to make a variety with short style and long column and filaments and this would be largely free from out-crossing.

The following figures are quoted for out-crossing: Webber (1902, USA) 5%, Balls (1906, Egypt) 10%, Leake (1907, India) 10%. In the present paper Balls
records a case of 25% outcrossing.


Deals with (1) Caravonica cotton, (2) Egyptian cotton in Arizona and (3) Mendelian heredity in cotton, the latter being a review of Fyson (1909).


Further figures are given in support of those recorded in 1908. It is shown that Afi fi x Upland segregated in $F_2$ into 3 Egyptian quality: 1 Upland quality, the actual figures being 83 : 27. $F_3$ results bore out this interpretation.


Records observations on the inheritance of number of boll loculi, seed weight and lint length but points out that the error due to vicinism is a serious obstacle.


In interspecific hybrids outcrossing was found to be as high as 30–100% of the plants remaining after thinning. Either Upland or Egyptian plants pollinated with mixed pollen from both gave 5% vicinists, whereas when pollinated with a mixture of self pollen and $F_1$ pollen this figure rose to 25%.


Chapter 8 deals with the genetics of qualitative characters. The leaf spot (pulvinus) of Upland and Hindi, crossed with Egyptian, gave 1 : 2 : 1 ratios in the $F_2$. Upland x Egyptian gave no clear ratios in the $F_2$ for petal colour inheritance. It is suggested that petal colour in such crosses is controlled by not less than three pairs of alleles. Balls concluded that in American x Egyptian crosses petal spot is not controlled by a single pair of alleles and that "there is strong evidence for complication of this mechanism by gametic coupling in some cases."

Anther colour in Egyptian (yellow) x American (whitish) gave 1 : 2 : 1 ratios in the $F_2$.

Upland x Egyptian crosses gave no clear ratios for the inheritance of hairiness although some of the progenies were taken to the $F_5$.

In Afi fi (wide stipule) x Sultani (narrow stipule) the $F_1$ had narrow stipules. In the $F_2$, 48 had Afi fi type stipules, 59 had Sultani type and 27 were 'doubtful.'
Upland (smooth boll) x Egyptian (pitted boll) gave 17 smooth: 33 intermediate: 14 pitted in F2 but Balls warns that this "must not be taken as evidence of simple segregation."

Within the Egyptian crop, seed fuzz was inherited simply, 3:1 ratios of more fuzz to less fuzz being the rule. In Egyptian x Upland crosses entire fuzz was dominant and 15:1 ratios of entire fuzz: slight were attained in the F2. Naked-seeded 'Hindi' x Egyptian gave a 15:1 ratio in the F2 of entire fuzz: slight. The naked Hindi type did not reappear. Presence or absence of colour in the fuzz hairs formed a Mendelian pair.

Brown-lined Egyptians crossed with Uplands having white lint gave 1:2:1 ratios in F2 though the extracted 'brown' types were not uniform. A cross between a very light brown Egyptian (Charara) and Upland gave 9 brownish: 60 creamy: 109 white in the F2.

Chapter 9 deals with quantitative characters, notably height of stem, form of leaf, form of flower, bract form, width and form of boll, number of loculi, weight of seed and lint length. Long styles were dominant over short in Upland x Egyptian crosses and gave 3:1 ratios of long to short in the F2.

Boll loculi: a cross between Upland (mean loculus number 4·8) and Egyptian (mean 3·0) gave an F1 of 4·1, and in the F2 a range from 3·0 to 4·7 with modes at 3·2, 3·6, 4·1 and 4·4 "and possibly elsewhere." In the F3 a 4·8 bred true to 4·8 and a 3·1 bred true to 3·2.

Afifi (2·8) x Truitt (4·5) gave an F1 with 3·6 and the F2 ranged from 2·9 to 4·8. A 3·3 plant from the F2 gave a range from 2·9 to 3·4 in its 21-plant progeny. A 4·6 plant gave progeny ranging from 4·6 to 4·9 and a 4·5 plant gave 4·2 to 4·6. On the other hand a 4·3 form gave a scatter from 3·3 to 4·9.

Seed weight: a cross between Afifi (mean seed wt. 0·105 grm.) and Truitt (0·135 grm.) gave an F1 of 0·165 grm. The F2 ranged from 0·08 to 0·175 with two marked modes at 0·095 and 0·115.


From Upland x Egyptian crosses new strains have been bred bearing typical Egyptian and even Sea Island lints on plants possessing some or most of the Upland characteristics. The inheritance was complex.

It is noted that the first Sakel plant was selected in 1906-7 and that in 14-15 years the variety covered three-quarters of the cotton area of Egypt.


Egyptian cotton typically has a concentration of about 0·3% NaCl in the cell sap; this varies with soil salinity, though not proportionately, and with variety. Plants of two Egyptian strains growing with interlacing root systems showed differences of the order of 10:7 in the salinity of their cell sap. Strain 310, which showed the higher salt content, flourishes in the salty lands of the northern Delta.


Emphasizes that varietal deterioration is not real; what happens is merely contamination. Records that there were, at that time, two varieties at Giza still identical with their ancestors of 1905-07. These had been kept pure by selling and avoiding all chance of admixture. In the open field with all possible care in ginning and handling the seed, about 300 rogue plants (1% of the population) find their way into every acre sown. This ‘infection’ spreads and is further augmented in each successive year. Also, even with 100 metres isolation, 2 or 3 seeds per thousand are cross-fertilized. “Thus it becomes humanly impossible to preserve any variety from contamination when it is growing in the fields.”


In Egypt, natural crossing is about 0.4% at 10 metres distance and this figure is halved for every doubling of the distance. In Egypt vicissitudes in the crop diminish rapidly from June to August because of a drop in the bee population in the cotton fields. Late pickings are therefore to be preferred for purity.


A semi-popular account of the financial effect of cotton breeding work in Egypt.


*G. hirsutum* var. *punctatum* yields more seed than Egyptian cottons and can double its proportion in a contaminated seed stock in approximately two years.

Reports of results of seed control by artificial selection are included for Sakel, Ashmouni, Pilion, Farouki, Casuli, Nahda, Fuadi and Maarad. Similarity in rates of increase of var. *punctatum* in all varieties is observed, and the age of any variety can be calculated from its content of this type.

Natural selection of low quality cotton has also occurred in certain areas where the varieties Sakel, Malaki, Karnak and Sakha 4 have not been sufficiently safeguarded by seed renewal. Spinning test control is being adopted to prevent further deterioration within the seed renewal system.


Deals with breeding work in the major cotton-growing countries, covering breeding objectives; species and varieties of the genus *Gossypium*; breeding methods; propagation and conservation of cotton varieties and strains; and trends of cotton breeding in some of the chief cotton-growing countries. There is a bibliography of 75 titles.


A comparison of plants from selfed and unselfed seed of Pima, Giza 7, Giza 12 and Giza 19 showed that plants from unselfed seed were more vigorous and yielded more.

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Cotton pollen is spherical with numerous points of emergence. The mean diameter of the Indian cottons studied measured from spine to spine is between 116-60 and 125-95 microns. Two forms of pollen grains characteristically different and occurring in the same androecium were noted in some cases in *herbaceum* cottons.

Artificial germination of cotton pollen depends upon delicate lights being observed, as well as moisture requirements. Pollen grains retain their viability under natural conditions up to the twenty-fourth hour after their liberation from the microsporangium and lose their potency within the next 24 hours. The more active pollen tubes were found to have traversed the entire stylar length within 12 hours after pollination.

The inheritance of pollen colour in a natural cross of Sea Island cotton was dependent on a single gene.


All American (including Egyptian) cottons examined were found to have 26 chromosomes, and all Indian 13.


Seven Old World species were found to have 26 diploid chromosomes; these were *Gossypium stocksii*, *G. arboreum*, *G. nanking*, *G. obtusifolium*, *G. herbaceum*, *G. abyssinicum* and *G. intermedium*, whilst 7 New World species, *G. punctatum*, *G. hirsutum*, *G. palmeri*, *G. peruvianum*, *G. mexicanum*, *G. purpurascens* and *G. barbadense*, had 52 chromosomes.

A detailed examination was made of chromosome morphology in the various species. Clear differences were evident, chromosomes with equal and unequal arms, divided and undivided arms and with or without satellites being observed, as well as differences in size of the respective arms and of the satellites.

Microsporogenesis was studied in the 26 and 52-chromosome groups. The process is described for the Navrotskii variety of *G. hirsutum*. The pollen grains were of two types, some echinate and others smooth and smaller.

A detailed study of embryo sac development was also made and the development is described for *G. herbaceum*. In many cases more than one embryo sac arose in one ovule, but only one of these finally developed. The whole development is extremely complicated.

The process of fertilization was studied for Navrotskii.

Cytological examinations were made on the following hybrids: *G. herbaceum* x *G. hirsutum*; (*G. herbaceum* x *G. nanking*) x (*G. hirsutum* x *G. barbadense*); *G. hirsutum* x *G. barbadense*; *G. barbadense* x *G. herbaceum*; *G. arboreum* x *G. barbadense*. These crosses have all proved of extreme interest at Tashkent. In *G. hirsutum* x *G. herbaceum*, 13 bivalents and 13 univalents were observed, the latter passing irregularly to one pole or the other.

At meiosis in *G. peruvianum* auxiliary spindles and lagging chromosomes characteristic of a hybrid were observed and half the chromosomes coloured more
strongly with hematoxylin than the other half.


Meiosis in American x Egyptian hybrids was normal, there being 52 chromosomes. In G. hirsutum x G. herbaceum tri-, tetra- and pentavalents were formed in addition to bivalents. A backcross (G. barbadense x G. herbaceum) x G. barbadense in which the somatic chromosome number was 65 indicated non-reduction in the 39-chromosome hybrids.

The somatic number 39 was observed in the following hybrids: (1) G. barbadense x G. arboreum, (2) G. hirsutum x G. herbaceum and (3) G. barbadense x G. herbaceum. All were self sterile but gave seed by backcrossing.

Barker, H. D. 1930. See Forbes, R. H. and Barker, H. D.


It is noted, inter alia, that the crop consists mainly of G. arboreum var. cernuum, the Garo Hills in Assam being its centre of origin, but a recent botanical survey of the hill cottons revealed that the present crop shows wide variation in economic characters.


Compares a sample of 1913 Sakel with one from 1923 season and draws attention to the deterioration in length of staple in the material from the latter season. The hair diameter rose from 13.44 in 1913 to 15.37 in 1923 and this is compared with comber waste which showed a mean diameter of 15.83. The author considers that probable causes of this deterioration are either contamination with inferior varieties or that the original variety was not uniform.


Polyploids were produced from hybrids of G. hirsutum x G. anomalum, and of G. arboreum var. neglectum x G. anomalum. A study of the meiotic chromosome behaviour of G. hirsutum x G. anomalum gave an average of about eight pairs most of which became attenuated at first metaphase.

The attenuated chromatin structures were interpreted as chromosome bridges, which resulted from structural differences of paired chromosomes. These observations are evidence that structural differences exist between most of the chromosomes. A cytological study of the hybrid G. arboreum var. neglectum x G. anomalum gave evidence of structural differences between the two species. Haploids have been found in Acala and Stoneville and more than a dozen haploids of G. barbadense and G. hirsutum have been X-irradiated to produce gene mutations and structural changes.


In reciprocal crosses of American x Asiatic cottons, the pollen germinates and pollen tubes enter more than half the embryo sacs. Embryo and endosperm development is initiated, but soon becomes aberrant.

By using the American type as female and a few grains of pollen from a 26-chromosome type along with all excess of Asiatic pollen, it is possible to obtain minute hybrid seeds. Plants can be produced from such seeds by germinating them on sterile culture media. Hybrids involving six combinations of American x Asiatic cottons were made.

It is suggested that this method of obtaining hybrids between American and Asiatic cottons will be useful in making numerous hybrids from which polyploids can be produced.


Polyploids were produced from eleven types of *Gossypium*. The induced polyploids include autotetraploids, hexaploids, and octoploids; pentaploids and heptaploids were obtained from hybrids. The polyploids were obtained by the immersion of apical meristems in 0.2% aqueous solution of colchicine for 24 hours. This treatment caused 10 to 55% of the treated plants to produce polyploid branches.

A system of formulae is outlined for making the composition of polyploids clear. Each chromosome set is given a capital letter and a number is placed before the letter to indicate the number of times a chromosome set is present.

Polyploids from sterile hybrids between distantly related types are usually fertile, but one exception was found. Polyploids of pure *Gossypium* species or of hybrids between closely related species are female fertile, but are almost or completely male sterile. Fibres on induced polyploids usually have a greater length and diameter than those of the types from which they came.

Pure lines of *G. hirsutum* and *G. barbadense* were made by doubling the chromosome number of haploids.


Records the production of a synthetic allotetraploid by doubling the hybrid of *G. thurberi* (= *thurberi*) x *G. arboreum*. The synthetic tetraploid is female fertile, but usually male sterile, in crosses with American (*n* = 26) cottons, and the hybrids so formed are fertile.


A hexaploid produced by doubling the chromosome complement of a hybrid of *G. hirsutum* x *G. anomalum* had remarkably regular meiotic chromosome behaviour; about 85% of the pollen was viable, and fibres were finer than Upland, with finer convolutions. The hexaploid has been backcrossed twice to Upland. Seeds produced from plants of doubled *G. arboreum* x *G. thurberi* crossed with *G. hirsutum* (Coker 100) and backcrossed to *G. hirsutum* gave an extremely variable population.
Some of the plants were prolific, but the ginning turnout was low. The fibres of some of the plants were finer than those of the Upland parent, had fewer convolutions, and were stronger. About 80 plants from a hexaploid of Upland x Asiatic backcrossed twice to Upland gave a range in fertility from 0 to over 50%. All the plants examined had over 26 pairs of chromosomes, and some had 4–5 extra Asiatic ones. As many as possible of the plants were self-pollinated and also backcrossed again to the Upland parent. Some of the plants had fibres coarser than Upland and others showed some of the resistance to angular leafspot possessed by the Asiatic parent. Plants selected for high fertility from the F₂ of a hexaploid of G. hirsutum x G. arboreum gave progenies with approximately the same percentage of sterile plants as the F₂ progeny. Doubling the chromosome number in a plant in which about half of the homologous chromosomes failed to pair did not increase the percentage of chromosomes capable of pairing.


Part of this brief review is concerned with work previously published by the author (see Beasley 1940a, 1940b and 1940c).

From chromosome behaviour at meiosis in hybrids it is concluded that the 13-chromosome species comprise five types. The chromosomes of different types have numerous structural differences.

All types are more closely related to the Asiatic type (G. arboreum and G. herbaceum) than to each other. The Australian (G. siurtii), African (G. anomalum) and American types (G. thurberi, G. davidsonii, etc.) are more closely related to the Asiatic type than is the Arabia-India type G. stocksii.

Haploid-diploid twins such as frequently occur in G. barbadense have been found, though extremely rarely, in G. hirsutum. The haploids of the latter have a maximum of 5 bivalents. A number of pure lines have been produced by doubling the chromosomes of haploids.


In 1941 six species hybrids were produced in addition to the ones already available at this station. From some of these sterile hybrids and hybrids produced earlier, seven additional polyploids were produced, three of which are considered new species. Seven polyploids produced from American Upland and wild species crossed with Asiatic cultivated cottons have been backcrossed one to three times in attempts to transfer genes of economic value to American Upland types. Some of these progenies showed no infection of angular leafspot. A few plants from the second backcross of a hybrid involving the wild cotton from the southwestern USA and American Upland cotton had fibres with a strength index equal to that of fibres of Sea Island cotton. From the backcross work in which hexaploids were backcrossed to American Upland, which is tetraploid,
one or more generations can be eliminated by using the first backcross, a pentaploid, as the pollen parent. In a population grown from seeds produced by pollinating normal flowers of Rogers Acala with X-irradiated pollen, one haploid was found. If this haploid was the result of X-irradiating pollen, the frequency of the haploids is too low to be of commercial value. The chromosome number has been doubled in haploids of three Upland varieties, Acala, Stoneville, and Mexican, to produce pure lines.


The meiotic chromosome behaviour is regular in 13-chromosome species of *Gossypium*, but there are a few irregularities in 26-chromosome species. In meiosis of autopolyploids about two-thirds of the chromosomes form quadrivalents. In a haploid of a 26-chromosome species a maximum of five pairs of chromosomes was found.

In hybrids between species the amount of chromosome pairing varies from 0 to 100%. In hybrids with a reduced amount of pairing there was evidence that structural differences existed between certain chromosomes, and in some interspecific hybrids apparently all the chromosomes were structurally dissimilar. Most of the chromosomes formed bivalents in polyploids that were produced from hybrids with a reduced amount of chromosome pairing; usually, however, cells in first metaphase and anaphase had one or more anomalies.

The tetraploid species of *Gossypium* have one set of chromosomes similar to that of the Asiatic 13-chromosome species, and the other set similar to that of the American 13-chromosome species. The species of *Gossypium* are separated into six general types chiefly on the basis of chromosome pairing, structure (arrangement of the genes) and chromosome number. The degree of relationship of the types is discussed.

Structural changes in the chromosomes probably had little importance in the initial speciation of *Gossypium*.


In the F₁ of *G. hirsutum* × *G. barbadense*, fertile and sterile asynaptic plants were found in a 15 : 1 ratio. At first metaphase the fertile plants had the normal 26 pairs of chromosomes while the asynaptic plants averaged 6–12 pairs of chromosomes. Doubling the chromosome number in the sterile plants failed to restore normal chromosome pairing and fertility.


Additional chromosome pairs have been added to the chromosome complements of American...
Upland cottons by crossing this tetraploid type with diploid species, duplicating the chromosome sets of the triploid hybrids by means of colchicine, and subsequent repeated backcrossing to Upland cotton. In this way, 54-chromosome strains have been obtained containing in one case, two chromosomes from *G. arboreum* var. *nanking* and in the other, a pair from *G. harknessii*. The meiotic behaviour of these new forms is briefly described.

Beatriz, M. G. 1948. See Quintanilha, A., Beatriz, M. G. and Eça, L. S.


*G. sturtii* was successfully budded on *G. davidsonii* and *G. arboreum*, and inarched with Upland. *Thurberia thespesioides* was budded on *G. arboreum* and *G. calycotum*. *Paritium tiliaceum* was inarched with *G. davidsonii*, Upland from Mexico, and *Thurberia thespesioides*. *Thepesia populnea* was inarched with *G. sturtii* and *G. morrilli*, and *Erioxylon aridum* was budded on *G. arboreum*.


Supernumerary carpels in cotton bolls are usually limited to a white slender body extending through the centre of the boll from the base almost to the apex. In 1932 and 1933, this abnormal growth was observed in a large proportion of the bolls of a strain of *G. herbaceum*. In some cases small intracapsulary bolls developed containing from 1 to 3 mature seeds which were covered with lint of fair quality.

The abnormal boll growth in this strain of *G. herbaceum* appears to be hereditary, though largely influenced by environment.


Low yields constitute the chief problem of cotton growing in Hyderabad. The improved Gaorani (*G. arboreum*) varieties developed by single plant selection can be further improved in staple length, ginning outturn, boll size and wilt resistance by hybridization. Suitable parents are available in Gaorani and other types of *G. arboreum*. Fundamental research should also be carried out on the lodging habit of Gaorani 6E-3 and its inheritance.


A brief discussion of induced mutations and their value in plant breeding. Work in progress is outlined.

Benedict, L. I. 1947. See Ware, J. O., Benedict, L. I. and Rolfe, W. H.


The following extract shows the type recommended for early, rapid, and prolific fruiting to escape boll weevil:

"The first fruit limb must be low, not higher than the fifth or
sixth joint above the seed-leaf joint. The wood or primary limbs must be low, and it is desirable that they should not exceed four in number. The first limb should not be higher than the fifth or sixth joint above the seed-leaf joint. The joints in the main stem, in the fruit limbs, and in the primary limbs must be short, not exceeding 1 to 3 in. in the lower part of the plant. Fruit limbs should grow at the successive joints of both the main stem and the wood limbs. Fruit limbs should be continuous in growth for continuous fruiting until the plant is matured. The largest leaves should not be wider than 5 or 6 in. across at right angles to the midrib.”


For early fruiting the first fruit limbs should not be higher than the fifth joint above the cotyledons and the first monopodium not above the fifth joint and not exceeding four in number. For rapid fruiting the joints on the main stem, fruit limbs, and primary limbs must be short, preferably not over 2 or 3 in. The fruit limbs should grow in succession at each joint of the main stem and primary limbs and be continuous in growth for continuous fruiting, and for productiveness the bolls should be at least 1 1/2 in. in diameter, the ginning outturn not less than 33 1/3% and the growth rapid and vigorous.


Sea Island plants grown under cover and kept at low temperatures during the first stage of phasic development gave anomalous forms in the first generation including dwarfs which ripened very early. These plants also had bolls which opened wide as in Upland cotton. Variation occurred in the entire population in respect of time of maturity. Progenies of the 51 best plants showed variation again in time of maturity, some lines being up to 29, and odd ones even 35–40, days earlier than the control. The progeny of the dwarf plants had the habit of Sea Island plants but were the earliest of all in maturity, some of them ripening 29 days before the control; when sown in the open on 20 April they ripened in 130–140 days.

The treatment was applied again to some of these second generation plants; the progeny proved distinctly harder than untreated plants, earlier in flowering by 1–19 days and in ripening by 2–3 weeks. In ripening they were simultaneous with the Egyptian cottons. As regards other characters, including the quality of the lint, the plants were indistinguishable from ordinary Sea Island.

BHOLA NATI. 1938. See Hutchison, J. B. and BHOLA NATI.
BHOLA NATI. 1939. See Hutchison, J. B., GHOSE, R. L. M. and BHOLA NATI.
BHOLA NATI. 1941 a and b. See RAMIAII, K. and BHOLA NATI.

157. BHOLA NATI. 1942. Genetics of petal colour in Asiatic cottons.
It is shown that two factors, \( Y_a \) and \( Y_b \), are necessary for the production of yellow petal in Asiatic cotton; \( Y_b \) is shown to assort independently of the gene \( R \).

Bhola Nath. 1943. See Ramiah, K. and Bhola Nath.


Rozi (\( G. \) arboreum) is shown to be of \( Cp_a \) \( Cp_b \) constitution with regard to the complementary dominant genes for the crumpled character.

Bhola Nath. 1944 a and b. See Ramiah, K. and Bhola Nath.

Bhola Nath. 1946. See Ramiah, K. and Bhola Nath.


Bilbrandt, F. C. 1926. See Mebane, W. M. and Bilbrandt, F. C.


The resistance of Stoneville 20 (Upland) to \( Xanthomonas malvacearum \) was found to be due to a single recessive gene. Resistance was judged after spraying the undersides of leaves with inoculum.


A detailed report of statistical information collected in connexion with a programme for improving the existing types by field selection. The detailed composition of the commercial types is given and it is shown how greatly the different varieties are mixed.


The Afghan cottons, mostly \( G. \) herbaceum, are of interest in breeding on account of their closed bolls which are of value for mechanical harvesting and for windy districts; some bolls are very large and contain white, silky lint, varying from 15 to 30 mm. in length with a ginning outturn of over 25%. They appear to be resistant to drought and to shedding. Their general high quality and range of variation make this species worthy of more attention. Other characters in the group are absence of petal spot, principally near Herat, exceedingly early forms near Kabul, and forms with the tips of the valves bent down.

The characteristics of cottons of different parts of the country are described and illustrated; they resemble the local cottons of Central Asia in many features and it is suggested that the latter derive from Afghanistan, contrary to the reverse opinion expressed by Zaitsev and others.
COTTON BREEDING AND GENETICS

These forms are mainly found in the foothills and the closed-boll forms are concentrated in the high mountains in the neighbourhood of Herat. Here there is a remarkable variety of forms of this type, some of which have long silky fibre, and the region is obviously a very ancient centre of these cottons.

The cottons of other species found in Afghanistan are apparently of an adventive nature.


A review of the literature on cotton genetics and breeding.


Information is presented on the occurrence of cotton stenosis in Colombia, where the UA–83 variety appears to be the most resistant.


Tangiis combines wilt resistance with other valuable qualities. The plant from which it arose produced offspring segregating sharply into resistant and susceptible types. It is suggested that the new type arose by mutation from Suave (degenerated Upland) and that the actual parent plant was a hybrid between the mutant and Suave. Because of degeneration due to out-crossing a scheme of controlled seed production and plant selection has been started. The basis of selection is outlined. Some of the lines are cleistogamous.


Deals among other things, with the merits of Tangiis. The organism to which it is resistant has now been shown to be Verticillium and not Fusarium. Crosses have been made between Tangiis and Giza 7, which is also resistant to wilt.


One of the chief problems in Peru is the development of selections of Tangiis combining resistance to wilt (Verticillium sp.) with desirable commercial characters. Outstanding from this point of view is the line Cn–LM7–35. Some degree of tolerance has also been shown by Giza 7, and to a lesser extent by Sakellaridis, Pima, S X P, Sea Island, Semíaspéro and Rinón, in contrast to the susceptible representatives of the Upland group cultivated locally, viz. Mars Rose, Coker-Wilds, Miller, Dixie 14–5, Dixie Triumph, Delfos, and Acala.

It is suggested that *G. raimondii* is more closely related to *G. armourianum*, *G. triolubum*, *G. harknessii* and *G. aridum* than to *G. davidsonii* and *G. klotzschianum*. (cf. Hutchinson, 1939; Newcombe, 1939).


The description of *G. raimondii* by Ulbrich (1932) was corrected by Newcombe (1939) who inadvertently stated the pollen and staminal column were yellow. A detailed description compiled from living material at La Molina is given.

The species occurs in the departments of Cajamarca and La Libertad, northern Peru. In Cajamarca it is found in the upper part of the Jequetepeque valley, along the Las Huertas river, near Chiletel, and along the banks of the rivers Santa Ana and Magdalena. In La Libertad, it is found on the bank of the river Chicama, near the bridge on Chiclin farm (Trujillo). Although *G. raimondii* exists in these regions side by side with *G. peruvianum* (*G. barbadense*, L.) no natural hybrids between the species have ever been observed.

This study records 2n = 26 for *G. raimondii* and 131 in first metaphase.

A hybrid of *G. thurberi* x *G. raimondii* is reported with 2n = 26 chromosomes and a chromosome conjugation of 131 in 19 pollen mother cells and 121 + 2l in two pollen mother cells. The hybrid is intermediate and fertile.

*G. raimondii* x *G. armourianum* gave good seeds although no plants were raised.

*G. raimondii* x *G. harknessii* gave seven empty seeds in one boll.

The hybrids *G. barbadense* x *G. raimondii* and *G. purpurascens* x *G. raimondii*, showed 2n = 39 chromosomes, in somatic tissue.

The hybrid *G. hirsutum* x *G. raimondii* shows 2n = 39 chromosomes and the chromosome conjugation 12·571 + 11·651 + 0·8711 + 0·1251v. It is vigorous, intermediate and one plant has been grown from unselfed bolls.

*G. raimondii* behaves similarly in hybridization to, and possesses chromosome homology with, *G. armourianum*, *G. aridum*, *G. harknessii* and *G. thurberi*, and with the set of chromosomes homologous to these species in n = 26 chromosome cottons.

*G. davidsonii* and *G. klotzschianum* are regarded as forming a subgroup with which *G. raimondii* cannot be included.

Little evidence exists as to the relationship of *G. raimondii* to *G. sturtii*, *G. anomalum*, *G. stocksii*, *G. herbaceum* and *G. arboreum*, but from chromosome conjugation and hybridization behaviour in this genus as a whole its relationship with them must be regarded as distant.

*G. raimondii* is therefore grouped with the species *G. armourianum*, *G. harknessii*, *G. thurberi* and *G. aridum*, rather than with *G. davidsonii* and *G. klotzschianum*.


The first plant breeding achievements mentioned in Peru are the selection by two private
planters of Tanguis and Peruvian Pima. Later commercial selections of Tanguis are also briefly described. One of the best of these is LM 7–35, which is heavy yielding and is a month earlier than Tanguis. LM 117–381 has given still better yields and lint quality. Some F₅–F₁₀ selections of Tanguis x Sakel and Tanguis x Giza 7 are specially promising among the long-linted group. Several selections resistant to Verticillium wilt are undergoing multiplication, and the selection work is being continued. One specially promising resistant selection is LM 12–40w. This variety excels ordinary Tanguis in all characters except lint length. A world collection of cottons comprising some 450 specimens is maintained, and special interest is attached to work with a C. raimondii x C. hirsutum hybrid. Promising results are being obtained in breeding for resistance to attack by Dysdercus ruficollis. Selection in Pima has led to marked improvements in yield and quality; certain types with double sympodia are expected to effect still further improvements in yield.


A preliminary account of selection in Tanguis for resistance to infection following attack by D. ruficollis.


This includes an account of selection work in Colombia on local cotton populations of G. hirsutum var. marie-galante and of G. barbadense. Recommendations for future breeding and genetical work are listed.


Cottons of the American group, all with n = 26, occur both wild and cultivated in Colombia, the predominant types being G. hirsutum var. marie-galante and var. punctatum, and G. barbadense. Indications are given of the distribution of the main types. Some of them are of distinct interest for breeding purposes and are described. A form of G. hirsutum var. marie-galante known as Native Hybrid of the Coast, is characterized by extreme tolerance of unfavourable conditions, lint percentage of 31–32, weight of fibre per boll 2.5–2.7 grm., lint index 2.5 grm. and staple length 26–30 mm. Another form of the same hybrid has a staple length of 34.9 mm. and up to 9 seeds per locule.

175. BOZA BARDUCCI, T. 1949 b. (The efficiency of the new lines of Tanguis cotton obtained in Peru and the methods used in producing them). Lilloa, 18, pp. 155–164. [Spanish].


A study was made of five
phenotypically distinct varieties of Upland cotton (G. hirsutum) with brown lint and one brown-linted variety of G. barbadense. The Upland varieties Algerian, Texas Rust, Arvin and Nankeen were found to carry members of the same series of alleles for lint colour. Lint colour in the remaining Upland variety, Brymer, is controlled by a gene at another independent locus.

The locus for lint colour in Nankeen is non-homologous with the locus for lint colour in Mohaux (G. barbadense). Additional investigations are to be carried out before symbols are proposed for the genes determining brown lint colour.

BRANNON, L. H. 1929. See GRIFFIN, F., LIGON, L. L. and BRANNON, L. H.


This article includes a short review of selection and breeding from the time of the introduction of the varieties Triumph Big Boll, Allen Long Staple, and Stoneville to the introduction of U 4. Crosses of U 4 by Triumph gave the Gar hybrids, selections from which are gradually replacing Triumph in the southern cotton area.

Mention is also made of the introduction of Morogoro 998, a selection made from U 4 derivatives in Tanganyika.


A general article on the subject.


Varietal purity is tested by plotting correlation diagrams for pairs of characters. Types within the general mean of the bulk but with greater purity, are selected.

Off-types deviating in any particular direction are also selected.


By use of the ‘target diagram’ a family has been selected from Sakha 4 showing improved lint length and ginning outturn.


No correlation was found between ginning outturn and halo length or between boll-content weight and hair weight per cm., but there was a positive correlation between seed weight and boll-content weight and between seed weight and hair weight per cm. and a negative correlation between ginning outturn and seed weight. A close correlation between seed weight and hair weight per cm. was established for Giza 19. This correlation is thought to be general.
Gives a short account of selection work at Giza.

The most important conclusion to be drawn from this paper is that, in Egyptian types, new genetic complexes can be selected from hybrid progenies, with little or no apparent relation to the characters of the two parents. In practically all crosses at Giza the aim has been entirely different from the achievement.

An outline of the breeding methods used by the Botanical Section at Giza.


Crossing between adjoining rows ranged from 1.6 to 14.7% over four years and averaged 6.2%. If the areas are large, the crossing extends to a greater distance, and is more frequent on the adjoining rows. Individual green-leaved plants grown at various points in a plot of red-leaved cotton produced more than 50% hybrid seed. A limited amount of crossing will take place at a distance of more than 100 yards.

Descriptions of Ambassador, Deltapine and Washington.

Gives the origin and characteristics of the following varieties: Acala 5, Acala 8, New Boykin, Cleveland 5, Cleveland 884, Piedmont Cleveland, Wannamaker Cleveland, Cook 307–6, Delta, Delta and Pineland 8, Delta and Pineland 10, Delta Webber, Dixie Triumph, Dixie 14, Express 121, Lightning Express, Half and Half, Kasch, Lone Star, Mcbeane, Missdel, Station Miller, Mexican Big Boll, Oklahoma Triumph 44, Pima, Rowden, Arkansas Rowden 40, Toole, Stoneville, Trice and Wilds.

A round-leaved true breeding mutant appeared in a plot of Express–317 cotton in 1930. The type is described and illustrated photographically. Round-leaved plants sometimes produced branches with normal leaves but selfed seed from such branches produced only round-leaved plants. A cross with normal-leaved cotton gave 15 'round' : 31 'normal' plants in the F2. A cross between round-leaved and
okra-leaved plants gave an F₂ with 21 okra : 11 normal : 3 round : 30 intermediate between normal and okra : 9 intermediate between okra and round : 5 okra-leaved types with the crinkly character of the round-leaf. A repeat sowing of this gave similar proportions.

Brown, H. B. 1939. See Neal, D. C. and Brown, H. B.


Describes Texacala, a selection from Acala previously called Rogers Acala III.

Brown, H. B. 1940. See Neal, D. C. and Brown, H. B.


Covers Station Miller, Dixie Triumph, Deltapine, Stoneville 5 and Stoneville 2 B, Delfos 531 and Delfos 425, and Wilds.


Flowering rate was reduced by 6.2% boll size by 9.3% and seed cotton production by 9.3%. Seed germination, vegetative growth, earliness, staple length, ginning outturn and seed weight were not appreciably affected.


Deals with Bobshaw, a medium early, partially wilt-resistant derivative of Stoneville with improved lint quality.


Pima on soil containing 0.2–0.4% sodium chloride was resistant to angular leafspot. Near the tolerance limit of cotton (0.4%) Pima was practically immune. Sodium carbonate in the soil was not protective.

Brown, M. S. 1942. See Beasley, J. O. and Brown, M. S.

Brown, M. S. 1943. See Beasley, J. O. and Brown, M. S.


As a result of pollinating G. hirsutum with pollen of Hibiscus esculentus, a plant containing approximately twice the 2n number of chromosomes of cotton was obtained.

Phenotypically and cytologically there are no indications that okra chromosomes have taken part in the development of the variant plant.

The absence of typical polyplloid characteristics and the low incidence of quadrivalents indicate that despite the approximate 4n number of chromosomes, the chromosomes do not represent an exact duplication of the 2n complex, but a modified assortment.

After several seasons, the number of chromosomes was reduced to 2n−1 in a grafted branch.

The somatic reduction in chromosome number to a number approximating the normal complex, whether by chance or in response to an unfavourable genotypic environment, represents a
mechanism whereby unbalanced plant types may eliminate incompatible chromosomes and thus establish more viable forms.


Aceto-carmine smears were made from pollen mother cells of 11 cotton plants grown from seed exposed to atom bomb radiation at Bikini.

The types of meiotic irregularities found indicate that gamma irradiation had produced translocations, loss of chromosomes and possibly an inversion, in the embryonic tissue of the cotton seed.


Among the progeny of a monosomic plant with quadrivalents were sterile plants in which cytological analyses disclosed 52 univalents at meiotic metaphase, multipolar spindles at anaphase, and numerous microspores in the tetrad stage. Since a gene for asynapsis at metaphase is known to occur in the parent variety of *G. hirsutum*, Coker 100, which in combination with a similar gene in *G. barbadense* gives asynaptic plants in the F$_2$, the occurrence of asynapsis in the progeny of the aberrant plants suggests that through irregularities in chromosome segregation, the sterile plants may have received the asynaptic gene in triplicate or quadruplicate.


Fertility in synthetic polyploids from species hybrids is inversely correlated with the taxogenetic relationship between the parent species. Trisomics derived from hexaploids (of which more than 12 have been produced by doubling hybrids between tetraploids and diploids) have given rise to partially stable lines with an extra pair of chromosomes from diploid species. Monosomics, but no nullisomics, have been observed in *Gossypium*.

Fertile amphidiploids have been made from the following hybrids: *G. davidsonii* x *G. anomalum* (this doubled spontaneously), *G. arboreum* x *G. anomalum*, *G. arboreum* x *G. stocksi*, and *G. arboreum* x *G. thurberi*. This last has been used to introduce genes for strength into cultivated varieties.


Describes work on seeds of *G. hirsutum* which had been exposed to the first atom bomb explosion at Bikini. Exposure to gamma radiation produced hereditary structural chromosome changes. The configurations seen were like those to be found in material exposed to X-rays or other ionizing radiations.


Two tetraploid trispecific hybrids produced by crossing the hexaploids *G. hirsutum* x *G. herbaceum* and *G. hirsutum* x *G. arboreum* with *G. harknessii* are described. Chromosome pairing is compared between the two
hybrids and with the *arboreum-thurberi - hirsutum* trispecies hybrid. In addition the following new trispecies hybrids have been made: *hirsutum-stocksii-armourianum* and *hirsutum-stocksii-harknessii* from the hexaploid *G. hirsutum* × *G. stocksii* crossed with *G. armourianum* and *G. harknessii* respectively; *hirsutum-stocksii-raimondii* from the hexaploid *G. hirsutum* × *G. stocksii* crossed with *G. raimondii*; and *hirsutum-anomalum-harknessii* from the hexaploid *G. hirsutum* × *G. anomalum* crossed with *G. harknessii*.


A critical analysis of a number of the most promising varieties of cotton grown in, or believed to be adapted to, South Carolina, carried out with a view to determining the characteristics of each strain and its possibilities from the standpoint of future breeding operations.


Describes a sterile dwarfed rogue in Sea Island, V 135.


In crosses between a short-stapled, white-flowered strain of Sea Island and normal Sea Island, flower colour and lint length were inherited independently. In the F3 a ratio of 3 yellow + intermediate : 1 white was obtained.


The history of the classification of this species by various workers is traced and it is concluded that although *G. obtusifolium* is widely grown in India, the exact race which Roxburgh grew has not been grown in recent experiments in India. The species is illustrated.


Cawnpore-American cotton was found to be a mixture of different races of varying value. A number of the best of these have been isolated. These pure races are superior to the field crop in yield, ginning outturn and uniformity of staple.

All newly imported cottons have given unsatisfactory results, probably because none of them possessed a fully hairy leaf.


A pure race has been isolated from the mixed acclimatized exotic known as Cawnpore-American cotton. This yields well, has a staple of 1 1/16" to 1 3/4" and is suitable for spinning 25's warps and 30's wefts in Cawnpore and up to 36's in Lancashire.
COTTON BREEDING AND GENETICS


A survey has been made of the more important commercial cottons of Bundelkhand. These have been grown and examined in detail and pure lines isolated and tested.


A general article on the subject.

Byrom, M. H. 1939. See Smith, H. P., Kilough, D. T., Jones, D. L. and Byrom, M. A.

Cabral, A. 1947. See Quintanilha, A., Cabral, A. and Quintanilha, L.

Campos Goes, O. See Goes, O. C.


Crosses were attempted in both directions between *G. obtusifolium* (2n = 26) and *G. barbadense* and between *G. punctatum* and the variety Blanco of *G. paniculatum* (2n = 52). No hybrids were obtained between diploids and tetraploids. F1 hybrids between the tetraploid species had 52 somatic chromosomes.

Carrera, J. L. 1932. See Wille, J. E., Carrera, J. L. and Tijero, L.


Naked seed and fuzzy-tip seed proved simple Mendelian dominants to entire fuzzy seed. Five naked seed characters, having ginning outturns varying from about 30% almost to 0%, proved genetically identical with regard to the absence of fuzz. Naked seed proved dominant to fuzzy-tip seed and gave an F2 with 12 naked: 3 fuzzy-tip: 1 fuzzy.

Green fuzz and brown fuzz were dominant to white, each giving monohybrid segregation in the F2. Green fuzz in turn was dominant over brown, and apparently nonallelic.

Red leaf, petal spot, naked seed, buff anthers and okra leaf were crossed in all possible ways and no evidence of linkage was obtained.

Cassidy, B. J. 1946. See Stephens, S. G. and Cassidy, B. J.


Describes a means of multiplying a specially promising plant by striking cuttings under glass.


Deals with the wilt resistant varieties Dillon, Modella, Cook,
Wood, Covington-Toole, Wilt-Resistant, Tri-Cook, Cook 307-6, Dixie and Dixie-Afifi.

CHAKRABANDHU, M. C. 1940. See BALTAZAR, E. P. and CHAKRABANDHU, M. C.


A selection of Delfos 531 showing red plant, okra leaf, nonvirescence and naked seed (genotype $R_2^{MO} R_3^{MO} L^0 L^0 VV FmFm$) was crossed with a cotton showing sun red plant, nonokra leaf, virescence and fuzzy seeds (genotype $R_2^{AO} R_3^{AO}llvv FmFm$) with a view to finding a marker character for use in maintaining varietal purity. The ginning outturn of naked seed is low, so that this character was discarded. Yield was significantly affected by red plant, okra leaf and virescence which are therefore unsuitable for the purpose under consideration. In combination, however, it was found that $L^0$ and $V$, the genes for okra leaf and nonvirescence respectively, exerted practically no influence upon yield.

CHANG, T. S. 1948. See YU, C. P. and HSIEH, L. C.


Tests conducted in 26 districts in eight provinces showed that Trice and Acala are adapted to China, but on the coast the improvement of Chinese cotton should be encouraged. Native cotton is grown on about 52% of the total cotton area. Trice and King are the dominant introduced cottons in Hopei, Shantung and Shensi provinces. In regional tests Stoneville 4 outyielded both Trice and improved Chinese cotton in Northern China. Stoneville 4 is definitely better in Hopei, both in yield and quality, than Trice, King, and the native varieties of Chinese and foreign cotton. In northeastern Hopei, a King type called Mu Pu 113 is best.

The importance of reselecting in Stoneville 4 especially for earliness is stressed.


A brief account of perennial G. barbadense types in Yunnan, China.


A fungus, tentatively identified as Verticillium dahliae, was detected on cotton (G. barbadense) for the first time in China at Mengtse, Yunnan, in 1939. Of nine plants used in host range tests, only egg plant was infected by the strain isolated from cotton. A strain of Egyptian cotton immune from the wilt was discovered.


Chicken Foot cotton is resistant to cotton leaf roller because
its narrow, deeply cut leaves are not suitable for the leaf-rolling habit of the larvae.


On morphological grounds it is concluded that G. anomalum is a true Gossypium and not a form of Cienfugosia, in which genus it was placed by Gürke.


Gives genetic evidence confirming that G. anomalum is a true Gossypium.


Chou, F. M. 1925. See Kuo, T. S. and Chou, F. M.

Chou, F. M. 1926. See Kuo, T. S. and Chou, F. M.

Chowdhari, S. P. 1947. See Kelkar, S. G., Chowdhari, S. P. and Hiremath, N. B.


Foreign varieties from the USA, Egypt, etc., with or without previous selection, are not suited to Greek conditions, with the exception of selections from the American variety Carolina Foster. The most promising strains are selections from local seed.


It is noted, inter alia, that Coker 100 Wilt strain 2 proved much more resistant to Alternaria macrospora in Venezuela than the indigenous cotton.

Cinda, K. I. See Tsinda, K. I.

Clark, J. C. 1938. See Dunnam, E. W. and Clark, J. C.

Clouston, T. W. 1939. See Knight, R. L. and Clouston, T. W.
COTTON BREEDING AND GENETICS

CLOUSTON, T. W. 1941. See KNIGHT, R. L. and CLOUSTON, T. W.


Rows of green-leaved cotton were grown at various distances from a field of red-leaved plants. The highest percentage of outcrossing 4% was in one of the rows at 20 ft. distance. No vicinists were found in seed from plants over 40 ft. away.


Arkansas Green Lint has a wax content of 14–17% based on the dry weight, compared with 0.4–0.7% for most cotton lint.


The wax content of the white-linted (Half-and-Half) parent ranged from 0.48 to 0.65% and that of the Arkansas Green Lint parent from 12.64 to 15.04%. The F₁ was intermediate green, with a mean wax content between that of the two parents but closer to that of the white parent. In the analyses of samples from the backcross, F₂ and F₃ phenotypes, it was shown that green lint and high wax content were closely associated.


In dealing with the origin of Upland the author concludes that *G. hirsutum* is a native of tropical America. Both Upland and Sea Island were originally described from the West Indies.


The weevil-eating kelep, by making cotton-growing possible in weevil-infested regions, has facilitated the evolution of resistant characters. Weevil-resisting adaptations are classified as: avoiding weevils, excluding weevils, attracting the kelep, and preventing the development of weevil larvae. The adaptive characters of different types of cotton, including Kekchi, Rabinal, Paclion, San Lucas, Sea Island, Kidney, and Upland cottons, are also listed.

Egyptian and Sea Island were more susceptible to weevil than the hairy Upland types. The weevils prefer smooth varieties while the kelevs find the hairiness advantageous. Kelep nests were found at the bases of only 41% of plants of US Upland and Sea Island varieties as compared with 76% of the plants of Kekchi.

In Parker, King, and Allen the bracts very seldom attain a width of 30 mm., while in Kekchi the average width for all except the smallest buds was above 30 mm. The larger bracts permit the involucre to be more effectively closed as a weevil-resisting adaptation.

Proliferation of internal tissues of the buds seemed more frequent in the Kekchi cotton than in any of our domestic varieties. Proliferation prevents the development of the larvae.

Weevil-resisting characters are more highly developed in Kekchi than in any other type yet
known; Kekchi produces large bolls and lint of good length and quality.


Crosses of Kekchi cottons of Guatemala with Egyptian and Sea Island types commonly yield green fuzzy seeds in the F1. This character is not apparent in either parent and is considered to be an ancestral character of both.


The danger of persistent selection for ginning outturn is stressed. Smaller seeds raise the ginning outturn but large seeds have several advantages.

A Mexican cotton with 27% of lint hybridized by Egyptian cotton having a somewhat higher percentage gave progeny with a percentage of only 22.9, while the lint increased from 4.05 grm. to 4.45 grm. per 100 seeds. The seed weight, however, increased from 10.95 to 14.75 grm. per 100 seeds. For a higher ginning outturn to be accompanied by an increased amount of lint the seed weight and volume must remain constant.

Ginning outturns cannot be substituted for tests of yield, and selection based on ginning outturn may diminish the agricultural value of a variety. No necessary connexion between lint percentages and yields seems to exist, as very high yields are obtained from varieties with relatively low percentages of lint. "Lint percentage is important as long as the other features are not left out of account, but persistent selection for lint percentage alone would be as likely to reduce the crop as to increase it."


Describes the off-types which appear in Egyptian cotton after out-crossing with other types has occurred.


Reversions may not be confined to single characters. They do not depend on recent hybridization, but may occur suddenly as a variation in a pure stock. Reversions may vary in extent and frequency with environmental changes.


A popular account which includes information on the use of progeny rows and on the production of seed for sale.


A parallelism of variation in leaf characters extends through the species and varieties of cotton as well as the related genera. Modification of these dimorphic differences is said to represent one of the most serious
disturbances of normal heredity induced by external conditions.


A general discussion of cotton breeding.

The author foreshadows the backcross technique in his statement "Variations toward Upland or Hindi characters arising in dilute hybrid stocks of Egyptian cotton have been found to yield progenies with more stable expression of characters than direct hybrids between Egyptian and Upland cotton. Such facts suggest the possibility of developing a new method of breeding by dilute hybridization."


Records Thurberia thespesioides as a host, possibly the original host, of boll weevil.


Brachysm, comprising shortening of the vegetative internodes, is a hereditary abnormality, indicating degeneracy, that has appeared in independent mutative variations in many distinct families of plants. Brachytic variations are frequent in cotton, giving rise to 'cluster' and 'limbless' varieties.

Brachytic cottons usually show abnormalities of the internodes, leaves and bracts, and a tendency to abortion of floral buds, which often remain attached to the plant.

The value of brachytic varieties is impaired by the tendency to abnormal variations and sterility and by undue susceptibility to unfavourable conditions.


A detailed description of this abnormality is given. The severity of attack is related to the variety of cotton. The possibility of selection for resistance is discussed.


The local Haitan cotton (G. purpurascens) is immune to smalling. The malformation is illustrated in detail.


This paper includes a general account of growth disorders in cotton. The following are illustrated in considerable detail: crazy-top in Upland and Pima, fastigate Egyptian cotton, tomosis, hybosis (leaf-curl), cyrtosis and stenosis.


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G. davidsonii was found in abundance among other desert vegetation in two localities near Guaymas. G. merrilli is recorded on sand dunes near the coast in the Yaqui valley, below Caijeme. G. dictadum is characterized by the production of two branches, one sympodial and one monopodial, from most of the main stem nodes. G. hypadenum has unusually broad leaves which lie nearly flat; many of the larger leaves have the margins ruffled. In this type the nectaries are inserted lower down, i.e. on the pedicel rather than on the receptacle. G. patens has small involucral bracts which are narrowed at the base. In G. contextum the inner surface of the mature carpels is finely and closely wrinkled and the ends of some of the fibres apparently are caught and held in these wrinkles. In other cases the fibres are held by what may prove to be hardened exudation.


A very detailed account of Acala cotton illustrated by photographs.


G. evertum has an open involucere, the bracts, though full sized, being strongly concave and turned outward away from the bud. This is considered to be an adaptation to humid conditions. Open involucres should offer less shelter for boll weevils, bollworms and diseases like anthracnose and bacterial boll rot. A commercial cotton with such bracts would have less trash. G. trident has very narrow bracts which have only 3-5 teeth, the smallest bracts and the fewest teeth in any of the true cottons yet described. These bracts are not appressed to the bud but are set out from the receptacle on a narrow curved base. G. calyctum (calyx-eared) has large auriform crests around the base of the calyx. G. auritum has involucral bracts with very broad auricles, and has 12-13 seeds per locule.


Selection should aim at maintenance of desirable varieties as opposed to the production of numbers of new varieties. Adaptability is as important as uniformity. Selection can be mass, individual, progeny, or type. A combination of progeny and type selection gives maintenance of uniformity coupled with adaptability. Groups of progenies should be maintained in various regions to cover the environmental range required.

COSTA, A. S. 1949. See ABRAHÃO, J. and COSTA, A. S.

COTTON, J. R. 1937. Notes on


Cotton, J. R. 1937. See Brown, H. B. and Cotton, J. R.


By a process of roguing under conditions of wilt infection, an Upland strain with at least 98% wilt resistance was obtained from a parent stock with only 35% wilt resistance. The process took 4 years to complete.


An account of the mass selection method employed for maintenance of varietal purity at Gandajka Station.


An account of the breeding of variety 172.


All the malvaceous types examined have, or are derived from, forms with the basic chromosome number 7.

Satellites in the somatic tissue occur in the group sporadically.

In *G. herbaceum* the presence of a pair of chromosomes longer than any of the remainder suggests that chromosome fusion in an allotetraploid with 28 chromosomes has given rise to a hypotetraploid with $4x - 2$ chromosomes.

Observations of mitosis and meiosis confirm and extend the theory of secondary association of chromosomes in polyploids. The relative ages of the genera under observation are estimated on this theory and the possible course of evolution of the genus *Gossypium* is discussed.

At meiosis, multivalent associations occur, though infrequently, and chromosomes with interstitial chiasmata are more frequent, though not so rapid in their anaphase separation, as those without interstitial chiasmata.


The last four pages are devoted to a discussion of the evolution of New World cultivated cottons. The author (p. 494) considers it "more likely that the New World cottons arose from a cross between a wild American diploid and *G. mexicanum* or *G. brasilense* than between a diploid American and a diploid Asiatic . . . ." Later (p. 496-7) he states that "it seems highly probable that tetraploidy arose in the New World cottons in.
Pre-Columbian times and from crosses between American diploid species either in the wild or under conditions of aboriginal cultivation."


De, B. 1950. See Barooah, S. R. and De, B.


In the event of mixed planting of cotton, the quantity of natural hybrids in the second generation reaches 7%. By planting the two forms of cotton in alternate rows, it was found that natural hybridization amounted to 1-5%. The insects which aid natural hybridization are mainly: Anthrena dubilatct, Halictus albipes, H. sexcinctus and Apis mellifica.


Describes early experiments in hybridizing the Cook and Kilgore cotton varieties.


Chromosome numbers of some 32 varieties of cotton examined fall into two groups: \( n = 13 \) for Asiatic types and \( n = 26 \) for New World types.


Deo, K. G. 1947. See GADKARI, P. D., Deo, K. G. and NADKERNY, N. T.


Synthetic hybrids and polyploids involving G. anomalum are remarkable in growth, vigour, healthiness and tolerance to some diseases and pests. Their fibre is strong, fine, lustrous, smooth and silky. To transfer these characters to cultivated cottons, a synthetic hexaploid of G. hirsutum x G. anomalum is being repeatedly backcrossed to G. hirsutum.

The chromosome numbers in the first backcross individuals occur as \( 2n = 65 + 0 \) to 4. In the case of pentaploid individuals (\( 2n = 65 \)), the mean meiotic conjugation consists of \( 11\cdot281 + 18\cdot4811 + 0\cdot211 + 3\cdot1111 + 0\cdot581v \). Among other contributory factors, formation of allosynthetic multivalents through the bridging influence of B chromosomes, possibly accounts for the discrepancy between the expected
COTTON BREEDING AND GENETICS

and actual modes of meiotic pairing. Multivalents show chromatin bridges during their anaphasic separation. Majority of the anomalous chromosomes appear as univalents scattered at random in isolated groups, each of which develops into a micronucleus, variable in size and number (1-11 per pollen mother cell), by a process of internal free-cell formation.

During recurrent backcrossing the following results may be expected:

1. Exchange of genes between A and D sets of cultivated New World Cottons (AA DD), through the bridging influence of anomalous B chromosomes.

2. Transfer of anomalous genes to A and D chromosomes.

3. Substitution of A and D chromosomes by their homologues from the anomalous B set.

4. Addition of anomalous chromosomes to the (AA DD) complement of cultivated tetraploid cottons.

These possibilities are discussed.


Describes techniques for crossing herbaceum ♀ with hirsutum ♂, the two most successful of which were (1) pollinating after painting the stigma with 1% citric acid and 0-5% cane sugar solution at 4 p.m. and (2) pollinating after painting the stigma with 1½% citric acid solution.

It should be noted that success was judged by whether or not the boll remained on the plant for thirty days. It is claimed that the one hybrid plant which was obtained was used successfully as pollen parent in back-crossing both to G. herbaceum and to G. hirsutum.

Desai, M. K. 1934. See Kottur, G. L. and Desai, M. K.


Resistance of Cambodia cotton to attack by Pempherulus affinis takes two forms, the production of a gall and the exudation of gum.


Resistant varieties engulf and disintegrate the burrowing larvae of P. affinis in a gummy exudate. Two South American barbadense types, Verdao and Peruvian, and Moco, a purpurascens type, proved highly resistant under conditions of artificial infestation.

Bourbon (G. purpurascens) and Nadam (G. arboreum) were tolerant, being able quickly to repair affected regions. Co. 2 is susceptible, and reselection for resistance was unsuccessful. In G. barbadense x G. hirsutum (Upland) and in G. purpurascens x G. hirsutum hybrids resistance was lowered when more than one susceptible parent was involved. Moco and Bourbon proved the best donor parents.

Though it proved possible to breed for resistance, the simultaneous synthesis of quality with resistance was more difficult and required a slow transference of one or two genes at a time. No relationship was found between
morphological characters and resistance.

Dick, J. B. 1938. See Tisdale, H. B. and Dick, J. B.
Dick, J. B. 1942. See Tisdale, H. B. and Dick, J. B.


A method of emasculating cotton flowers by removal of corolla and androecium in a single piece is described. This technique is combined with the substitution of a soda straw for the customary paper bag.

J. O. Beasley points out *(Ibid, p. 502)* that it subsequently proved better to wrap the base of the stigma and soda straw in a wisp of lint.


The ontogeny and structure of the pistil are described. Pollen grains placed on a given lobe of the stigma tend to fertilize ovules in the corresponding locule. Certain locules can thus be used to produce sufficient non-hybrid seed to ensure setting of the boll, while others are used for obtaining distant crosses or parthenogenetic embryos. If the female parent is homozygous for r (green leaves) and the pollen used for producing the normal seed carries R (red leaves), any seeds obtained through pollen crossing over to a different locule can be distinguished.

One or two stigma lobes were removed from each of a number of pistils on rr plants and the remainder were pollinated with R pollen. Of 378 seeds obtained from decapitated locules one gave a green seedling. The green individual must have been produced parthenogenetically or have been due to a mutation. Some 3,342 ovules were available for parthenogenetic development. In another experiment the stigma was split in two, between lobes, and the two halves separated by a card while pollen of the same species (*G. hirsutum*) was applied on one side and of a Chinese cotton on the other. The R–r test was again used. No hybrid seed was obtained, though 5,369 ovules were available and a set of 69.9% fruits was obtained. The Chinese pollen was apparently able to cause an increased set, for the set in the previous experiment was only 37.2%.


Several types of economic value were selected from F₅ and F₆ progenies of the cross (*G. cernuum* x *G. obtusifolium*) x (*G. herbaceum* x *G. arboreum*).


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The efficiency of selection within many varieties of cotton can be increased by preceding the selection by three to five years of inbreeding.

DOYLE, C. B. 1927. See COOK, O. F. and DOYLE, C. B.


A detailed account of the subject.


The author concludes that the life of an Egyptian variety is not long, because it is usually rapidly broken down by cross fertilization and careless mixture of seed. He assumes a mutational origin of the various Egyptian varieties from their parental stocks.

DUNCAN, E. N. 1944. See POPE, O. A., SIMPSON, D. M. and DUNCAN, E. N.


Inadequate light may cause immature bolls to shed: certain varieties of Upland are resistant to this effect.


Distinct varietal differences were noted in the response to different intensities of light and to alterations in length of day.


In Watson Acala the highest percentage of 5-lock bolls is found in the first picking; the next highest in the second picking; and the lowest percentage in the last picking.

From the weighing of 1186 5-lock bolls and 725 4-lock bolls it was found that the 5-lock bolls were 11·24% heavier than the 4-lock types.

No variety in the American group regularly produces 100% 5-lock bolls.


There was very little difference between the 5-lock boll production of the progeny of 4- and 5-lock bolls from the same mother plant, but plants with the highest proportion of 5-lock bolls gave progenies with the highest proportion. The average weight of 5-lock bolls in Mebane cotton

55
was 13.8% heavier than the 4-lock average.


As bolls age, they become less susceptible. Hume Cleveland was less susceptible than Webber 49 and Dixie Triumph. There was no relation between thickness of the boll wall and weevil susceptibility although weevils lay fewer eggs in thick-hulled varieties. Boll hardness, as determined by the pressure required to puncture the wall, appears to be the determining factor in resistance.


Aphid population increased in direct proportion to the number of hairs on the lower leaf surfaces. No correlation was found between the numbers of parasitized aphids and the pilosity of leaves, although the percentage of parasitization was greater on the glabrous types of cotton with the smaller aphid populations.


EÇA, L. S. DE. 1948. See QUINTANILHA, A., BEATRIZ, M. G. and EÇA, L. S. DE.


All the cottons tested were very susceptible to Colletotrichum gossypii, and such differences as were found were not considered important.


The appearance of the nucleus before mitosis in cotton is described as being intermediate between the type with “chromocentres” and that with “prochromosomes” already distinguished by the author. In the resting nucleus there is to be found the large nucleolus to which is attached a small granule of chromatin and a large number of granulations more or less grouped together in twos and threes. When mitosis commences the granulations unite to form the small and regular chromosomes and mitosis proceeds in a normal way.


A review of the work and methods of the plant breeding section at Giza.


In pollen mother cell preparations of a New World cotton fixed in Navaschin’s fluid and stained with iron alum-haematoxylin there were to be seen, at second metaphase, thirteen deeply stained and thirteen lightly stained chromosomes, the regularity and certain other features of the phenomenon betokening a real difference between the two sets. It is suggested that this
difference is in the nature of amphiplasty.

Secondary pairing was observed, in which 24 of the 26 chromosomes participated, and was always between similarly stained chromosomes. The results are taken to confirm the hypothesis that the New World cottons are modified octoploids.


A rather complete bibliographical survey of cotton genetics in all countries.


Brief but comprehensive reviews of the published work on the classification, chromosome numbers and genetics of cotton.


These reports are published annually and cover the work done at E.C.G.C. Stations throughout the Commonwealth and in the Sudan. The following territories are covered: Australia, Fiji, Iraq, Nigeria, Northern Rhodesia, Nyasaland, South Africa, Southern Rhodesia, Sudan, Swaziland, Tanganyika, Uganda and the West Indies.


Two cotton varieties are compared in respect of their reaction to immersion in inorganic salt solutions, especially in as far as this affects germination.


EZEKIEL, W. N. 1936. See TAUBENHAUS, J. J. and EZEKIEL, W. N.


Describes the symptoms of cotton wilt (F. vasinfectum) in Egypt. Different varieties show marked variation in susceptibility. Sakel is extremely susceptible, while Ashmouni and Zagora are immune. Breeding experiments have resulted in the isolation of four wilt immune strains of Sakel.

308. FAHMY, T. 1927 b. The Fusarium disease (wilt) of cotton and

A survey made during 1924 and 1925 showed that the *Fusarium* wilt of cotton was so destructive in parts of Lower Egypt as to necessitate the substitution of the resistant but less profitable varieties, Ashmouni and Zagora, for the highly susceptible Sakel.

In a test of varietal susceptibility, Garofalou showed 92% infection, Sakel 96%, 310 73%, Assili 54%, Nahida 50%, Toudri 16%, Pilion 13% and Fathi 6%. Ashmouni and Zagora were immune.

The Egyptian *Fusarium* was found to be capable of attacking some of the Indian varieties, while the pathogenicity of the Indian and American forms was practically restricted to the varieties of their respective countries of origin. The author refers the Egyptian fungus to *F. vasinfectum var. egypiticum*.

Four wilt resistant strains of Sakel have been bred by selection.


A popular account.


The $F_2$ of genotypic immune $x$ susceptible segregates into 75% immune plants, 15% resistant and 10% susceptible. The immune types may breed true or segregate. In the resistant types, segregation occurs giving either immune and resistant plants, or all three groups. The susceptible types normally die as seedlings, but plants of Domains Sakel that revive after “partial” death on an infected field may give segregating progenies, although the mother plant showed typical susceptibility.

The immune parent in a susceptible $x$ immune cross is able to hand over an element of resistance to some of its susceptible progeny which is manifest in the $F_2$ by an increased incubation period. The same thing occurs in a heterozygous $x$ susceptible cross. Plants with a long incubation period have a higher percentage of immune progenies than mother plants of shorter incubation period.

Domains Sakel contains on an average 3% of immune, 2% resistant and 95% of susceptible plants. In this variety there is not a complete correlation between long halo-length and susceptibility; though resistant plants are usually of inferior lint quality there are a few plants of fair staple length. A brief description is given of two strains isolated from Domains Sakel in 1923. These immune strains are high yielding and have lint of relatively good quality.


Besides immunity to wilt, Sakha 4 Gidid (= Myco 19) has a better yield than, and a lint quality as good as, the original Sakha 4. The selection methods used are described in detail.

In continuation of the author’s previous work, details are given of the results of tests made on the progenies of phenotypically immune, resistant and susceptible plants from a number of different crosses and from some strains of unknown genetical origin.

Two types of immunity are distinguished: (a) fixed immunity shown by plants and their progenies under all degrees and conditions of infection; and (b) shifting immunity, when segregation continues to occur and a small percentage of resistant plants appear under extreme conditions of infection.

The importance of using a standard and optimum method of infection for a comparison of the behaviour of different types is stressed, and of determining the precise degree of infection under normal field conditions, under which those plants with the shifting type of immunity might behave as true immunes.

A study of the segregation of resistant plants suggests the cumulative nature of the inheritance of resistance. Such plants are of no value in selection for immunity as segregation always occurs.


A general discussion on immunity and resistance of plants against disease is followed by a detailed description of the experiments started in 1923 in Egypt to develop strains of cotton resistant to F. vasinfectum var. egypticum. A standard method for the study of the genetics of resistance was derived. This consisted in growing single seeds, in small pots, in soil with a known concentration of infection and kept under optimum conditions for the growth of the parasite. Susceptible seedlings develop the symptoms of the disease about five days after germination and die. Tolerant seedlings develop characteristic mottling but recover. Other seedlings are immune; these may breed true to immunity or segregate.

The F1 of immune x susceptible is immune. Segregation in the F2 gives 75% of phenotypic immunes, 15% of tolerants and 10% of susceptibles. The F2 phenotypic immunes give rise to totally immune families which breed true, or to segregating families, the phenotypic immunes of which behave as those of the F2 generation.

Tolerant plants give rise to segregating progenies from which genotypic immune families have not yet been isolated.

Susceptible plants either give rise to susceptible families, or segregate giving a high percentage of susceptibles.

It has been found possible to select highly resistant families by breeding for a number of generations from plants belonging to the families with the highest percentages of phenotypic immunes. At Giza there are now several strains of cotton of excellent lint quality which can be grown on heavily infected soils without loss.

315. FAHMY, T. 1937. Giza 27, a wilt immune strain of long staple
The local cotton, Erbaceo–Paraibano, is very mixed and inferior in quality; the imported Texas is in a good state of uniformity and quality, but the selection H–105 made by G. C. Bolland at Ceará is still more promising and seems more suited to local conditions than the variety Texas.


Mocó cotton is very drought resistant. Selection was begun on it in 1938, and 5,000 plants have already been studied. Material was resorted by discarding the naked seeds. The technique employed by Harland has been applied to Mocó selection, with good practical results.


Preliminary studies described in some detail showed that the globulin fraction of the albumin extracted from the seed of a number of varieties of G. barbadense, G. hirsutum and G. herbaceum, reacted either positively or negatively with sera derived from rabbits sensitized by injection with cultures of Verticillium dahliae, Fusarium bauharcum and Bac. malvacearum, according to whether the varieties were susceptible or resistant to attack by these micro-organisms in the field. There also were indications that the degree of susceptibility or resistance of the
varieties could be fairly accurately estimated by the intensity of the reaction. A bibliography of 198 titles is appended.

319a Feng, C. C. 1926 a. Improved technic for cotton pollination. Science, China, 11, No. 3.


Out of 1017 crosses of Asiatic Ø x American Ø one hybrid was produced, while in 691 crosses of American Ø x Asiatic Ø five hybrids were obtained. This agrees with the general observation that crosses using the species with the higher chromosome number as the female are more successful.

Studies of pollen tube growth suggest that the low percentage of success in crosses between Asiatic and American species crosses is due, not to the slowness of foreign pollen tube growth, but probably to incompatibility of gametes.

The F₁ plants were completely sterile when selfed. Their pollen grains were very irregular in size and did not burst when mounted in water. The ovules were also abortive, as evidenced by their shrunken appearance.

The somatic chromosome number of G. nanking is 26 (haploid 13) and that of G. hirsutum is 52.

Meiosis in the microsporocytes of the F₁ was irregular. In metaphase I, 13₁₁ + 13₁ were observed. The univalents were distributed at random and some of the bivalents disjoined at the first division. Nondisjunction of bivalents was often observed. Some chromosomes were eliminated at the first division and formed micronuclei. In the second division chromosome distribution was irregular and more than two spindles were often observed. Thus more than four nuclei are formed; these are unequal in size and consequently lead to the formation of abortive pollen grains of irregular size.


The author considers that Tanguiis originated from a cross between Semi-aspero (G. peruvianum) and Suave. Suave itself is regarded as being of hybrid origin (G. hirsutum x G. mexicanum).


Gives details of the technique used at Barberton, South Africa.


It is concluded that 4% outcrossing occurs. Pollen was not carried further than 40 metres.


The first part of this article deals with dominance in relation to the Crinkled Dwarf character.

325. Fletcher, F. 1906. The improvement of the cottons of the
The original cotton of Egypt was of Asiatic type, both annual and perennial varieties being grown (G. herbaceum and G. nankein). As early as 1640 a tree cotton of American type was known (probably G. vilisfolium); this gave a rough brown cotton. In the first half of the nineteenth century, Sea Island (G. maritimum) was introduced, and by crossing with G. vilisfolium gave rise to our present varieties.

With regard to the origin of Hindi we are on less certain ground. It would appear unlikely that its home is in Asia since all the indigenous cottons of Asia bear a strong family likeness. Hindi has its nearest relation in Upland American and in a central and western African variety, G. punctatum, though it is distinct from these last named forms in many ways. It is cultivated near Baghdad under this same title and is supposed to have been introduced there from India. It is not, however, grown in India at the present day.

Many samples of seed from central Africa have been grown but none of these have given rise to Hindi plants.


Points out that the original G. hirsutum had green seeds and suggests that the present Upland came from Cochin China. “White Siam seed” was introduced into Louisiana in 1768.


The local cotton consists largely of mixtures of four species. Selection work is carried out on G. vilisfolium barbadense which among other desirable characters possesses considerable resistance to fungus and insect attacks. The work of selection, beginning in 1927, is described and the standards used for selection are enumerated: quality, percentage of fibres, yield and resistance being the main points. The origin and characters of a large number of lines are tabulated and certain outstanding ones indicated.


Outlines a plan for purification and improvement of Egyptian cottons, in which seed would never be more than six years


Fujimoto, I. 1947. See Kawayama, Y. and Fujimoto, I.

Fulton, H. J. 1934. See Harrison, G. J. and Fulton, H. J.


Emasculated flowers of Acala cotton were pollinated with (1) Pima pollen, (2) Acala pollen, and (3) Hopi pollen. Significant differences among means for the several cross pollinations were obtained in number of seeds per boll, seed index, lint index, fibre length and boll maturation period.

It is shown that the expression of these characters is influenced by (1) different years, (2) different days of anthesis in the same year, and (3) different individual plants used as pistillate parents to such an extent that the effects of different pollens are completely masked.


Clear $F_2$ segregations of 3 yellow petals: 1 white and of 3 narrow leaf segments: 1 wide were obtained.


This article includes a description of the cotton breeding technique used at Barberton.

Gadkari, P. D. 1935. See Hutchinson, J. B. and Gadkari, P. D.

Gadkari, P. D. 1937. See Hutchinson, J. B. and Gadkari, P. D.

Gadkari, P. D. 1938. See Hutchinson, J. B., Gadkari, P. D. and Ansari, M. A. A.


Census data of Hutchinson and Ghose (1937) suggest an association, in the Malwa and Nimar tracts, between leaf shape and corolla colour, despite absence of linkage between the two gene loci. The author shows experimentally that there is a selection pressure in favour of $Y_L$ and $y_L$ phenotypes in G. arboreum in Central India.

Gadkari, P. D. 1941 a, b. and c. See Ramiah, K. and Gadkari, P. D.


It was shown that Gaorâni did not change genetically, during its multiplication to the seventh stage, in respect of viability, yield, earliness, vigour, staple, seed weight, fibre weight, fibre diameter, fibre maturity, and spinning performance. There was a slight tendency for ginning outturn to decrease.


Covers the origin, history, botanical composition, technological properties and cultivation of the varieties grown in this region.


A botanical study, fully illustrated in colour, of the cultivated Indian cottons with keys to species, varieties and subvarieties. Nine species, including G. hirsutum, are recognized.


The manifestation of hybrid vigour in the seed, in crosses between three closely related strains of G. arboreum is described. It is concluded that seed weight by itself gives ample evidence of the manifestation of hybrid vigour in the seed, and is a good index in forecasting hybrid vigour in the postgermination period, provided no factors work against this at this latter period.


The chromosome complement of the hybrid G. arboreum x G. thurberi has been doubled by colchicine to make G. thurboreum. This latter is male sterile except during the monsoon (July to October) when self-pollinated bolls set. G. thurboreum crosses well, as female parent, with both G. hirsutum and G. barbadense and the F1s are self fertile.

G. thurboreum shows some degree of bollworm resistance, especially in the shoot tips, flower buds and flowers. It is suggested that a more fruitful line of attack would be to transfer the immunity from G. thurberi to G. arboreum, then cross this form with G. thurberi and double with colchicine.
G. hirsutum has been crossed with G. raimondii and the hybrid was treated with colchicine. The hexaploid was self fertile but did not backcross to G. hirsutum. The C₂ generation was crossed successfully with G. hirsutum and backcrossed to the latter. The fine and strong lint of G. raimondii is also found in the hybrids.

To transfer the fine lint of G. anomalum to cultivated tetraploids, G. arboreum x G. anomalum was doubled and crossed with G. hirsutum. Of the 300 plants raised, all but one died of wilt, to which G. anomalum itself is highly susceptible. The remaining plant was cross and self sterile.


Seeds obtained from a widely spaced and unmanured cotton crop are found to have a high yielding potentiality. A closely spaced and manured (ammonium sulphate) crop, on the other hand, is found to have a deleterious effect on the quality of the seed; due partly to the lowering of the seed weight in the case of closer spacing, and probably also due to some change of a chemical nature in the case of ammonium sulphate.


A survey of the results achieved and methods used from 1932 to 1941.


A semi-popular account with speculations as to the origin of the New World tetraploid cottons.


A survey of recent advances in the knowledge of this subject.


The variety 1306 is the earliest cotton grown and has enabled cotton cultivation to be extended northwards as far as latitude 50° N. Its lint, however, is exceedingly short. New varieties have been released which are about equal to 1306 in earliness but distinctly superior in lint quality, size of boll and many other features, including yield.

The history of the variety 1306 and a number of its variants is outlined, and there follow descriptions of the new improved varieties.

Gavaudan, P. 1932. See Szymański, J. and Gavaudan, P.
Early varieties were crossed with varieties possessed of other desirable qualities. In the F1, only those plants equal or superior in earliness to the early parent were selected.

In this way the variety C-925 was produced, which in 1938 yielded 32 c. per ha. as compared with 20 c. from the standard variety 1306. This new variety and C-2186 from the same cross, have also excelled the existing varieties in spinning tests, the results of which are recorded.


Ghose, R. L. M. 1937a, b, c, d and e. See Hutchinson, J. B. and Ghose, R. L. M.


Gospeed, T. H. 1930. See Mckay, J. W. and Gosspeed, T. H.


Quebradinho cotton has 2n = 52 chromosomes; these are described and illustrated.


On the basis of the chromosome number (n = 26) found in the Mocó variety of northeastern Brazil, the author believes it should be grouped with the American cottons and affiliated with one of the species G. hirsutum, G. purpurascens or G. barbadense.


Selection for resistance to root rot caused by P. omnivorum has been carried out on the following lines: the growth rate of the fungus on decoctions of the roots of single plants was measured and inbred progenies were raised from those plants giving lower growth rates. The initial material was a collection of varieties and a large number of F2 families.

Field tests showed that this method of selection was effective in reducing the percentage of plants killed as compared with unselected material, that some varieties were more promising than others as sources of resistant material and that the progress due to selection was more rapid in the F2 than in the varieties.


Seeds from the mottled portions of a variegated plant gave some green and some cream seedlings; these latter died.


The development of the female gametophyte and early stages of embryo development were studied.
in Sea Island, Pima Egyptian, and Upland cottons of the Delfos 6102 and Mebane varieties. The embryo sac develops from the chalazal megaspore of the tetrad. The antipodals degenerate early, and the polars begin fusing before entrance of the male gametes. The pollen tube enters the ovule 15-20 hours after pollination, and by digesting its way through the nucellus reaches the embryo sac. Fertilization is completed 24-30 hours after opening of the flower. The endosperm in cotton usually results from the fusion of the second male gamete with the polar fusion nucleus. Various methods of triple fusion are reported.

Govande, G. K. 1938. See Hutchinson, J. B. and Govande, G. K.

Govande, G. K. 1938. See Hutchinson, J. B., Panse, V. G. and Govande, G. K.


Crosses between Cocanada 45 (with white pollen, yp) and two other Asiatics, A 8 and N 6, showed white pollen and leaf nectaries to be linked with a cross-over value of 18-3% in the F2 and 14-7% in the F3. There was no linkage of white pollen with petal colour, anthocyanin, leaf shape or lint colour.


Cotton plants which survived in fields infested with *Macrophomina phaseolica* were selected. Continued selection within this material has given types with a mortality of 20-30% compared with 95% in the susceptible variety Broach 9.

Govanade, G. K. 1943. See Bhola Nath and Govanade, G. K.


A lintless mutant, with hairy plant body and thickly fuzzy seed-coat, appeared in *G. herbaceum*. A single recessive gene proved responsible and this was shown to be an independent mutation at the same locus as, and identical with, the gene controlling lintlessness in Viramgam Lintless. This gene is designated \( U_a \) and its behaviour in crosses with other lintless genes is reported.


The \( U_a \) gene for lintlessness in the Baroda lintless mutant is linked with the leaf shape locus with a cross-over value of 17-05% \( \pm 1.72 \), and with the lint colour locus with a cross-over value of 20-46% \( \pm 1.97 \). The leaf shape gene is linked with the lint colour gene with a cross-over value of 26-93% \( \pm 2.28 \), a value which confirms Hutchinson’s (1934) value of approximately 30%.


The new mutant appeared in *G. herbaceum*. It had a monopodial habit and was sterile. The petals and bracts had an indefinite number of whorls and the buds often shed without opening. The gene pair responsible for normal/multibracteolate flowers.
is designated $M^p - m^p$. The $M^p$ locus is shown to be independent of $Ne, Y_a, P_b$ and $R_2$.


A plea, with practical recommendations, for the preservation of natural populations of cotton.


Two new mutations in Asiatic cottons, namely the Baroda lintless and the Viramgam lintless, are reported and their genetics worked out in relation to other known lintless mutants. It has been shown that the Baroda lintless and the Viramgam lintless represent independent mutations at the same locus and that the new gene in these is distinct from other lintless genes so far reported in Asiatic cottons. The factor pair corresponding to the normal type and new mutants has been designated as $L_{i_d} - H_{3}$.

It is suggested that the Punjab hairy lintless mutant is of recent origin.

The linkage relations of the new $H_{3}$ gene for lintlessness were studied. The results show that the $H_{3}$ gene in the Baroda lintless and the Viramgam lintless mutants is linked with the leaf shape locus with a cross-over value of 17.05% ± 1.72 and with the lint colour locus with a cross-over value of 20.46% ± 1.97. The leaf shape gene is linked with the lint colour gene with a cross-over value of 20.93% ± 2.28 and confirms linkages previously reported. Since the cross-over value of the Baroda lintless and Viramgam lintless gene with either leaf shape or lint colour genes are nearly equal, the locus of the new gene, $L_{i_d}$, is approximately midway between $L$ and $L_{1}$. $L_{i_d}$ was shown to be independent of $Ne, P_b, Y_a$ and $R_2$.


A study of ginning outturn, staple length and node number in three *G. arboreum* crosses. In the F₁s there was strong heterosis. On the theory that heterosis is the result of dominance established in past selection, hybrid vigour would be expected to be in the direction in which selection had been applied. Thus in respect of ginning outturn and staple length, heterosis bias was towards a higher value, whilst in node number it was towards a lower value.


Cotton plants were discovered which had smooth seeds and practically no lint. The character is shown to be inherited as a simple recessive and the gene pair involved is designated $L - 1$. Lintlessness is independent of the petal spot locus.


Reviews correlation studies in cotton, and correlation coefficients are calculated from published data of variety tests in a number of localities of the cotton belt. The four characters given emphasis in these studies are yield, ginning outturn, lint length and size of boll. There is considerable variability in the degree of correlation among these characters. The correlations vary from year to year and from one locality to another, with the exception of the two characters, lint length and lint %. These two are negatively correlated in all years and in all sections. In several instances the relation is sufficiently close to be of value in predicting one character from values of the other.


Pages 5-8 deal with the acclimatization of American cotton in China. Efforts to introduce American cotton have been carried on for many years but in no instance has the original quality and character been maintained. Specimens of degenerate American cotton are common in fields of Chinese cotton.

To speed up acclimatization the following method was used: the two most favourable varieties, Trice and Acala, were imported and established on widely separated seed farms. About 30% of all off-types were rogued out and then 7000 of the best plants were picked separately and examined. Next year the best 300 of these were grown in progeny rows which were picked separately and examined. Some of these were kept separate as superior strains and the remainder furnished the seed for an extended propagation area.

Pages 8-11 deal with the improvement of Chinese cotton, it having been found that American cotton cannot be successfully grown near the coast. Over 1000 markedly superior plants were picked, these were found here and there over hundreds of fields in several different provinces. After laboratory examination, 300 of the best of these selections were grown in progeny rows and selfed. Of all these progenies, three gave great promise in yield and quality. These were multiplied in isolation. The most promising of these three strains was given the name Million Dollar. This has a 1 1/16” staple and the cotton is white, strong, and finer than other Chinese cottons.

Part II. (pp. 31-44). It is noteworthy that the author found “the phenomenon of break-up of variety type into diverse forms has been universally true of all imported stocks even including pure strains such as College No. 1.”


Describes the 5-locaul Asiatic type Million Dollar.


381. Groszmann, A. 1943. (Five
years of cotton breeding by the

Under the heading of genetical work, reference is made to a type collection of thirteen Gossypium species and a large number of cotton varieties. Two hybrids of G. barbadense and G. hirsutum have proved resistant to Verticillium albo-atrum. A new leaf colour, described as ferrugem (rust), appeared in the F2 of Texas Green Lint x Virescent.

In practical breeding work, complex crossing is used. Some of the selections combine the characters of five parents. Growth habit of a type resembling Gatooma, fineness of lint, ginning outturn and yield are the characters selected for. A specially promising F2 selection is described with a lint index of 12.9, a hundred seed weight of 19·15 grn., a ginning out turn of 40.3% and a lint length of 28·2 ± 2 mm.

Some of the pure line selections from existing varieties such as Acala have also given promising results. The system of seed production and distribution is described.


Cotton cultivation penetrated into China from the west, through eastern Turkestan, where it was already widespread by the fourth century A.D., and also from the south through Indo-China. G. herbaceum came from the west and G. nanking from the south.

The transition from perennial types to annuals was protracted over centuries and not till then could the crop extend to the more northerly regions.

About 1368 the Chinese Government took the introduction of large scale cotton growing into its own hands. A mixture of compulsion and propaganda led to a further spread of the crop and by the beginning of the fifteenth century, China had joined the ranks of the cotton growing countries of the world.

(For Author's summary of this paper see Emp. Cott. Gr. Rev., 14, pp. 64–66).


The author concludes that cotton has penetrated into China in comparatively recent times, only becoming general in the thirteenth and fourteenth centuries. It entered from two distinct sources, from south-western Asia (Gossypium herbaceum) and from Indo-China (G. arbo reum). The cottons of the latter species were perennials and several centuries elapsed before annual forms suitable for growing in the north were evolved.

In China proper the majority of cottons belong to a peculiar endemic group G. arbo reum var. nanking. Variation occurs in respect of all the main morphological and agronomic features. Many characteristic local races have evolved and forms with naked seeds and also forms without petal spot are very frequent.
COTTON BREEDING AND GENETICS

Similarly in Sin-Kiang the species *G. herbaceum* is predominant and is represented by a group of peculiar local forms quite different from those of Turkey, Iran and other countries. They are extremely early, having a vegetation period of 95 to 122 days in central Asia. They are also very drought-resistant and though they are susceptible to gummosis (*Bact. malvacearum*) and wilt they are being used for hybridization.

Upland varieties are also present now.

An outline is given of the work of cotton breeding in China, based on the published literature, reference being made to the production of the variety Million Dollar. Grown at Tashkent, this variety is mid-early but the period from flower bud formation to flowering is unusually short, so that it will make a valuable parent for breeding early cottons. Valuable hybrids of it with Indian cottons resistant to cyrtosil and wilt have been obtained in China.


Eighteen Russian cotton varieties are listed, of which eleven are resistant to *Verticillium* wilt and seven varieties highly susceptible to the disease. Susceptibility to wilt is associated with accumulation in the wood cells of large amounts of tannin substances. A method of testing plant breeding material for resistance to wilt is suggested, consisting of a crude test for tannins by means of a 0·05% solution of caustic soda.

Gubanov, G. Ja. 1950. See


An examination of cotton cloth from Mohenjo-Daro (c. 3000 B.C.) indicated that the fibres resembled *G. arboreum* more closely than *G. herbaceum*.

Gulati, A. N. 1929. See Turner, A. J. and Gulati, A. N.

Gulati, A. N. 1940. See Koshal, R. S., Gulati, A. N. and Ahmad, N.

Gurevich, L. I. 1950. See Ter-Avanesjan, D. V. and Gurevich, L. I.

Haddon, C. B. 1938. See Neal, D. C. and Haddon, C. B.

Haider, N. 1919. See Burt, B. C. and Haider, N.


A quantitative allometric study of monogenic differences in leaf shape was undertaken in *G. hirsutum* and *G. arboreum*.

In Acala (*G. hirsutum*) the action of three allelic genes determining normal (broad), okra (narrow) and super-okra leaf shape was compared.

In *G. arboreum*, the allelic genes, laciniate, intermediate broad, recessive broad and mutant broad were studied against the same genetic background, and two other genes of the multiple allelic series, narrow
and L, were observed against different backgrounds. A detailed account of the developmental effect of the leaf shape genes in both species is given.


In the Giza seed maintenance system, every propagation bulk is expanded from a single plant selected from a selfed line. The progeny of this plant pass through a purity checker, and are then expanded in 1/2 acre wire gauze cages. Seed from this source constitutes a renewal nucleus, which is sown in the centre of a large bulk of the same variety, bulks from it being grown in surrounding zones, until there is seed sufficient to sow about one-sixth of the commercial crop. Every three or four years a fresh renewal nucleus is expanded from another pedigree plant; a number of progenies are tested for yield and spinning quality, one only being selected. The possibilities in secondary selection are greater than was formerly realized and varietal improvement can often be achieved by a number of small advances.

For the long-stapled varieties, refusal of seed is now based on spinning tests; all the commercial crops of these varieties are grown directly from seed whose lint has passed the spinning standards.


New Egyptian varieties were formerly developed from off-types in commercial varieties. Nineteen types given Giza numbers (one was Giza 7) were picked out of commercial Ashmouni, and a dozen improved types were selected from pedigree lines of contemporary varieties.

Much faster advances in plant breeding were made by hybridization, pedigree plants being mated instead of plants from the partly deteriorated commercial varieties. Selections from hybrid lines were again mated, and so on for several cycles, the populations being carried to successively higher economic levels. Stress is laid on the possibilities inherent in secondary selection, and response to selection is ascribed to recombination of plus and minus modifiers in polygenic systems.


In extreme cases, varietal deterioration led to a fall in yarn strength of about 20%. Deterioration in general is ascribed to the dispersal of minor genes, regarded as the “wild-type” most suited to the environment, and to the polygenic system operating. These minor genes, and certain major genes, have a strong selective advantage in varieties carried to a high economic level by human selection, in which the objectives are quite different from the objectives in natural selection.

Continuous attention has been
paid at Giza to the initial purity of seed, and to its further protection; but seed cannot be kept pure in bulk, and increased attention is being paid to methods of elimination. Elimination of seed for the long staples is now based on spinning quality, and the Dated Seed System, to be applied to all varieties, is projected.


A brief account is given of changes in the distribution of varieties during the war. The spinning qualities and general characteristics of the cottons now and recently grown are described. Attention is drawn to the steadily rising grade of the crop in recent years, and the distribution of quantities, according to grade, is tabulated.


Cotton varieties have been examined for the nitrogen and oil content of the seeds. The four varieties Washington, Deltaupine 11A, Stoneville 2B and Coker 200 are recommended. These characters do not appear to be linked with other desirable economic characters.


These characters, though genetic, are shown to be markedly conditioned by environment.


Breeding work in Tennessee is reviewed in two pages of this bulletin.


Reviews the literature on the distribution of this host of the wild cotton boll weevil (Anthonomus grandis thurberiae) in Arizona. The distribution of both host and parasite is indicated by map.


There appears to be no relation between the amount of lint and that of oil or protein, but the amount of oil seems to bear some relation to the weight of the seeds, to the percentage of protein, and possibly to the amount of inorganic constituents.


Describes segregation in the interspecific hybrid G. barbadense x G. purpurascens. Bracts, boll characters, calyx and lint characters were studied. No clear Mendelian inheritance appeared, but only a series of imperceptible gradations from one parent to the other, often exceeding the parental limits.

The barbadense (Sea Island)
parent was susceptible to cotton leaf blister mite, while the \textit{purpurasceus} parent was immune. The $F_1$ was nearly immune, and the $F_2$ showed blending with the appearance of a large number of immunes.


West Indian native and Sero cottons from Brazil exhibited periodicity, producing no flowers from June to September. Upland and Sea Island showed no periodicity. In the $F_1$ of West Indian native x Sea Island, periodicity was dominant whereas West Indian native x Upland gave a nonperiodic $F_1$.

A correlation between resistance to cotton leaf blister mite (\textit{Eriophyes gossypii}) and periodicity is suggested.


Grafting experiments demonstrated that when the stock was susceptible and the scion immune, the scion retained its immunity. When the stock was immune and the scion susceptible, the resistance of the latter was apparently slightly increased. The $F_1$ results of a further series of crosses were given, and it was shown that the cross $G. \textit{barbadense}$ x $G. \textit{purpurasceus}$ gave a nearly immune $F_1$, while the cross susceptible $G. \textit{hirsutum}$ x $G. \textit{purpurasceus}$ (immune) gave $F_1$ susceptible.


Gives notes on resistance or susceptibility to this pest in various cottons. A type of \textit{G. purpurasceus} from north Brazil was found to be almost immune, and when grafted on to the summit of badly infected Sea Island, the immunity was retained.


The crinkled dwarf mutant was found to be a simple recessive to the normal type in Sea Island.


Shows that different varieties of cotton are characterized by differences in the mean number of teeth on the bracts. In two crosses the $F_1$ showed complete dominance of the larger number of teeth, but another cross gave an $F_1$ with a larger number of teeth than either parent.


The analysis of yield was presented schematically thus:

\[
\text{maximum value of lint per acre = value of lint per lb. x lbs. lint per acre.}
\]

\[
\text{Lbs. lint per acre = number of bolls per acre x weight of lint per boll.}
\]

\[
\text{Number of bolls per acre = number of bolls per plant x number of plants per acre.}
\]
Weight of lint per boll = number of seeds per boll x weight of lint per seed.

Number of seeds per boll = number of loculi per boll x number of seeds per loculus.

The first paper examines the selection possibilities of weight of lint per boll, weight of lint per seed, number of seeds per loculus, etc., and shows that the level of every morphological character bearing on yield, can be raised considerably by selection. No single strain possessed the maximum association, but one strain had a weight of lint per boll 31% higher than that of the ordinary type grown in the island.

The second paper covers the following points:

1. Short linted plants can be eliminated easily from the commercial crop by pedigree culture.

2. Slight differences in lint length, weight of lint per seed, seed weight, and weight of lint per boll are hereditary, and are maintained from season to season.

3. The yield of Sea Island cotton can be increased by selecting strains possessing certain combinations of morphological characters, since some of these are highly correlated with yield.

Correlations:

- Lint weight and lint per boll, \( r = +0.90 \).
- Lint weight and lint per acre, \( r = +0.75 \) and +0.56 (two seasons).
- Lint per boll and lint per acre, \( r = +0.54 \) and +0.84 (two seasons).
- Lint per acre parent and lint per acre daughter, \( r = +0.46 \).

4. In general, the characters of single plants afford only a slight guide to the kind of progeny they will produce, and therefore selection should be shifted away from the single plant to the mean of the strain.

5. In selection work, valuable combinations of genes may be permanently lost unless full attention is given throughout the period of selection to all the morphological and physiological factors bearing on yield.


Gives an account of the F₁, F₂ and F₃ of a cross between immune *G. purpurascens* and susceptible *G. hirsutum* (Upland). The F₁ was susceptible, though not quite as susceptible as Upland. The F₂ gave a graded series, with roughly 365 susceptible:100 immune. In the F₃, immune plants bred true (9 families), and susceptible plants gave rise to susceptible and immune offspring in varying proportions (35 families).

It is not considered that the results demonstrate simple Mendelian inheritance, but the work does open up the way to the production of immune types of cultivated cottons.


Discusses the existence of elementary species among the native cottons of the West Indies, and proceeds to describe the inheritance of corolla colour. There are at least six grades of colour which breed true, and a cross between any two shades gave an intermediate F₁. The F₂ and F₃ results of the cross medium yellow x white indicated that these two colours constituted an allelomorphic pair. Another
cross possibly involved duplicate genes.


Surveys previous work by Balls and concludes from this and from the work recorded in the present paper that there is strong evidence that the results are capable of being interpreted on a factorial basis as regards the proportion of 3, 4 and 5-locular bolls.


Leake and Ram Prasad's (1912 a) conclusions on the deleterious effects of inbreeding in cotton are criticized. Their cases of reduction in fertility as measured by the ability of selfed plants to set bolls are discussed, and it is pointed out that (a) the results are not statistically significant and (b) the neglect of environmental causes of shedding invalidates the data.

It is thought that the cases of contabescence observed by Leake were either environmental or due to lethals.

A case of complete male sterility in Sea Island is considered to be genetic.

Continued inbreeding has not resulted in progressive diminution in fertility, as measured by percentage of ovules set, either in Sea Island (Harland) or Kumpa (Kottur, 1921). Indeed, inbreeding may result in the isolation of types more resistant to shedding than the commercial ancestors.

Continued inbreeding does not necessarily lead to sterility, as measured by abortion of pollen grains, for such abortion is not more frequent in elementary species or pure lines than commercial stocks or F₁ hybrids.

Inbred lines of cotton are in no way distinguishable from commercial stocks except in a reduction of general vigour, which is usually slight and of little consequence to those engaged in cotton breeding.


A general survey. It is noted that there seems to be linkage between pollen colour and boll loculus number and that flower colour is probably linked with one of the factors for hairiness.

Crinkled dwarf, controlled by a single recessive gene, was described by Harland in 1916. It was not observed again till 1925 when it appeared in a pure line in St. Vincent. Again in 1927 it appeared as one plant in a two acre plot of uniform Sea Island.

White flowered Sea Island, also, is a mutation.

"Inheritance in New World cottons is usually complicated by modifying factors, and this is probably due to the number of chromosomes. . . . Mutations appear to occur less frequently in Old World Cottons."


Describes the application of Blakeslee and Farnham’s system of bottle-grafting to cotton. The process is illustrated.


Reports the following pairs of alleles in New World cottons: tufted and naked seed, fuzzy and tufted seed, dominant naked and woolly seed, red and green leaves, yellow and white flowers and green and chlorophyll deficient plants. One chromosome in the Asiatic group may be represented in the New World group, since red leaf and a node number factor appear to be linked in both groups.


The author first analyses yield per acre into its basic components of plants per acre, fruiting branches per plant, bolls per branch, locules per boll, seeds per loculus, hairs per seed, and mean hair weight. General considerations in breeding for such of these characters as are genetic, are discussed.

Work carried out on petal spot is summarized. The genes concerned are:

- **S** Full spot of Sea Island and Egyptian.
- **S** Full spot of Grena-dines White Pollen.
- **S** Weak spot of Trinidad Red Kidney.
- **S** Faint spot of Jamaica Long Staple.
- **S** Extinguished spot of Cassava.
- **S** Spotless of Upland.

The leaf-shape genes listed are:

- **O** Upland leaf shape.
- **O** Cassava leaf shape.
- **O** Upland Okra leaf shape.
- **O** Upland Super-okra leaf shape.

The seed fuzz genes are:

- **T** Tufted (dominant to naked); found only in the Peruvian group.
- **T** Tufted found in Meade; dominant to Sea Island tufted and to the fuzzy gene of *G. tomentosum*.
- **Z** A dominant fuzz factor found in most Uplands; dominant to Sea Island tufted, present also in *G. tomentosum*.
- **F** A fuzz factor dominant over Meade tufted.
- **N** A factor for naked seed found in Upland; completely dominant over all other forms of fuzz distribution.


Weak spot of Trinidad Red Kidney, **S**, is allelomorphic to spotless Upland, **S**; **S** and **R** (red) are linked.
Extinguished spot of Cassava, \( S^e \), is allelomorphic to spotless Upland, \( S^s \); \( S^e \) and \( R \) are linked.

Full spot of Pima Egyptian, \( S^a \), is allelomorphic to extinguished spot of Cassava, \( S^e \); \( S^a \) and \( R \) are linked.

Full spot of Sea Island, \( S^a \), is allelomorphic to weak spot of Trinidad Red Kidney, \( S^w \); \( S^a \) and \( R \) are linked.

Full spot, weak spot, extinguished spot and spotless form a system of multiple allelomorphs.

Red and spot of the multiple allelomorph series are linked with 4.3% cross-over value.

Full spot of Pima Egyptian, \( S^a \), is allelomorphic to intermediate spot of Grenadines White Pollen \( S^i \).

Full spot of Grenadines Naked, \( S^a \), is allelomorphic to faint spot \( S^f \) of Jamaica Long Staple.

Weak spot of Trinidad Red Kidney, \( S^w \), is allelomorphic to faint spot of Jamaica Long Staple, \( S^f \), since \( R \) and weak spot are linked.

Strong spot, above grade 7, in Upland x Sea Island White may be due to two complementary linked genes, but the evidence is not complete. The main gene for strong spot in (Upland x Sea Island) x Sea Island is linked with \( Y \) (yellow corolla) with 25% cross-over value. In this cross, linkage also exists between \( Y \) and a spot modifier with 20 to 33% cross-over value. The spot gene linked with \( Y \) is not the same as the spot gene linked with \( R \).

Modifying factors may profoundly affect the development of spot in a plus or minus direction.


Yellow and pale cream form a simple pair of factors, \( P \) and \( p \).

Modifying genes act on the basal gene for yellow, producing a complex series of shades from pale yellow (0.5) to deep golden (4.0). These modifying genes can be carried by grade 0, producing such minute variations in shade as are exemplified by Super-okra and Grenadines White Pollen.

\( P \) produces little effect when unsupported by modifiers, and the distinction between \( P \) and \( p \) is often hard to make in segregating families lacking such modifiers. It is possible that in the absence of any modifier at all, the distinction between \( P \) and \( p \) would vanish, i.e., \( P \) would produce too pale a shade of yellow to observe segregation.

In crosses between cottons of the same class segregation is usually sharp, owing to similar modifying factors being present in a homozygous condition in both parents.

In the selfed backcross (Upland x Sea Island) x Sea Island, an intensifier, \( Q \), was demonstrated, having no visible effect except in presence of \( P \).

418. HARLAND, S. C. 1929 d. The genetics of cotton. III. The inheritance of corolla colour in New World cottons. *J. Genet.*, 21, pp. 95–111. (Condensed from Author's summary).

Pale cream of Upland or Sea Island White, and yellow of grades 1 to 7, form an allelomorphic pair of characters controlled by the genes \( Y - y \).

Segregation in interspecific crosses is more complicated than in inter-Peruvian crosses. In the inter-Peruvian cross involving...
Sea Island White there is sharp segregation in the F2, with absence of intermediate grades.

Upland and Sea Island White are both genetically y, but Sea Island White, having arisen directly from the yellow form by a single locus mutation, possesses a series of plus modifiers for yellow, while Upland possesses fewer modifiers. Segregation of modifiers produces the intermediate grades of yellow.


Earliness is a function of: speed of germination; growth rate of main axis; position of lowest sympodium; time intervals between nodes along sympodia and between one sympodium and the next; genetic liability to bud and boll shedding; disease susceptibility (causing shedding); boll maturation period; and form of flowering and fruiting cone as affected by spacing.

Rate of growth is primarily genetic but is affected by environmental conditions.

Shedding of buds before flowering commences is correlated with subsequent boll shedding. Certain strains constantly shed buds on the first few sympodia, and even shed the whole sympodium. This tendency can be minimised by continued selection of plants which produce their first flower on the first node of the first fruiting branch.

It is suggested that facultative shedding may be a photoperiodic response.

A big flowering curve, descending very slowly may merely indicate excessive bud and boll shedding.

Boll maturation period ranges from 30 days in some Asiatics to 51 days for Sea Island in Trini-
dad (or up to 70 days with lower temperatures).


Describes hybrids between tetraploid New World cottons and *Thurberia thespesioides*. These hybrids were sterile. Suggests *Thurberia* be transferred to *Gossypium*. Crosses between *G. stocksii* and *T. thespesioides* were also made, but died after forming two or three leaves. Crosses between *G. davidsonii* and *T. thespesioides* died in the cotyledon stage as a result of progressive necrosis.


A preliminary report on a hybrid between *G. barbadense* and *G. arboreum* which proved partially male fertile, thus making possible the initiation of experiments to transfer Asiatic genes to New World cottons. Progenies of first and second backcrosses to *G. barbadense* were raised.


A detailed survey of the knowledge of cotton genetics to date, with a bibliography of 76 references. A fairly full index is provided.

COTTON BREEDING AND GENETICS

Crosses of crinkled dwarf x Sea Island exhibit complete dominance of Sea Island, but in crosses with other Peruvian types, dominance is slightly disturbed, producing in the F₁ normals with a slight trace of crinkling and some variation of the crinkled class in the F₂.

A cross of crinkled dwarf x Upland gave an intermediate F₁ with dominance becoming increasingly manifest in backcrosses of the heterozygote to Upland.

Selfed heterozygotes from the first backcross produced in one case a family indicating true reversal of dominance, the ratio 3 crinkled : 1 normal being obtained. Reversal of dominance persisted in the next generation from this family.

Crosses involving crinkled dwarf and G. sturtii gave an F₁ which was strongly crinkled, but a heterozygous crinkled dwarf x G. sanguinum gave an F₁ only slightly crinkled.

The bearing of the experiments on Fisher's theory of dominance is discussed, and it is concluded that while the behaviour of crinkled dwarf in Upland crosses is in accordance with the Fisher theory, the process by which genes modifying dominance are thought to have become homozygous in Peruvian, involves the assumption that normals, descended from heterozygotes, have replaced the original normal population. This assumption is thought to be improbable.

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COTTON BREEDING AND GENETICS

and by the building up of new dominance mechanisms. This thesis is illustrated by reference to *G. hirsutum* and *G. barbadense*.


Observations were made on the crinkled character when transferred by repeated backcrossing to *G. hirsutum*. Selfing of the heterozygotes of the fourth backcross produced normal, intermediate crinkled, and extreme crinkled in a 1:2:1 ratio, and the results from selfing sixth backcross heterozygotes showed that no change had taken place through further backcrossing.

The new *G. hirsutum* crinkled type appeared less vigorous and productive than the original *G. barbadense* mutant, though under good conditions little difference was observable.

*G. hirsutum* heterozygous for the crinkled factor was shown to have a slight advantage over normal under good conditions and was not at any considerable disadvantage under bad conditions.

Transference of the crinkled character to two further types of *G. hirsutum* revealed complete or nearly complete dominance of *G. hirsutum* to the crinkled type.

The bearing of the experiments on Fisher's theory of dominance is discussed and it is concluded that modification of the theory is necessary. Complete dominance of normal over crinkled exists in two types of *G. hirsutum* although the crinkled mutant does not occur in that species.

It is concluded that modifiers of dominance are of advantage to the wild type and are thus selected on their own account.


Inspection of the Upland-Egyptian hybrids growing on a vast scale cast doubt on the Russian claim that such hybrids offer great possibilities.

In the Asiatic (*n* = 13) group the problem of improvement seems to lie in the synthesis of the economic characters already extant in one or other form, through crossing with *G. anomalum*, and the possibilities of inducing tetraploidy are worth investigating.

In the New World (*n* = 26) group there are 7 species and the taxonomic relationships of these are briefly described. It is suggested that in some cases, such as Upland and Sea Island-Egyptian, each species possesses a co-ordinated gene system adapted to a given set of environmental conditions and that to cross them partakes of the nature of trying to build a better car by combining the parts of two cars of different makes.

Before indulging in speculation on the value of such crosses it is necessary to have information as to the extent to which single genes can be transferred from one species to another and the extent to which whole sections of
COTTON BREEDING AND GENETICS

chromosomes can be so transferred. Results bearing on these questions are described. In such work backcrossing would have to be used.


In Sea Island (Heaton), lint index is shown to be strongly correlated with yield. By selection on family means in material which had been selfed for 17 generations, plants with lint indices as high as 7.4 have been obtained.


A semi-popular account of the history and work of the station.

432. HARLAND, S. C. 1934 d. Two cases of linkage in New World cottons. Trop. Agriculture, Trin., 11, p. 316. (Author's summary).

Records a cross-over value of 13.9% for G. hirsutum red R and hirsutum cluster G, and shows that crinkled (cr) is linked with green lint (G) with a 5% cross-over value.


Further experiments are described on the mode of inheritance and distribution in six species of New World cottons of a pair of duplicate factors for chlorophyll deficiency.

Duplication of factors is considered to have taken place through polyploidy with subsequent mutation of one or other of the members constituting the pair in some of the species. G. barbadense and G. darwinii have become monomeric through the loss of factor Ch, while purpurascens, hirsutum, and tastense, when monomeric, are shown to have lost Ch.

The experimental data support Haldane's view that in polyploid species one member of a pair of duplicate genes may mutate without disadvantage, provided its functions can be performed by a gene in one of the other sets of chromosomes.

The taxonomic and evolutionary significance of the results is discussed and it is suggested that the extent to which the dimeric condition is converted to the monomorphic in polyploid species may provide some indication of the age of the species. In an old series of allopolyploids such as the New World species of Gossypium are considered to be, cases of dimery might be expected only infrequently, and usually only in interspecific crosses.


Transference of the gene R from G. arboreum to G. hirsutum was carried out by several backcrosses, in the course of which the initial sterility was ultimately modified to complete fertility.

In the G. arboreum genotype, R produced the character complex red plant body, red flower and intense petal spot. In the G. hirsutum genotype the phenotypic effect of R involved a great
reduction in the intensity of red coloration in the plant body and in the flower, and a total disappearance of the petal spot.

It is considered that in the Asiatic group, R is accompanied by modifiers enhancing anthocyanin pigmentation, while G. hirsutum either lacks such modifiers altogether or carries a neutralizing or diluting set of modifiers in the other 13-chromosome subgenome.

R, already established to be a member of multiple allelomorphic series of factors conditioning anthocyanin pigmentation in Asiaties, is probably a new allelomorph in a similar multiple allelomorphic series characterizing the New World group. The theory of Skovsted (1934) that the New World n = 26 group is amphidiploid, with one subgenom homologous with the n = 13 Asiatic species G. arboreum and G. herbaceum, is thus strengthened by genetic evidence.

From the present geographical distribution of the Asiatic and New World groups, it is suggested that the New World amphidiploids arose during late Cretaceous or early Tertiary times.


The cross G. hirsutum crinkled (Type 9) x G. barbadense crinkled, gave in the F1 a series of crinkled type ranging from super-crinkled to pseudonormal. In later generations several new types of crinkled were extracted in homozygous form.

It is considered that G. barbadense and G. hirsutum possess dissimilar modifier complexes, which in the interspecific cross are broken down, leading to the production of a varying series of genotypical backgrounds upon which the crinkled mutant manifests itself in a corresponding series of reactions, some favorably and others unfavourably.

The conversion of the crinkled mutant to pseudonormal by genic recombination resulting from the interaction of G. barbadense and G. hirsutum modifiers favours Fisher's view that recessives may ultimately become merged in the wild type by accumulating modifiers.

A new method for the production of duplicate genes is suggested.


Egyptian brown x Sea Island white gave an intermediate F1 and blended inheritance in the F2. This was demonstrated to be because the factor Kb of the brown parent was accompanied by a number of plus modifiers absent in the white parent.

Selfing after three backcrosses to the brown parent gave simple segregation into 3 brown : 1 light brown.

There was a negative correlation between lint colour and lint length, the factor Kp or a factor closely linked to it shortening lint length by approximately 5-1 mm. when homozygous and 2-7 mm. when heterozygous.

Minor colour factors were also correlated with variations in lint length.

The blending inheritance of brown lint in Egyptian x Sea.
COTTON BREEDING AND GENETICS

Island is considered to be due to the disintegration of an original brown lint factor complex.

The cross of brown-linted *G. barbadense* x brown-linted *G. hirsutum* was shown to involve duplicate genes for lint colour.


Davie's (1935) suggestion that the New World cottons arose from a cross between a wild American diploid and *G. mexicanum* or *G. brasiliensis* is refuted because these latter species are themselves closely related to *G. hirsutum* and *G. barbadense* respectively and are tetraploids. It is pointed out that Asiatic cottons introduced in the sixteenth and seventeenth centuries would not be likely to continue in cultivation and that the hybridization assumed in Skovsted's and Harland's theories probably occurred in late Cretaceous or early Tertiary times.

Okra cotton is a form of *G. hirsutum* and not, as Davie said, an Asiatic form.


Polyembryonic haploidy is described in *G. barbadense* and *G. hirsutum*.

The practical importance of haploids in cotton breeding work is discussed.


\[ G. \text{ darwinii} \] (endemic in the Galapagos Islands) has been isolated from its nearest congeners in South America for some millions of years. Yellow corolla colour in *G. darwinii* is due to a different gene from that conditioning yellow corolla in *G. barbadense*. Duplicate genes for corolla colour are the fourth case of duplication in New World cottons. It is demonstrated that the origin of the New World amphidiploids must have taken place prior to the time when the Galapagos Islands became isolated.


Begins with a short survey of the literature of species crosses, from which two main principles emerge: (i) blending is characteristic of interspecific crosses, (ii) taxonomic divergence is correlated with an increasing tendency to change genes from an identical to an allelomorphic state.

The comparative genetics of *Gossypium* is then discussed in detail. Blending inheritance of characters which are simply inherited within species is due to segregation of modifier complexes which differ from species to species. Cases of blending are converted into simple monohybrid inheritance after a sufficient number of backcrosses to either parental species.

Tables are given showing the prevalence and distribution of a large number of genes in the six species of New World *Gossypium*.

In *Gossypium* long separation has given rise to profound genetic changes. Genes have evolved into new alleles, homologous
characters have become constructed in different ways, and new co-ordinated modifier systems set up.

Changes in structural characters have been less important than changes in physiology. The differences between *G. tomentosum*, an extreme xerophyte, and the other species may be a matter of hundreds or possibly thousands of minute physiological genes. Climatic adaptation seems to be directly proportional to the number of *G. tomentosum* or *G. barbadense* genes present.

In the six species of New World cottons, it is known that alleles at the same locus are held in common, and probably certain common recessives are identical. If, however the genetical architecture of *G. barbadense* and *G. hirsutum* were completely different in respect of complex morphological entities such as the flower, we should expect more or less mutual disintegration of the whole genetical complex and many abnormalities in the morphology and developmental physiology of the flower. Some abnormalities do occur, but since most combinations possess perfect flowers, the species presumably possess either a common stock of genes or an assemblage of mutually replaceable ones.


The centre of origin of the *G. barbadense* group is probably in the Valle del Cauca, Western Colombia, since the highest concentration of dominant genes yet encountered occurs in this region.


A plant of *G. armouri-anum* with yellow corolla, yellow pollen and petal spot was crossed with a Sea Island type with cream petal, cream pollen and spotless petal. Backcrosses gave 1:1 ratios in each pair of characters, establishing the three independent pairs of alleles $Y^{ARM}, Y^{ARM}$ (yellow/cream corolla) $P^{ARM}, P^{ARM}$ (yellow pollen/cream pollen), $S^{ARM}, S^{ARM}$ (petal spot/no petal spot).


The gene $S^H$ (*hirsutum* petal spot) is slightly mutable somatically on (a) a *G. hirsutum* background, and (b) a background predominantly *G. barbadense*.

The gene $S^P$ (*purpurascens* petal spot) becomes increasingly mutable, both somatically and gametically, pari passu with the replacement of *purpurascens* by *hirsutum* genes.

It is believed that species may possess modifier complexes, the effect of which is to preserve the stability of genes and prevent them from mutating at an excessive rate. *G. hirsutum* and *G. purpurascens* are assumed to differ in the nature of such of their modifiers as affect the mutation rate of $S^P$.


Chlorophyll deficiency, known only to occur in the $F_2$ of *G. barbadense* x *G. hirsutum*, was
transferred to the genetical background of both these species by repeated backcrossing.

On the background of *G. barbadense*, chlorophyll deficiency was reduced to nongerminable seeds, while on that of *G. hirsutum* it was manifested as a pale yellow form not viable beyond the seedling stage.

In the F2, by recombination of species modifiers, chlorophyll deficiency can be raised to complete viability; thus mature plants may possess green leaves, although they had pale yellow cotyledons in the seedling stage.


The following transferences, made by repeated backcrossing, are recorded: normal C^n from *G. aridum*, *G. armourianum* and *G. thurberi* to *G. barbadense* recessive crinkled c^n; petal spot from both *G. aridum* and *G. armourianum* to *G. barbadense*; and *G. aridum* petal spot to *G. hirsutum* also.

The normal alleles of crinkled, present in *G. aridum* and *G. thurberi* resemble the corresponding allele in *G. hirsutum* in being weakly dominant, while the petal spots of *G. aridum* and *G. armourianum* seem to differ from the petal spot genes of either *G. barbadense* or *G. hirsutum*.


The author places little reliance on field selection but advocates growing the maximum manageable number of short progeny rows. He also recommends making use of backcrossing and of compound hybridization in plant breeding.


Reference is made to the transference of the gene for red leaf from *G. arboreum* to *G. barbadense*, where it proved to be a new member of an existing allelic series. New World wild diploids of the groups *G. armourianum*, *G. harknessii*, *G. aridum* and *G. trilobum* have also been shown to possess homology with the tetraploid group. Cytological evidence is adduced in support of the view that these two groups of diploids represent the respective ancestors of the tetraploid New World group. The union is thought to have occurred when there was land connexion between the Pacific coast and Malaya, probably in the Cretaceous period. Relics of other tetraploids have remained on islands such as Hawaii and Fiji, the only parts of this land connexion that have not been submerged. *G. barbadense* was apparently domesticated by the Incas, *G. hirsutum* by the Aztecs and *G. punctatum* (= *G. Hopi* Lewton) by the North American Indians, the tropical monopodial (tree) forms being the original types. The greatest concentration of genes of *G. barbadense* has.
been found by the author in the Valle del Cauca, Colombia, which is therefore regarded as the probable centre of origin of this species. The corresponding centres for G. hirsutum and G. punctatum appear to be southern Mexico; the centre for G. purpureascens remains doubtful. This last-named species is thought to have great possibilities for breeding, since it is adapted to an unusually wide range of climatic conditions and has lint of first-rate quality.


The n = 26 hybrid of G. arboreum x G. thurberi was crossed with a number of G. hirsutum and G. barbadense types, and the importance of this, in view of the pink bollworm immunity of G. thurberi, is emphasized.


Disagrees with the view of Hutchinson that the Bourbon group of cottons should be merged in G. hirsutum. Presents genetical evidence to support the view that the assemblage of Bourbon cottons constitutes a good species which should be known as G. purpureascens pending a better name.


Amplifies previous information on genetical architecture in the genus Gossypium. Puts forward the hypothesis that it is a huge interlocking series of modifier complexes that characteristically marks off one species from another in a given genus.

Petal spot in G. armourianum, SARM, and in G. aridum, SART, is due to two new genes, which are both at the same locus as Rh (hirsutum red).

A resynthesis of the New World amphidiploid was effected by doubling the chromosome complement of the hybrid G. thurberi x G. arboreum with colchicine. The new amphidiploid was male sterile, but completely fertile as the female parent in crosses with both G. barbadense and G. hirsutum.

Discussing the genic effects of prolonged isolation, it is pointed out that in G. hirsutum, G. barbadense, G. purpureascens, G. arbo reum, G. aridum and G. armourianum, there are as many different ways of constructing petal spot as there are species. Thus the first genetical effect of geographical isolation is that homologous characters become built up in different ways, with three main types of construction:

Type 1. A strong key gene with few or no modifiers (e.g. hirsutum spot).

Type 2. A weak key gene accompanied by plus modifiers, (barbadense spot).

Type 3. An association of modifiers with no key gene (arboreum spot).

The distinction between these three methods is regarded as of great evolutionary significance.
COTTON BREEDING AND GENETICS


Genes from three North American diploid species, *G. thurberi*, *G. armourianum* and *G. aridum*, were transferred by repeated backcrossing to the amphidiploid species *G. barbadense* and *G. hirsutum*.

All three species possess normal alleles of the *G. barbadense* crinkled mutant *C*<sup>n</sup>. *G. thurberi* has a normal allele with a low degree of dominance corresponding to that found in *G. hirsutum*, while *G. armourianum* has a normal allele with a high degree of dominance corresponding to that found in *G. barbadense*. The degree of dominance of *G. aridum* appeared to be less than that of *G. armourianum*.

The *G. armourianum* petal spot, *S<sub>arm</sub>*<sup>n</sup>, was not reduced in size or intensity on a *G. hirsutum* background, but on a *G. barbadense* background was increased in size and intensity. It proved to be at the same locus as *R*<sup>n</sup> (*hirsutum* red).

The *G. aridum* anthocyanin colour complex *S<sub>arm</sub>* was reduced in intensity on a *G. hirsutum* background and also proved to be at the same locus as *S<sub>arm</sub>* and *R*<sup>n</sup>. Although behaving as an indivisible unit in linkage relations with *R*<sup>n</sup>, the colour complex became mutable on a *G. hirsutum* background in the third and subsequent backcrosses. This phenomenon is regarded as being most probably due to mutation of a single gene in two different directions as a result of transference to a new species background.

The demonstration that *S<sub>arm</sub>* and *S<sub>arm</sub>* of *G. aridum* and *G. armourianum* are at the same locus as *R*<sup>n</sup>, proves that the New World cottons contain two 18-chromosome genomes of Asiatic and North American affinities respectively.

454. HARLAND, S. C. and ATTECK, O. M. 1941 b. The genetics of cotton. XIX. Normal alleles of the crinkled mutant of *Gossypium barbadense* L. differing in dominance potency, and an experimental verification of Fisher's theory of dominance. *J. Genet.*, 42, pp. 21-47.

It is believed that there have been two methods by which dominance at the crinkled locus in the six New World species of *Gossypium* has been attained. The first method is that proposed by Fisher, whereby dominance has been reached by modification of the heterozygous phase (*G. hirsutum*, *G. purpureascens* and *G. taitense*). The modifiers improving the heterozygous phase have simultaneously improved the recessive. The second method is that proposed by Haldane, in which dominance is attained by the employment of a normal allele with a high degree of dominance (*G. barbadense*, *G. tomentosum* and *G. darwinii*), the recessive phase being relatively unmodified.

Evidence is brought forward indicating that the normal allele of *G. barbadense*, *C*<sup>ab</sup>, may become mutable on the genetic background of one type of *G. purpureascens*.

455. HARLAND, S. C. 1942. Abstracts of papers by Sydney Cross...


Some F₁ pollen of G. barbadense x G. hirsutum is prepotent over the self pollen of the parents. This suggested the possibility of concentrating the genes controlling velocity of pollen tube growth, and thereby of breeding a type in which self pollen would grow so rapidly that outcrossing would be impossible.

Pollen from G. hirsutum x G. barbadense F₁ hybrids, carrying the dominant genes RYP, was applied to G. hirsutum (ryp) at hourly intervals following selfing. Some 11 plants of RYP type were obtained from the 4-hour, 5-hour and 6-hour treatments. A mixture of pollen from these 11 plants was similarly used in making the second backcross, an increased number of RYP plants resulting from the 4-6 hour treatments. A third backcross was made and the RYP plants from this were selfed. In the selfed progeny, all ryp plants were extracted to produce lines carrying the genes for rapid pollen growth.


Tanguis originated from a single plant of G. barbadense found in a crop of G. hirsutum. This plant was presumably a relic of the indigenous G. barbadense variety Semi-aspero, remnants of which survived as an impurity in G. hirsutum for many years, and were modified by natural selection in the direction of early maturity. Tanguis was originally resistant to Verticillium wilt and was very high yielding. The lint was long, coarse and white, and the ginning outturn very high. In the course of its spread through Peru, the variety became mixed and breeding work to establish a superior type was started in 1940. The methods used are reported in detail.

The initial material for breeding consisted of 22,000 single boll samples. These were reduced to 2863 by eliminating those with lint less than 1½ in. long or of bad colour. A single row of 11 plants was raised from each boll in 1940-1, rows which fell below fixed standards for lint length, boll weight, ginning percentage or yield being rejected. Subsequent rejection of rows with bad lint colour reduced their number to 41, from which 200 plants were selected. Seed from these was sown in a replicated trial.

In 1942, correlation studies showed that selection for lint length, boll weight, ginning outturn and yield had been effective even on single rows of 11 plants. A considerable all-round improvement was obtained in the variety. The 200 strains under trial were reduced to 43 on the basis of the above four characters and also on fineness and colour of lint, individual strains failing to come up to a set standard in any one of the six characters being rejected. These 43 strains formed the basis of the first two commercial multiplications of seed distributed by the institute. For further breeding, 10 plants from each of the best 10 strains were
taken, the selection being on much the same lines as previously. Of the 100 plants so tested, 63 were retained for bulk multiplication. It is intended to continue breeding in this way, so that successive distributions of seed will displace older types, and deterioration through admixture or crossing will be minimized.

In an appendix some genetical data are given. In crosses with Sea Island, Tanguis is shown to carry dominant genes for hairiness (H), yellow corolla (Y) and yellow pollen (P).


After briefly surveying the history of cotton breeding, the author expounds the thesis that pure line selection should not be practised, but that a mixture of strains should be multiplied, each strain having to conform to a series of specified genotypic standards before acceptance as a component of the mixture.


The author summarizes his system as follows:

1. To examine a large number of single plant samples from the heterogeneous commercial crop, in order to obtain quantitative estimates of the mean characters which are to be worked on, and to establish specifications or norms of the characters required.

2. To grow in progeny rows a large number of single plant samples which have passed preliminary tests (one replication).

3. To examine bulk samples from these progeny rows and to eliminate lines which fail to conform to the norms set up. This may be called the bulk norm test.

4. To examine all the single plants of the lines passing this test and to eliminate plants which themselves fail to conform to the norms. This may be called the single plant norm test.

5. From this material to select an elite of, say, 200 plants. To grow these in progeny rows with an adequate number of replications.

6. To apply the bulk norm test to eliminate undesirable lines and also to eliminate lines which in yield of seed cotton per plant are below the mean of the whole population of lines.

7. To mix the seed of lines which pass the norm test and to institute a multiplication plot on the Experiment Station.

8. To plant the whole production of No. 7 in an isolated field or a large farm.

9. To plant the whole production of No. 8 on a large area of the same farm.

10. To distribute the production of No. 9, as the first commercial wave of seed, approximately 1,000,000 lb.
11. To continue the steps from 2 to 10, with such modifications as practical exigencies necessitate, so that each year a new wave of approximately 1,000,000 lb. of seed can be distributed.

Evidence is given showing considerable scope exists for selection for increased oil content of the seed.


A detailed account of the breeding methods used, which led to the production, amongst other strains, of N 17.

Harrell, D. C. 1943. See Ware, J. O., Jenkins, W. H. and Harrell, D. C.

Harrell, D. C. 1944. See Ware, J. O. and Harrell, D. C.

Harrell, D. C. 1944. See Ware, J. O., Jenkins, W. H. and Harrell, D. C.

Harris, C. T. 1925. See Harris, J. A., Harris, C. T. and Hoffman, W. F.


This paper records an intensive study of osmotic concentration, specific electrical conductivity, and hydrogen ion concentration in leaf tissue fluids of Pima, Meade and Acala, grown under irrigation in south Arizona. The Egyptian cotton had a higher osmotic concentration, a higher electrical conductivity and a higher acidity than either of the Upland types. The tissue fluids of the F₁ of Pima x Meade had a lower osmotic concentration and a lower specific electrical conductivity than either parent whereas the hydrogen ion concentration was intermediate between the parental values.


The sulphate content was higher in Meade and Lone Star than in Pima.


Mature Pima leaves gave average pH values ranging from 5·25 to 5·41 whereas Upland ranged from 5·35 to 5·46. The pH of the tissue fluids of the hybrid was intermediate between the parental values of Egyptian and Upland.


Egyptian varieties had a higher osmotic concentration and specific electrical conductivity, a higher chloride content and a lower sulphate content than Upland varieties.

466. Harris, J. A. 1927. Physiological differences in varieties, a graphical representation of
chemical differences in the tissue fluids of Egyptian and Upland cotton. *J. Hered.*, 18, pp. 277-279.


This paper is mainly concerned with statistical criteria for measuring seedling stand differences. Pima and Sea Island showed marked superiority over the Upland varieties in capacity to establish seedling stands on saline soil.

HARRISON, G. J. 1940. See RUDOLPH, B. A. and HARRISON, G. J.

HARRISON, G. J. 1924. See KEARNEY, T. H. and HARRISON, G. J.

HARRISON, G. J. 1927. See KEARNEY, T. H. and HARRISON, G. J.

HARRISON, G. J. 1928. See KEARNEY, T. H. and HARRISON, G. J.

HARRISON, G. J. 1929. See Harris, J. A., Harrison, G. J. and LOCKWOOD, E. K.


Pollination of Pima flowers by Hopi reduced the boll maturation period by 1.1 days, significantly reduced lint length by 16 in., significantly reduced seed fuzz, and significantly increased seed weight.

Durango flowers pollinated by Pima gave a slightly increased boll maturation period and the seeds had longer lint and a higher lint index.


The best method of storing Pima pollen was by refrigeration of flowers collected early on the day of anthesis. Even so there was a reduction in effectiveness as measured by tests at 2, 3 and 4 days.


Some cotton varieties having fibre of exceptional strength have been obtained, though their yield is below average.

Verticillium wilt resistance has been shown to be generally associated with late maturity, small bolls and short staple, but certain American-Egyptian varieties have also shown resistance.

HASKINS, C. P. 1933. See MOORE, C. N. and HASKINS, C. P.


When the leaf stems are immersed in various salt solutions and the leaves are exposed to
diffused daylight, yellow spots and patches appear after varying lengths of time, depending on the tolerance of the given variety to the salts. Leaves of plants grown in salty soils exhibit high tolerance, and yellowing appears only when the salt concentration of the leaf juice is much greater than that found in normal plants exhibiting an equal degree of chloroplast destruction.

    Describes a method of sewing up the tip of the bud with a needle and cotton.


    A sample of 100 seeds chosen as nearly as possible from 100 different locks is adequate for determining average seed weight and average weight of lint per seed. The probable error of one such determination is 1·3% for seed and 1·4% for lint.
    Errors due to fluctuations in humidity may be ignored provided weighing is restricted to either the dry weather or the monsoon period and provided the weighing is not done on days of excessive humidity.

    Hiremath, N. B. 1947. See

    The number of basal monopodia was controlled by variety and environment but was not correlated with any physical character. The number of fruiting branches was closely correlated with plant height. There was a low correlation between number of fruiting branches and number of bolls per plant. Lint percentage was negatively correlated with seed weight and lint length and there was a high correlation between weight of boll and weight of seed.


A dosage of 100 KV, 5 ma. at a target distance of 17 cm. for 60 min. did not lower the germination of good cotton seed appreciably. The following abnormalities appeared in X-irradiated material: 3 cotyledons (1 normal and 2 small), 1 cotyledon (2 fused), crumpled leaves, leaf variegation (both splotched and angular), a somatic mutation from virescent yellow to green, and types with intermediate leaves in a laciniate population.


Radiation of seed of G. hirsutum gave numerous variants. Yellow seedlings which behaved as simple recessives occurred in the X₂.

Radiation of the seed of plants homozygous for forked leaf (nn) gave an intermediate (Nn) X₁, and in the X₂ a plant with normal leaves (NN) occurred. Seeds with embryos heterozygous for leaf shape were X-irradiated, and among the progeny of the selfed bolls from these plants some produced only plants with normal leaves.

The radiation of the seed of virescent yellow plants produced some green plants, another example of a progressive gene mutation.


Plants grown from X-irradiated dry seed developed numerous variegated leaves with chlorophyll deficient areas, especially when a line of virescent yellow cotton was used. All plants from seed of this line that had been subjected to 100 KV, 5 ma., for 50 minutes at a target distance of 17 cm. produced variegated leaves of two types, splotched and angular.

Chlorophyll deficient individuals appeared among the progeny from three different plants that had been grown from X-irradiated seed. Seedlings grown from heterozygous plants showed a ratio of 3 green (or virescent green) : 1 chlorophyll deficient.


Mutations which are progressive have been produced in cotton (Gossypium hirsutum) by X-ray treatment of the dry seeds. These mutations consist of:

1. A mutation from forked leaf shape to normal leaf shape. This was induced in two different lines of cotton, viz.:
   a. An F₁ which was heterozygous, Nn.
   b. A homozygous forked leaf line, nn.

2. A mutation from virescent yellow leaf and plant colour to normal green leaf and plant colour.

The mutation rate in each case was less than 1%.

Evidence is also presented for reversible mutations in cotton. There are indications that a mutation has been induced from normal leaf to forked leaf, the reverse of the mutation from
forked leaf to normal leaf. The induced mutation from virescent yellow to green is the reversal of the mutation from green to virescent yellow which had previously occurred in nature.

HORLACHER, W. R. 1933. See KILLOUGH, D. T. and HORLACHER, W. R.

HSI, Y. L. 1934. See Yu, C. P. and HSI, Y. L.

HSIEH, L. C. 1937. See Yu, C. P. and HSIEH, L. C.


A brief survey of cotton research in China during the last 25 years.

G. arboreum is most widely distributed; G. herbaceum is confined to Sinkiang and Kansu; G. hirsutum, introduced from America, is common in North China; G. barbadense occurs in southwest China; and G. purpureascens is cultivated in Kwangtung and Kwangsi.

Introduction of American varieties began in 1911 and the first adaptation study was conducted in 1918-19 followed later by acclimatization work. A second large scale adaptation trial was made in 1933-37 with 31 newly-introduced varieties. It was found that Stoneville No. 4 was best for the Huang-ho delta and Delfos No. 531 for the Yang-tze delta. Since the war further trials have been made in the southwestern provinces. Many local and imported varieties have been tested and the best ones determined for each locality. Many American varieties are cultivated in China with success. In general the early ripening varieties are suitable but the big-bolled varieties are not. The indigenous varieties are, less adaptable; they generally do best in the particular localities in which they are found. The imported varieties are most important in the Huang-ho delta but not in the Yang-tze delta where local varieties are mostly grown because of the more varied natural and farming conditions. In the southwest, the cultivation of G. barbadense, Egyptian and Sea Island, is more promising. Breeding work consists of the acclimatization of the imported varieties, pure line selection of local varieties, and hybridization. Pure line selection since 1921 on both quality and yield has resulted in many improved varieties. The most important are: (1) Improved Blue-stem Arboreum, (2) Improved Small White Flower, (3) Improved Kiangyin White Seed, (4) Shaogan Smooth-seed Long-staple, (5) Pei-wan Chinese, (6) Funghsien American No. 72, and (7) Chungnun New Delfos. Important varieties obtained from hybridization are: (1) Kwu's cotton (Kiangyin White seed x Peking Long Staple), (2) Changfeng (Pei-wan x Shaogan Long-staple); (3) Multi-valve Ta-seh (Kiangyin White Seed x Five-valve Arboreum); (4) Resistant Long Staple (Indian Arboreum x Shaogan Long-staple); and (5) Arboreum-Delfos (American Arboreum x Delfos No. 531).

A yellow seedling mutant has been found and proved to be a simple Mendelian recessive lethal, linked with anthocyanin pigmentation. Another chlorophyll deficient yellow-green mutant has also been shown to be a simple Mendelian recessive. Hutchinson's allelomorphic series of anthocyanin pigments has been revised, and a new parallel series...
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of allelomorphs has been discovered. A new leaf roll mutant has been shown to be a simple recessive and is linked with leaf shape with a cross- over value of 16-6%. Simple Mendelian inheritance has also been shown for leaf nectar-glands, corolla coloration and corolla base coloration. Statistical studies have been made on the quantitative inheritance of the number of valves, weight of fruit, and yield.


HUBBARD, J. W. 1926 a, b & c. See COOK, O. F. and HUBBARD, J. W.

HUBBARD, J. W. 1928. See COOK, O. F. and HUBBARD, J. W.


Records an Acala cotton plant with empty carpels and having the placentas expanded around fruiting buds. These buds were complete except for the involu- cral bracts.

HULL, W. W. 1930. See O'KELLY, J. F. and HULL, W. W.

HULL, W. W. 1933. See O'KELLY, J. F. and HULL, W. W.


Of seven mother plants examined, three with high oil content transmitted this character to their progeny. Forms with lower oil content gave progenies with lower average oil content.


The following somatic chromosome numbers are given: G. nanking, 26; G. nanking var. soudanensis, 26; G. neglectum 26; G. intermedium 26; G. harknessii, 26; G. herbaceum, 26; G. arboreum, 26; G. armouianum, 32-34; G. purpurascens, 52; G. hopi, 52; G. barbadense, 52; G. patens, 52; and G. hirsutum, 52.


Recommends the use of lemonade straw on the stigma, the straw containing anthers of the required parent and being attached to the plant by copper wire.


A highly significant negative correlation between staple length and lint percentage was found in five varieties, and no significant correlation was found in the remaining varieties.

Inbreeding cotton varieties rapidly segregates many types that become relatively uniform after two to three generations, the inbred lines being much more uniform in all cases than the varieties from which they arose.

Comparison of 2- and 7-year inbreds indicates that there is little increase in uniformity after 2 years of inbreeding.

Substantially the same as the preceding paper.


See Humphrey and Tuller, 1938.
HUMPHREY, L. M. 1943. See YOUNG, V. H. and HUMPHREY, L. M.


Empoasca devastans has come into prominence during the last 23 years, since the introduction of American cottons in the Punjab. No cotton which is not resistant to jassid has any chance of success in the Punjab. Desi cottons are more or less immune, while in general, American cottons are susceptible, though such varieties as 4F and LSS are less susceptible than, for instance, 38F, 43F and 289F. U 4, though immune in South Africa, becomes susceptible when grown in the Punjab.

Although practically all jassid resistant varieties are hairy, all hairy varieties are not always resistant.

Nymphs of E. devastans of all stages had no difficulty in developing on cotton varieties, which were either immune or resistant, hairy or nonhairy, but there was a marked reduction in egg laying on immune varieties. Nymphs reared on immune varieties were fertile.


In the Punjab, native cottons are relatively resistant and American cottons in general susceptible.

Nymphs of all instars can feed and develop on both resistant and susceptible, hairy and non-hairy cotton varieties; adults from nymphs reared on resistant plants show no reduction in fertility, but oviposition (or possibly hatching) is markedly reduced on resistant varieties.

Susceptibility was not correlated with the pH of the leaf sap.

Though nearly all resistant cottons are hairy, not all hairy varieties are resistant.
HUSAIN, M. A. 1945. See LAL, K. B. and HUSAIN, M. A.


Describes a broad-leaved bud mutation which occurred in a laciniate-leaved form of G. arboreum. Such a mutation involves two genes.

496. HUTCHINSON, J. B. 1931. The genetics of cotton. IV. The inheritance of corolla colour and petal size in Asiatic cottons. J. Genet., 24, pp. 325-353.

Given a similar genetic background, yellow-flowered plants (YY) have longer petals than pale-flowered plants (Yp Yp) and the latter have longer petals than white-flowered plants (yy).
heterozygotes are intermediate in both characters, but nearer to the higher grade parent with longer petals.

Modifying factors which affect petal length also affect corolla grade among yellows, and to a less extent among pales. Fairly long whites do occur and also short yellows, but the latter are lower in corolla grade than long yellows.

Crossing-over does not occur between genes for petal size and corolla colour, and flowers with a higher corolla grade have longer petals than flowers with a lower corolla grade on the same plant.


Two complementary factors, A and B, causing abnormal development have been demonstrated in Asiatic cottons, their effect being conditioned by a number of modifiers. A has been found in two strains of G. nanking var. soudanensis. B has been found in seventeen varieties of G. arboreum, G. nanking, G. herbaceum and G. obtusifolium, and in G. stocksii.


Records six anthocyanin alleles in Asiatic cotton: R, R', R'', R', r', and r''. Red, the highest member of the series depends on the presence of Y (yellow corolla) for full expression. The R chromosome carries genes affecting lint length and seed weight. The R locus is independent of the Y locus, and of the A (Hutchison, 1932 a) locus.

Hutchison, J. B. 1933. See Afzal, M. and Hutchison, J. B.


The main differences in leaf shape in Asiatic cottons result from the action of a multiple allelomorphic series of five members, L², L¹, L⁰, L and l. Of these, L⁰ and l give dominant and recessive broad respectively. L¹ gives dominant intermediate broad. L² gives laciniate, and L narrow leaf. L², L and l give intermediate heterozygotes. L² and L¹ are dominant over all other members of the series. L², L and l occur in nature in G. arboreum and its varieties. L⁰ and L¹ arose by mutation in cultures of a laciniate G. arboreum strain. All G. herbaceum varieties so far reported carry l.

The differences in leaf shape of taxonomic value are due to minor genes affecting such characters as lobe shape, leaf size and rumpling, but not laciniation.

The leaf shape multiple allelomorphic series is linked with a gene for brown lint (K), with about 30% crossing-over.

L², L¹, L and K were all found to be mutable.

Linkage exists between the L locus and genes affecting lint length, seed weight and lint percentage.

The L series and the corolla colour (Y) series assort freely. There appeared to be linkage between the L series and the anthocyanin (R) series in a single cross. In other crosses the two
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allelomorphic series assorted freely.

It is considered that a mutation from \( L^2 \) to \( L^3 \) involves a re-arangement of four episomes from a chain arrangement to a side-by-side formation in the gene base or protosome. A scheme is presented which attempts to unify the "step allelomorphism" and "side chain" theories. This scheme involves Agol's (1931) and Dubinin's (1932) theory that the protosome is divided into a number of gene centres arranged linearly along the axis of the chromosome.


Tufted seed (\( T \)) is shown to differ in a single gene from fuzzy (\( t \)), giving an intermediate heterozygote. Tufted and semitufted differ only in modifiers and these cause the heterozygote to be practically indistinguishable from fuzzy. They are also responsible for the difference between thick and thin fuzz on fuzzy seeds. One of these modifiers is located in the brown lint leaf shape linkage group.

Fuzz modifiers (but not \( T \)) affect plant hairiness slightly.

A long lint factor and a seed weight multiple allelomorphic series are located in the same chromosome as the tufted factor.

Tufted assorted freely with leaf shape (\( L \)), anthocyanin pigment (\( R^a \)), corolla colour (\( Y \)), lint colour (3 factors, \( K, D_1 \), and \( D_2 \)), leaf nectaries (\( N \)) and lintlessness (\( h^0 \)).


The genetic factors affecting leaf shape have little effect on leaf length, but mainly affect growth at right angles to the main leaf veins, the control being very local, possibly confined to the individual cell. Narrow and laciniated leaf are apparently recently acquired characters in cotton. *G. herbaceum* and *G. arboreum* are distinguished from one another by factors affecting shape of leaf lobes, small in individual effect, inherited quantitatively and affecting all foliar organs. In general, leaf form depends on factors with a local effect as regards differences within species, and on the factors with wide influence on the form of foliar organs as regards differences between species. Three main characters determine plant habit, viz. the node at which the first sympodial branch appears, the proportion of monopodial buds below that point which develop into branches and the length of the monopodial branches. In any species there is a series of types differing in these characters, but with a balance between them, and this balance is maintained in crosses within a species, but not in crosses between species, in which
case a complete range of all combinations of the three components appears in the $F_2$. Node number was found to be associated with three simple factors, but there are indications that many more factors are operating.


The almost complete sterility of a plant with bad pollen found in Million Dollar was shown to be due to a single recessive gene.


In an investigation of resistance to cotton root rot, alternate rows were sown with a uniform control strain.

By applying the method of covariance to the data, the error variance was reduced to about one-half by adjustment for the covariance of control and variety rows, giving the same advantage as would be obtained by doubling the number of plots.


Seven types of lintlessness occurring in Asiatic cottons are described. It is shown that at least four independent genes are involved. Two of these are complementary genes for the glabrous lintless ($h_a$ and $h_b$) character and two complementary genes ($l_a$ and $l_b$) for the hairy lintless character.

The relationship of the $L_i$ gene, carried by Punjab Hairy Lintless, to the rest has not been fully worked out, and it remains to be seen whether it is the same as one of the hairy lintless complementary pair. Data are presented to show that the hairy lintless homozygote $l_i^a l_i^a$ shown by Afzal and Hutchinson (1933) to be a lethal is now fully viable both in the original strain and in a hybrid with Narrow Kokati. The probable cause of the change and its bearing on Fisher's theory of the origin of dominance are discussed.


An investigation of the past history and present status of the cotton crop in Central India and Rajputana made with the object of discovering the causes and extent of deterioration.

A study of yield and quality in $F_2$ generations segregating for leaf shape and corolla colour showed that there is no necessary genetic association between morphological and agricultural characters, but a factor affecting yield in Malwa exists in the chromosome bearing genes for corolla colour, and factors affecting halo-length and lint index in the chromosome for leaf shape.

A similar study of the components of the Malvi crop showed
that yellow-flowered types yielded much more than white-flowered, had longer and finer lint, and a lower ginning outturn. Thus in the types under investigation, there are important associations between agricultural and morphological characters, Roseum being coarser, shorter, higher ginning, and, in Malwa, lower yielding than the yellow-flowered types.

The selection balance in Malwa and Nimar is discussed, and a preliminary outline is given of the effects of some of the more obvious selective forces.


This classification has since been superseded by that given in "The Evolution of Gossypium" by J. B. Hutchinson, R. A. Silow and S. G. Stephens (1947).


A letter pointing out that the gene governing petalody found in Karunganni by Ramanatha Ayyar and Sankaran (1934) is only partially (not fully) dominant. In a note following this letter, Ramanatha Ayyar agrees.


Crinkled in G. hirsutum arose as a mutant at the same locus as crinkled dwarf in G. barbadense. It behaves as a complete recessive in crosses with normal strains of Upland.

In an F2 of Indore crinkled x Egyptian Wrinkled Leaf (identical with Sea Island crinkled dwarf) all grades between fully normal and extremely crinkled were obtained, an exactly parallel behaviour to that found by Harland in crosses between Sea Island crinkled and the Upland genotype bearing the transferred crinkled character.

The occurrence of the crinkled character by mutation in G. hirsutum disposes of one of Harland's main objections to Fisher's selection theory. His other objection is that the intermediate heterozygote is not actually at a disadvantage compared with the normal. His data are re-examined, and it is shown that it was to be expected that the vigour of the heterozygote would be maintained by unconscious selection in the backcross series.

The available evidence on the history of the mutant and its dominance modifiers is reviewed, and it is concluded that, while the mutation has been recurrent since before the separation of the species, dominance of normal is probably a comparatively recent development. Dominance should therefore be broken down if the crinkled character is transferred from the cultivated annual forms of G. barbadense to primitive perennial types of the same species. It is considered that the modification of the crinkled character will have gone farther in G. hirsutum, annual types of which have long been cultivated, than in G. barbadense in which the annual habit is of late origin, and to which field cultivation has only recently been applied. The behaviour of Indore Crinkled provides good evidence of the correctness of this expectation. Not only is normal completely dominant, but the crinkled homozygote has also been considerably improved.
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The whole of the evidence now available is in agreement with expectation on Fisher's theory of the origin of dominance by the selective improvement of the heterozygote.


A new member, red spotless ($R_s^6$) of the anthocyanin multiple allelomorphic series is described, and its position in the series established. Red spotless differs from red leaf ($R_s^5$) in the absence of petal spot.

The existence is demonstrated of a petal spot reducer, $Sr$, in a strain of $G. arboreum$ from Nagpur. A second factor probably operates to intensify the effect of $Sr$.


An account is given of the distribution and relationships of the wild and cultivated species of $Gossypium$ and it is shown that the great extensions in distribution have led to rapid evolution, which has run parallel in the different species, producing early, annual, sympodial types from perennial, highly monopodial bushy forms.

The amphidiploid origin of the New World cottons with $n = 26$ chromosomes is also discussed.


A chlorophyll deficient seedling appeared in a cross between Malvi 9 and a $G. cernuum$ type.

It behaved as a monofactorial recessive for which no symbol was suggested, pending homology tests with material described by Ramanatha Ayyar and Balasubramanyan (1938).


A gene list is given covering 15 loci in the Asiatic and 25 loci in the New World cottons. The inheritance of quantitative characters is very briefly discussed as are also linkage and correlations. The inheritance of disease resistance is touched on in general terms and Fahmy's (1934) work on wilt resistance is criticized at length on the ground that Fahmy's data do not necessarily support his interpretation of a simple basis for resistance.
Backcrossing; pure lines; acclimatization; the genetic concept of the species; and species crosses and polyploidy are all briefly dealt with.


The different botanical types of Indian cottons differ greatly in mean spinning values and hair properties. The greatest differences are between the short, coarse, low-spinning G. arboresum var. neglectum forma bengalesis of northern India, and the other botanical groups. The other groups differ in hair weight, the Uplands being the finest and the herbaceum types coarsest, but have very similar hair length and spinning values.

The introduced Upland cottons differ little from the superior indigenous types in spinning value. If adequate botanical and technological surveys are made of the indigenous species, improvement in quality is likely to be attained as rapidly with them as with exotic types.


Three strains of G. arboresum var. neglectum were crossed in all three possible ways, and the parents, F₁ and F₂, grown in the same year in a ten-block randomized progeny row experiment.

Analyses of variance were carried out on plot values for germination, node number, kapas yield, staple length and ginning percentage. Strong heterosis was demonstrated in all characters. The direction of the heterosis bias was that which would be expected if heterosis was due to effects of selection. In node number the bias was towards a low number, and in other characters towards high values.

Differences between F₂ progenies from sister F₁ plants demonstrated the existence of genetic variance within the parental strains. Its distribution was as would be expected if selection is more efficient than random elimination of genes in reducing genetic variance.

It is concluded that the environmental contribution is a very high proportion of the total variance. Single plant selection in progeny rows is therefore likely to be inefficient, and estimates of within-plot variance of low value for genetic studies.


Charts illustrating grades of 'stem-tip' hairiness, stem colour, petal colour, degree of boll dehiscence, seed fuzz and lint colour are given together with a list of simply inherited characters in cotton.


Mainly a condensation of the material published by Hutchinson and Ghose (1937).

A letter commenting on C. H. Brown's (1939) paper on this subject.


The chromosome number of *G. raimondii* is given as 2n = 26, and a table is given of its crossing behaviour with a wide range of *Gossypium* spp. *G. raimondii* is morphologically similar to *G. klotzschianum* and *G. davidsonii* and, despite the failure of crossing between them, it must be grouped with these two (cf. Boza Barducci and Madoo 1940, and Newcombe 1939).


Records a new allelomorph in the leaf shape series. This gene, designated *L*², was found in a *G. arboreum* strain.


A list of known genes is given. Multiple alleles are shown by a series of alphabetic superscripts. Duplicate factors are shown by numerical subscripts. Complementary factors are shown by alphabetic subscripts. Genes in Old World cottons (2n = 26) are italicized. Genes in New World cultivated and Polynesian wild (2n = 52) cottons and in New World wild (2n = 26) species are given the same symbols but are not italicized unless homology of the locus with the Old World locus is proved.


The improvement of the lint index of Montserrat Sea Island cotton from 6·1 in 1931 to 6·6 in 1938 has led to an increase in coarseness of the fibre. The necessity for regular spinning tests to keep a check on any such decreases in quality due to breeding for other characters is stressed.


Selection for uniformity should not proceed beyond the stage needed to ensure a satisfactory grade in the marketable product, except where it is possible by further specialization to achieve closer adaptation to local climates. The records of breeding projects with Sea Island cotton show that in practice it is impossible to achieve genetic uniformity; purity may therefore be regarded as a secondary consideration. Reference is made to the studies of Vavilov and others on the distribution of variability and the importance is stressed of maintaining indigenous variability wherever this occurs. The paper examines the possibility of improving efficiency of selection. The advantages and shortcomings of progeny row breeding and the question whether secondary selection has been overemphasized at the
expense of primary selection are mentioned. In discussing the problems that confront the plant breeder Hutchinson mentions the synthesis of yield in different circumstances and in different strains. For this study the development of discriminant functions provides a useful tool. At present there is some knowledge of those characters which can most easily be influenced by selection, but nothing is known of the extent to which a change in one character will result in compensating changes which may perhaps be less easily detected in others.


Gives a botanical description of *G. brevilanatum* and records its chromosome number as $2n = 24$. *G. brevilanatum* grafts easily on *G. kirkii* but attempts to graft *G. aridum*, *G. arboreum*, *G. hirsutum* and *G. barbadense* on to it failed.


An account of the taxonomy of Jamaican cotton is presented together with an analysis of the synonymy and a key to the chief types.

The indigenous cotton is *G. hirsutum var. marie-galante* which occurs also in northern South America and in other islands of the Caribbean Sea. Its ecology and range of variation both in the wild and cultivated state are described. *G. hirsutum* is only known from a record by Watt in 1907 while *G. hirsutum* var. *punctatum* appears to be confined to a single plantation. *G. barbadense* is successfully established in some of the more mesophytic localities in the island.


A survey of the distribution of *G. barbadense* and *G. hirsutum* var. *marie-galante* in Trinidad.


The breeding history of Sea Island V 135 is described, and the achievements of selection evaluated from a comparison between modern strains of the variety and a representative of the 1920 stock.

The modern strains carry no appreciable genetic variance so that there has been no response to selection in them. Improvement was considerable in the earlier years, when genetic variance was greater.

The capacity to respond to selection is a function of the genetic variance available; this is illustrated by reference to the breeding history of U 4. Selection on progeny means is $m$ times as efficient as mass selection in the same material where $m$ is the number of plants per progeny. Furthermore a well-designed progeny row breeding programme will yield the information the breeder requires.


Perennial cottons are common in the coastal plains, uncommon
in the inland hilly country, and absent from higher elevations. Along the north coast nearly all the perennial cottons are *G. barbadense*. The commonest cotton is *G. hirsutum* var. *marie-galante* all through the south coast region from Guayama to Lajas and Mayagüez. *G. hirsutum* var. *punctatum* is rather rare. One form of *punctatum* has become truly wild (algodón brujo) and this is indistinguishable from the Polynesian wild cotton hitherto known as *G. taitense*.


It is considered that the French cotton was a fine-linted selection of *G. hirsutum* var. *marie-galante*. Lint length frequencies are given which show that two agronomic types of *marie-galante* still occur in the West Indies: a long-linted type corresponding to the French cotton of the eighteenth century and a shorter-linted type corresponding to the green-seeded cotton of the same period.


Sea Island cottons form a well-defined agricultural race of *G. barbadense*, consisting exclusively of cultivated annual cottons. Practically all the types now extant have been collected at the St. Vincent Station. Data on the history and relationships of this collection have been accumulated as a guide to breeding work, and an account of the varietal status of the group is presented.


Cytogenetical studies in *Gossypium* are sufficiently advanced to justify the preparation of a classification of the genus, including the cultivated cottons. The diploid species fall into three major groups, between which chromosome homology is low. Members related to two of these groups, one confined to the Old World and the other to the New, have entered into the ancestry of the amphidiploid American cottons. Within main cytological groups, progressive differentiation accompanying geographic divergence has led to the establishment of populations characterized by co-ordinated genetic systems harmoniously integrated to give a balanced genotype, but so different in gene content as to give rise to extensive polygenic
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segregation in crosses between them. Recombination products are less balanced than the parental forms, many being weak or partially sterile. Natural selection ensures their elimination. Populations whose integrity is maintained by such a genetic barrier are accorded specific rank.

In the hairs which occur on the seeds of wild diploid species, both Old World and American, secondary deposition of cellulose in spiral pattern, on the inner surface of the wall, proceeds until the central lumen is almost completely obliterated. Domestication, which occurred in the Old World, was dependent upon a reduction in amount of secondary thickening, so that, on drying, the hairs collapse into flat convoluted ribbons which can be spun. The New World amphidiploids presumably acquired their lint from their Old World ancestor. The extensive cultivation of cotton, and its comparatively recent spread into areas subject to frost, has followed the development of the annual habit. This has occurred independently in all four cultivated species.


The seeds of all species of Gossypium bear hairs. These are of two main types: the flattened, convoluted hairs of the cultivated cottons and the simple, untwisted hairs borne by the wild species.

From a comparison of the seed hairs of polyploids involving G. thurberi and various true cottons, it is shown that the D genome carried by the allopolyploids is inert in the formation of convoluted lint hairs, but has an important influence on the quantity of seed hairs developed.

It is concluded that the only known D-carrying wild species that would behave in this way in an allopolyploid with an Old World cotton is G. raimondii.

G. stocksi has the same type of seed hair as G. raimondii. Possible reasons why no allopolyploids have arisen from crosses between Old World cottons and G. stocksi are discussed. It is concluded that, in general, genome differentiation leads to low vigour in hybrids, and it is only in a comparatively narrow range, where sufficient chromosome differentiation is combined with good vigour in the F1 hybrid, that there is any prospect of successful allopolyploidy.


An allelomorphic series of not less than five members exists at the Cr locus. Of these, two (Cr\textsuperscript{a} and Cr\textsuperscript{m}) are normals, differing only in their heterozygotes with crinkled Cr\textsuperscript{D}. Full normal (Cr\textsuperscript{a}) is carried by most strains of Gossypium barbadense and is rare in G. hirsutum, and low normal (Cr\textsuperscript{m}) is carried by most strains of G. hirsutum and is rare in G. barbadense. The crinkled dwarf gene (Cr\textsuperscript{D}) controls a leaf abnormality in which vein growth fails to keep pace with lamina development. It arises by mutation fairly frequently in Sea Island and Egyptian cotton and the reverse mutation has also occurred.

Rugose (Cr\textsuperscript{R}) and contorta (Cr\textsuperscript{O}) give rise to leaf abnormalities in which lamina expansion fails to keep pace with vein growth. Contorta is responsible for a
muck greater degree of abnormality than rugose. Rugose arose by mutation in an Upland cotton. Only one occurrence has been reported. Contorta arises by mutation fairly frequently in the two commercial Sea Island varieties Superfine V 40 and MSI.

Compounds between Cr\(^b\), Cr\(^n\) and cr\(^b\), and those between Cr\(^n\), Cr\(^i\) and cr\(^i\), exhibit varying degrees of dominance, but the heterozygotes are never superior to the better homozygote. Compounds between cr\(^b\) and cr\(^i\) or cr\(^d\) are nearer normal than either component homozygote. It is concluded that the alleles govern two separate, but interdependent, reaction systems, one concerned with vein growth and the other with lamina development.

Modifying genes are not specific to the heterozygote, but act on all phases of the gene. The crinkled and rugose-contorta modifier systems are distinct.

A survey of the crinkled modifier status of a range of types of \(G. \) barbadense and \(G. \) hirsutum revealed very wide differences from strain to strain. Complete dominance over crinkled is universal in West Indian cottons, in which crinkled modifiers probably act as buffers against an environmental phenocopy of crinkled.

This distribution of the modifiers both of crinkled and rugose-contorta is incompatible with the Fisher theory of the acquisition of dominance by selection among heterozygotes. Extending the speculations of workers on gene interaction, it is suggested that genes control the rate of reactions that follow a sigmoid reaction curve. It is shown that the known facts of gene interaction, dominance and differences between phenotypes in susceptibility to genetic modification can all be interpreted on such a system. Examples are also given to show that differences in gene potency arising by mutation cannot be regarded as due to genetic loss or gene inactivation, and that in related species the wild type may occur at any point on the reaction curve.


An account is given of the genetics of deleterious characters in cottons. Six such characters, all apparently monogenic, have been recorded among Old World cottons. Genetic studies on five such characters in New World cottons have been published elsewhere. Further data are given on chlorophyll deficiency, and accounts are presented of the genetics of nine characters that have not been reported previously.

Of the fourteen deleterious characters in New World cottons for which data are available, three have a trifactorial, five a bifactorial and six a monofactorial basis. A remarkably close parallelism exists between the deleterious characters recorded from the Old World diploid and New World polyploid cottons.

The importance of gene duplication in making possible the survival of otherwise deleterious mutant genes is noted, but it is pointed out that since three triple gene characters have been discovered, the allopolyploid nature of the New World cottons is not alone sufficient to account for the multiple factor segregations observed.

No evidence was discovered of
divergence in function between duplicate loci, but it is suggested that a search among the allopolyploids for homologues of genes not markedly deleterious in the diploids, might reveal its existence.

All deleterious genes recorded in Old World cottons, with the exception of crumpled, are completely recessive. The deleterious characters in the New World cottons are very often not completely recessive, easily distinguished heterozygotes having been recorded in five characters, and incomplete dominance in four others. It is suggested that this low dominance level may be a consequence of the rapid evolution of the New World cottons, which has been such that a high degree of internal stability has not yet been achieved.


An account is given of genes causing brown coloration in the lint of New World cottons and of their modifiers. Of the colour genes, the independence of \( Lc_1^x \) in Upland and \( Lc_2^x \) in Egyptian has been demonstrated by Harland (1935). It is here shown that genes determining brown lint in \( G. \) punctatum and brown lint in \( G. \) darwinii are also independent of \( Lc_1^x \). Mahogany is distinct from these in the intensity of the colour induced, and in being highly dominant. It also has large effects on hair length, maturity and fineness. Two brown genes are present in \( G. \) tomentosum, but no evidence is available on their homologies.

Emphasis is laid on the distinction between genes which cause the development of colour, and those which only affect intensity when colour is already present. In Upland a gene occurs which intensifies brown but has no effect on white. In \( G. \) hirsutum var. punctatum and var. mariegalante, and in \( G. \) barbadense and \( G. \) tomentosum, minor colour genes change white to off-white, or even pale brown, as well as intensifying brown.

It is shown that the genotypic situation with regard to lint colour can be explained as the consequence of the comparatively recent origin of allopolyploidy from a cross between an Old World cotton and an American wild species with light brown seed hairs, followed by human selection for widely contrasted lint colours, white and deep brown or mahogany, for use in the weaving of patterned textiles.


Two types of \( G. \) arboreum are established in Africa, race soudanense in the Sudan and West Africa, and race indicum on the Tanganyika coast, and formerly in Zambesia.

The annual typical form of \( G. \) herbaceum was the first cotton of the Nile delta. The perennial var. acerifolium was the cotton of the Moslem empires of West Africa until the introduction of New World species. The perennial var. africanum is established in natural vegetation in South Africa where it was presumably formerly cultivated.
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G. hirsutum var. punctatum occurs throughout the West African savannah region and on the Tanganyika coast. Var. marie-galante is common in the Gold Coast and is recorded from the Ivory Coast. G. hirsutum proper, Upland cotton, is the commercial cotton of the rain-fed regions of Africa.

G. barbadense occurs sporadically in most parts of Africa but is only of importance in the forest regions of Southern Nigeria and Togoland, and in the Nile valley where a new annual race of G. barbadense has evolved.

The development of distinct African races of introduced cottons is discussed, and compared with the development of the acclimatized race of Upland in India.


The perennial forms of G. arboreum in Africa are assigned to two races, race soudanense in the Sudan and West Africa and race indicum on the East African coast and in Madagascar.

G. herbaceum is classified into five races, race persicum in south central Asia, race kuljanum in Chinese central Asia, race acerifolium in north Africa and Arabia, race wightianum in western India, and race africanum in South Africa.


Leaf curl is an extremely serious disease of Egyptian cotton and of bamia (Hibiscus esculentus) in the Sudan. A survey was made of the response to the disease of 671 strains of cotton. G. arboreum and G. herbaceum are effectively immune, and G. hirsutum and its varieties punctatum and marie-galante highly resistant, but G. barbadense contains a large proportion of susceptible strains.

Evidence is presented for the belief that the disease reached the Sudan from West Africa through a chain of host plants across the north equatorial region, and that its spread within the Sudan from one major cotton area to another was in the main along the riverain crops of bamia.

The variability of leaf curl symptoms in West Africa, as compared with the Sudan, indicates that several virus strains may be involved.

A large proportion of the cottons possess resistance that cannot have been developed under the selective impact of the disease, and it is shown that the breeding of resistant types has been accomplished repeatedly by the accumulation of minor genes by selection. It is suggested that leaf curl is not specific to cotton, and that even in susceptible varieties, little change in the genotype is needed to give virtual immunity.

Hutchinson, J. B. 1950. See Knight, R. L. and Hutchinson, J. B.


Tetraploid plants of G. arboreum were obtained by colchicine treatment. Though fertility was
low initially, seed was obtained later by selving and crossing with \textit{G. hirsutum}. The seeds of the tetraploids were heavier than those of the diploids, being equivalent in weight to the seed of Upland cotton. The length, width and strength of the fibre of the tetraploids was greater than in the diploids, but the number of kinks per unit length was less.


Covers the same field as Abst. 546.


A germination percentage of 55 to 68\% was obtained as follows. A thin layer of sucrose agar medium was dried by an electric fan and then distilled water was added and the excess wiped off with blotting paper. Pollen grains were placed over this layer, the upper surface of the medium being inverted over water to prevent drying.

HYDER, N. 1921. See BURT, B. C. and HYDER, N.

IHSAN-UR-RAHMAN KHAN. 1944. See SIKKA, S. M., IHSAN-UR-RAHMAN KHAN and AFZAL, M.


In crosses between strains of \textit{G. hirsutum}, cross section measurements of the lints showed that fineness was inherited as a dominant character in the \textit{F}_1.


Covers the history of the introduction of cotton into Morocco and gives information about varieties brought in from the Ivory Coast, Egypt, America, Algeria, the Riff and Turkestan.

ILTIS, M. 1947. See GRILLOT, M. and ILTIS, M.

549. Imperial Bureau of Plant Breeding and Genetics. 1937. The origin and selection of the cotton variety Tanguiis. 18 pp. (Mimeographed).


New varieties of Egyptian cotton distinguished by greater earliness, productivity and length of lint have been produced. The best are D–90 and 3408–1, which are 22–23 days earlier than the variety hitherto grown and have a lint length of 46–48 mm. They exceed the previous variety by 45–62\% in yield of seed cotton and by 18–27\% in lint yield; 89–91\% of their yield is collected before the frosts.

Boll weevils showed a marked preference for green-leaved cotton as compared with red-leaved cotton. Leaf size, as distinct from plant vigour appeared immaterial.


A comparative study has been made of the fresh and dry weights, dry matter content of the cell sap, diurnal fluctuation in water content, osmotic pressure, transpiration rate and carbon assimilation of diploid and autotetraploid strains of Hiroshimazairai (Hiroshima Normal) and the allotetraploid Kanno 1. The allotetraploid had a lower percentage dry matter content, lower osmotic pressure and lower transpiration rate than the diploid; the autotetraploid was intermediate.


In the section dealing with cotton and other crops, Stoneville 2B (hairy), is compared with Mebane Estate (smooth) in reaction to *Aphis gossypii*.

The first two tests showed that an average of 83% of the Stoneville 2B plants have curled leaves, due to *Aphis*, as compared with 11% for Mebane Estate. Two further tests were made and averaged 77% for Stoneville 2B and 48% for Mebane Estate. This confirms Dunnam’s (1948) findings.

Ivanova, M. M. 1935. See Borjakovsky, L. P. and Ivanova, M. M.


Desi cotton in Sind tolerates 0·52% salts in the soil but 0·78% is injurious. It is usually considered that 0·2 to 0·3% is harmful and the better tolerance of Sind desi cotton is probably partly the result of adaptation. The desi cotton 27 WN and the Upland type 285–F₂ were particularly tolerant to salt.


Describes female sterile plants which occurred in *G. herbaceum* (Strain 1281). In these plants the ovary was present but the style was much shortened and had a thin flattened stigma.


A detailed study of the subject in *G. herbaceum*, *G. arboreum*, *G. hirsutum* and *G. barbadense*.


Reports chromatin bridges in *F₁* triploid hybrids of *G. barbadense* (Sea Island) x *G. herbaceum* (1027 ALF) and *G. hirsutum* (Co. 2) x 1027 ALF composition.
A young F₁ plant of G. anomalum x G. arboreum with 4-5 leaves was treated with 0.08% colchicine by wetting the shoot tip. The wetting was done at intervals for 12 hours and the shoot was then washed with water. The treated shoot grew to 12 ft. before flowering. Its seed bred true. In crosses with G. hirsutum, G. barbadense and G. religiosum (G. hirsutum var. punctatum) seed setting was good but was improved when the synthetic tetraploid was used as the female.

The synthetic tetraploid had seed weight of 0.7 grm., lint index 19 grm., halo length 26.2 mm., fibre diameter 18.9 μ and a fibre weight of 1.22 (compared with 1.85 for the parental arboreum).

Chromosome conjugation has been studied in four pentaploid (2n = 65) cotton plants of interspecific origin. All these polyploids are characterized by the formation of many trivalents and in this respect conjugation is similar to that in the autotetraploid and the 52-chromosome cotton plants described by Skovsted (1933; 1934). Differences are, however, noticed in the mean values of conjugation amongst the polyploids dealt with in the body of the paper, owing to factors other than homology affecting the chromosome conjugation.

The autotetraploids are pollen sterile and do not cross with cultivated Asiatics, but some success was obtained when the autotetraploids were crossed on to cultivated Americans. The allotetraploids are partially self fertile and most of their progeny had 52 somatic chromosomes.

Meiosis in a sterile hybrid plant (2n = 52) obtained from autotetraploid G. herbaceum x G. hirsutum, showed that many of the chromosomes of the three A sets are associated as trivalents, and the chromosomes of the D set are left as univalents.

Chromosome conjugation has been studied in four hexaploid involving cultivated Asiatics and cultivated Americans, two hexaploids involving wild Americans and cultivated Americans and two hexaploids involving wild African and cultivated American cottons. Indian J. Agric. Sci., 14, pp. 142-151. (Author’s summary).

Chromosome conjugation has been studied in four hexaploids involving cultivated Asiatics and cultivated Americans, two hexaploids involving wild Americans and cultivated Americans and two hexaploids involving wild African and cultivated Ameri-
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cans. Conjugation has also been studied in the triploids from which the hexaploids were derived. Though the triploids showed marked variations in conjugation, the hexaploids showed only slight differences.

The progeny behaviour of the several hexaploids studied showed that gametes with 39 chromosomes seem to function most in the parent hexaploids and some of the gametes have the same constitution as the triploid progenitors.

Crosses of hexaploids with suitable diploids gave fertile tetraploids with 52 chromosomes. During meiosis, the chromosomes paired mostly as bivalents. These facts indirectly show that the cultivated American cottons with 52 chromosomes are allopolyploids having two sets of Asiatic and two sets of wild American chromosomes.


First backcross plants of the origin (cultivated American × cultivated Asiatic) × cultivated American show chromosome numbers ranging from 50 to 80, with two modes, one at 52 and the other at 65.

Chromosome conjugation in 52-chromosome first backcross plants showed that they have a general constitution AD(AD) in many cases and in some the chromosomes associate even as 26 bivalents. The proportion of multivalents is however, more in comparison with the cultivated Americans. The plants of this group are, in general, highly fertile.

Meiosis is also studied in 50-, 51-, 53- and 55-chromosome plants of the first backcrosses and in these most of the chromosomes showed good pairing. In the case of the deficient plants (i.e. 50- and 51-chromosome types) the chromosomes without partners were left as univalents. In the 53- and 55-chromosome plants, in addition to bivalents, univalents, trivalents and pentavalents were also seen. The 50- and 53-chromosome plants gave fertile 52-chromosome plants in later generations.

The progeny of 65-chromosome plants showed chromosome numbers ranging from 53 to 67. The plants showed wide variation in general morphology, maturity and fertility and meiosis was complicated by the formation of multivalents.


Chromosome conjugation is described in various allotetraploid cottons. In general, chromosome conjugation in the tetraploids depends upon the genomic relations of the species involved. Other factors like autosyndesis brought about by polyploidy in the present day diploid and tetraploid species, structural changes, etc., also influence conjugation. The utility of the allotetraploids for plant breeding and for species formation is briefly discussed.


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A new type of male sterility, found in the sixteenth generation from a natural cross between G. indicum and G. cernuum, is described.

IYER, R. B. 1933. See RAMANATHA AYYAR, V. and IYER, R. B.


Ring chromosomes, chromosomes with lateral satellites and cytomixis are recorded in root tips of G. herbaceum.


Records the occurrence of nuclear fusions in such cells.


Selfing had no immediate effect on the following characters: ovules per locule, seeds per locule, fertility index, lint length, lint weight per seed, seed weight and ginning outturn.

JAGANNATHA RAO, C. 1947. See BALASUBRAHMANYAN, R., MUDALIAR, V. R. and JAGANNATHA RAO, C.


Stresses the importance of primary selection and gives details of the basis of primary selection work in Uganda.

JANSSEN, G. 1932. See WARE, J. O., YOUNG, V. H. and JANSSEN, G.


JENKINS, W. H. 1944. See WARE, J. O., JENKINS, W. H. and HARRELL, D. C.


The dark red colour of a dwarf in a red Acala was found to be due to the complementary action of a gene Rd in the presence of Rd. Rd, the dwarfing factor, is independent of Rl, okra leaf, brown lint and naked seeds.


573. JONES, V. H. 1936. A summary of data on aboriginal cotton
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Joshi, N. V. 1950. See Govande, G. K. and Joshi, N. V.


An account of breeding work carried out mainly on Triumph Big Boll.


A brief description of the genetic improvement of cotton in Bombay, with particulars of the fibre characters, yields, ginning outturn and spinning values of new strains. The most successful strains evolved are Suyog in South Gujarat, 1-2 and 1-6 in Middle Gujarat, Wagolar (4-1) in North Gujarat, Jarila in the Deccan, and Jayawant in Khandesh. Reference is also made to the introduction of Gadag I in the Dharwar district.

Kaiwar, S. R. 1942. See Ramiah, K. and Kaiwar, S. R.


Kanash, M. S. 1936. See Baranov, P. A. and Kanash, M. S.

Kanash, M. S. 1949. See Arutyunova, L. G. and Kanash, M. S.


Hybridization within *Gossypium* has demonstrated the possibility of crossing all the different chromosome species of cotton (the 26-chromosome types with the 52-chromosome species), and that the direct and reciprocal crosses are equally successful. Fifty-nine F1 hybrids between species differing in chromosome number have been obtained:

- *G. barbadense* x *G. herbaceum*, 17 hybrids.
- *G. herbaceum* x *G. barbadense*, 6 hybrids.
- *G. barbadense* x *G. arboreum*,
- *G. neglectum* and *G. nanking*, 6 hybrids.
- *G. nanking* x *G. barbadense*, 1 hybrid.
- *G. hirsutum* x *G. herbaceum*, 16 hybrids.
- *G. herbaceum* x *G. hirsutum*, 5 hybrids.
- *G. hirsutum* x *G. arboreum*, 1 hybrid.
- *G. arboreum* and *G. neglectum* x *G. hirsutum*, 7 hybrids.

The percentage of F1 hybrids varies in different years and in the same cross from 0.1 to 2.5. Interspecific F1 hybrids from direct and reciprocal crosses are morphologically distinct.

All interspecific F1 hybrids were highly self sterile. Reciprocal crosses of the F1 with the parental forms yielded a number of somewhat fertile plants. In all backcrosses, fertilization was successful when the 52-chromosome species served as pollen parent.

In 1928, for the first time, two partially fertile F2 hybrids were produced from the cross *G. barbadense* x *G. arboreum*; in 1930, partially fertile hybrids from backcrosses were obtained.
in all combinations. In all, 10 partially fertile hybrids were obtained.

Interspecific F₁ hybrids displayed, in backcrosses also, very reduced fertility. Usually only one fruit was obtained per plant, containing one seed; from only two F₁ hybrids of G. barbadense x G. arboreum did the number of one-seeded fruits amount to 5 and 9 respectively. The seeds developed and were either entirely normal or very much increased in size.


An account of work with crosses between 26-chromosome and 52-chromosome species of cotton. In the majority of the crosses, the F₁ had 39 chromosomes as the somatic number, except in the cross of G. barbadense x G. herbaceum, in which 2n equalled 52 as a result of the combination of the haploid complement of the first species with two haploid complements of the second.

The general sterility noted in the F₁ generations was to some extent eliminated by repeated crossing with 52-chromosome species. A similar improvement in fertility was noted when the F₁ pollen was used on the parent forms.

Hybrids from the first backcross were more fertile than the F₁ and some forms even attained 10% fertility, but others showed a much lower percentage. Morphological features also varied greatly, while at the same time there was a marked predominance of the characters of the 52-chromosome species. In some backcrosses, characters absent in the parents appeared.

The chromosome complements of some of these various forms and of 65-chromosome hybrids resulting from nonreduced F₁ ♀ gametes, with 39 chromosomes, pollinated by 26-chromosome pollen are mentioned, with general observations on the cytological findings in the F₂ generations and backcrosses involving two or three species. Data are also cited showing that constant forms can be attained sooner in crosses between species of different chromosome number than in crosses of species with the same chromosome number or even in intraspecific crosses.


F₁ hybrids of G. barbadense x G. arboreum, G. hirsutum x G. herbaceum and G. barbadense x G. herbaceum had 39 somatic chromosomes, and were self sterile but gave seed when backcrossed with the 52-chromosome parent. The fertility of the backcross progeny was greater, ranging from 0 to 100%. Transgression of the parental limits occurred in most morphological characters, and characters unknown in either parent occasionally appeared; thus lint lengths of up to 50 mm. appeared and forms superior to the parents in boll size, ginning outturn and earliness occurred. Most forms showed also a greater propensity to cross with the 52-chromosome cottons and to a certain extent also with the 26-chromosome group.
Most plants of the backcross progeny had chromosome numbers in the neighbourhood of 52, but individuals with \(2n = 65\) occurred in the cross \((G. \text{ barbadense} \times G. \text{ herbaceum}) \times G. \text{ barbadense}\). The selfed progeny of these backcrosses also showed very varied segregation, which became less in the later generations where some individuals combined a lint length of 38-39 mm. with a ginning outturn of 36-38%, others a length of 39-42 mm. with an outturn of 35-36%; segregates with lint lengths up to 45 mm. occurred and some hybrids had cleistogamous flowers.


Seeds of a virescent yellow cotton strain were X-irradiated at different dosages and it was found that cotton seed could withstand a very heavy dosage of X rays. While 100 kv, 5 ma., applied for 1 hour at a distance of 17 cm. did not decrease germination, heavier treatment produced many dwarfed individuals. When transplanted to the field these plants developed as dwarfs, some attaining a height of only 6 to 8 ins. The many chimaeras produced in the leaves indicated somatic changes which were probably due in some cases to gene mutations and in others to chromosomal aberrations. Six plants from the okra-leaved X-irradiated line developed leaves intermediate in shape between okra leaf and normal leaf, typical of the heterozygous condition.


Records the doubling of the \(F_1\) of \(G. \text{ hirsutum}\) \(\times G. \text{ barbadense}\) by means of colchicine.


Records the doubling of \(G. \text{ arboreum}\) by means of colchicine. The tetraploid \(G. \text{ arboreum}\) plants crossed successfully with \(G. \text{ hirsutum}\) but failed to cross with diploid plants.


Deals with the varieties Kinshu 1 and Kinshu 2.


Gives an account of the crop in Egypt, of the special uses of this type of cotton, and of the beginning of the plant-breeding work in the United States.


A report of progress in plant breeding covering the early stages before serious breeding work began.
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The following extract shows the methods of selection used:

“At the outset all the plants in the test field were examined, and those individuals which were most fruitful, ripened earliest, and had the largest bolls and the best fiber were... picked separately. The seed cotton... was then carefully compared in the laboratory and the final selection of the most promising individuals was made.

The following year the seed from each of these selections was planted in a progeny row... When the bolls began to open in the fall the rows were carefully worked over, and the best individuals were selected. This process has been continued year after year.

Latterly more importance has been attached to the ‘projected efficiency’ of the individual selections as shown by the greater or lesser degree of uniformity in the good qualities of their progeny. It is now the practice to begin the work of selection each year by a general survey and comparison of the progeny rows as units.”


A popular publication on the subject, pointing out the dangers of varietal deterioration. One-variety communities are advocated, coupled with roguing and with the maintenance of an increase plot each year, from a few of the best plants in the grower’s fields.


The origin and mutability of Egyptian cotton are discussed. Yuma, Pima and Gila originated as mutations from Mit Afifi. Plant breeding progress with imported Mit Afifi was slow until 1908 when two distinct types were recognized and isolated. “If the tendency to produce mutants is a result of remote or complex hybridization, the mutability of Egyptian cotton might be accounted for upon either of the following grounds; (1) the supposed hybrid origin of the type as a whole or (2) later crossing with other types of cotton.”


It is stated that the maintenance of the Egyptian type of cotton has until recently depended on the appearance of successive desirable mutations which have given rise to new varieties.


There has been significant improvement in Pima, in the length and abundance of the fibre as well as in the uniformity of these characters, as a result of selection.
young bolls was partly genetic. Conclusive evidence was afforded by F₃ progenies. The coefficient of parent-offspring correlation (F₂ with F₃) was 0.715 ± 0.085 for the total shedding percentage (buds and bolls shed as a percentage of total buds), and 0.621 ± 0.107 for the boll-shedding percentage (bolls shed as a percentage of total flowers).


Bolls from the lower branches of Pima tended to have fuzzier seed, as did bolls nearer the main stem compared with distal ones.


Deals with the history of cotton from prehistoric times; description of the plant and of the development and structure of seed hairs and their biological significance; geographical distribution of Gossypium; classification of cultivated forms; wild species; and the origin of modern commercial cottons.


A short account of selection, breeding methods and multiplication in both New and Old World cottons.


A survey of knowledge of cotton genetics to date.


Short branch of Egyptian cotton is controlled by a single gene lacking dominance. The heterozygote is distinguishable with reasonable certainty.


Emasculated flowers of Pima and of Upland, pollinated with approximately equal quantities of pollen of both types, showed marked selective fertilization, the resulting populations being largely homozygous. There was no evidence of selective survival of zygotes, neither was there consistent evidence of difference in growth rates of the pollen tubes of the two varieties. It is suggested that the penetration of the tubes of like pollen induces a reaction in the stigma rendering it less suitable for the growth of the tubes of unlike pollen. This phenomenon is called pollen antagonism to distinguish it from selective fertilization due to differential growth rate of pollen tubes.

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A detailed description of *G. armouriannum*. Its distribution is given as San Marcos Island off the coast of Lower California.


A photographically illustrated account of *G. klotschianum*, *G. davidsonii*, *G. armouriannum*, *G. harknessii* and *G. thurberi* (under the name *Thurberia thespesioides*). A key is provided to the identification of the first four species.


Examination of specimens representing the original and only known collection of *Ingenhoutzia triloba* DC. indicates that this plant belongs to the genus *Gossypium*.

It is specifically distinct from what appear to be its nearest relatives, *G. thurberi* Tod. (*Thurberia thespesioides* A. Gray) and *G. gossypioides* (Ulbrich) Standley.

A new combination, *G. trilobum* (DC.) is proposed.

Evidence is presented that *Thurberia thespesioides* A. Gray is not generically separable from *Gossypium*, and that *G. thurberi* Tod. is the oldest name available for that species in the genus *Gossypium*.


Descriptions are given of the gross morphology and of the anatomy of the mesophyll and petiole of the parents, *F₁* and *F₂* of the cross *G. armouriannum* x *G. thurberi*. The ratios observed in the *F₂* for some of the more striking contrasting characters are given. In only one case was a simple segregation observed comprising a 1:2:1 ratio for circular v. quadrangular cross section of the twigs. In most cases the dominant characters were those of *G. armouriannum*.

In the *F₂* it appeared that the dominance tendencies of the characters petal spot and pollen colour were reversed, as compared with the position in intraspecific crosses; the populations were, however, too small to warrant a definite conclusion.

Possible physiological advantages and plant breeding possibilities of the compact mesophyll of *G. armouriannum* are discussed.


It is possible that the original ancestors of cultivated cottons no longer exist, and probably many and perhaps all of the wild linted species are escapes from types formerly cultivated. Systematic study of the group is not easy, especially as hybridization gives rise to many distinctive phenotypes. It is suggested that only a fifth of the 160 species listed in *Index herencias* are worthy of specific status. The difficulties in determining specific distinctions do not apply, however, to the wild lintless species, for these are usually
well-defined. The lintless types are most frequently found in rugged habitats; they have 26 chromosomes and are only distantly related to one another. Crossing is difficult to accomplish. Sterile hybrids usually result from hybridization between wild and cultivated species, but fertile crosses can easily be obtained from interspecific crosses within the American or Asiatic groups. No valuable types have so far resulted from interspecific hybridization in contrast to the successes resulting from intraspecific crossing. The origin of S x P cotton is traced in order to illustrate the value of the last-named method.


Jumel’s tree cotton (*G. barbadense*) probably came from the Upper Nile, Sudan. It presumably became mixed with Sea Island and selection out of this heterogeneous population gave the Ashmouni stock, Brown Egyptian. Ashmouni emerged in about 1860 and all subsequent Egyptian varieties derive from this, either directly or by hybridization.

Origin and characteristics of older Egyptian varieties:

Ashmouni (Uppers) (c. 1860), still grown extensively in improved form and is the most important of the shorter-stapled Egyptians. Zagora is essentially Ashmouni.

Gallini (c. 1870) was Sea Island type.

Mit Afifi (c. 1882) arose from Ashmouni; the fibre was brown.

Abbassi (c. 1892) was white fibred; supposedly of Sea Island origin.

Yannovich (c. 1896) arose from Mit Afifi.

Nubari (c. 1905) was selected from Mit Afifi. Its fibre was finer and longer than Mit Afifi.

Sakel (Sakellaridis) (c. 1906) was selected from Mit Afifi and has a light cream fibre.

Assili (Afifi-Assili) (c. 1906) was selected from Mit Afifi and had a brown fibre.

Voltos, believed to be a derivative of Abbassi, appeared between 1902 and 1910.

Zagora (c. 1916) arose from Ashmouni which it closely resembles.

Pilion (c. 1917) probably arose from a hybrid between Ashmouni and Sakel.

Casuli. The original Casuli arose about 1910 but a second variety was given this name in 1920. This latter had white fibre.

Fouadi (c. 1923) was superior to SalmI. in carliness, yield and ginning outturn but inferior in fibre quality.

Nahla arose by mass selection from Assili in the early 1920's and had brown lint.

Giza 3. A single plant selection from Ashmouni.

Origin and characteristics of modern varieties:

Ashmouni (including Zagora): Giza 2, selected from Ashmouni, was distributed as Ashmouni Gedid and substituted for the old type in 1928. Giza 19 and Giza 22 are improvements on Giza 2 in quality though indistinguishable from Ashmouni in the field. Giza 19 was substituted for Giza 2 throughout the Ashmouni-Zagora area in 1937. The name Zagora is still retained for
the Delta crop which differs in quality from that of Upper Egypt.

Giza 7 originated from a single plant selection made in 1922 in Ashmouni. It is wilt resistant and has a high ginning outturn and lint index.

Wafcer (Giza 12) originated from an Ashmouni x Sakel cross made in 1923. Its bolls are larger than any variety previously known in Egypt.

Menoufi (Giza 36) came into commercial production in 1943. It resembles Giza 7 but is said to be more productive and to have somewhat longer and stronger fibre.

Karnak (Giza 29) was developed about 1931 from a Maarad x Sakha 3 cross. Sakha 3 was itself selected from Sakel. In 1942 Karnak outyielded all the long and medium stapled Egyptian varieties and was only surpassed in average lint yield per acre by Ashmouni-Zagora.

Sakel. A new variety, 310, was selected from Sakel in 1912 at Sakha on the State Domains. Domains Sakel (Sakha 7), a selection from 310 with longer and finer lint was substituted in 1932. The lateness of maturity and susceptibility to wilt of the original Sakel have not been eliminated.

Sudan Sakel. Sakel 186 arose from Egyptian Sakel imported into the Sudan in 1913. From this the parent of the X 1530- X 1730 strains was selected in 1923-24. These strains show resistance to leaf curl but give weaker yarns than true Sudan Sakel.

Sakha 4 was selected from Sakel in 1927. It was replaced by a reselection in 1935 (Sakha 4 Gedid). Sakha 4 is more resistant to Fusarium than Sakel.

Malaki (Giza 26) was developed from a cross between Sakel and Sakha 11 (from St. Kitts Sea Island). Malaki has rather dark lint, large seeds and a low ginning outturn.

Maarad was developed from Pima.

Parentage of American-Egyptian varieties:

Yuma originated from a single plant selection made in Mit Aflifi in 1907.
Pima originated from a single plant selection made in Yuma in 1910.

S x P. Sakel was imported and grown at Sacalon in 1914. After several years selection, a uniform variety was produced. This was crossed with Pima in 1918 and from this cross the S x P type was bred.

Tables of boll weights, seed index, lint index, ginning outturn, grade of seed fuzziness and fibre properties of Egyptian cottons are given.


Intraspecific crosses are better than interspecific for improving local varieties, though the latter are of value in transferring a small number of genes. Geographically separated types of the same species are valuable, since more variability is obtained in the F1.

In crosses within G. herbaceum and between G. herbaceum and G. arboreum, positive associations were found between seed weight and (1) staple length, (2) yield and (3) lint index.

For improvement of staple, a variety with the desired staple but with smaller seeds should be...
crossed with the local type. To increase ginning outturn, the choice is recommended of a type with larger seed than the local variety, whose ginning outturn depends on density of hairs per unit area of seed coat, rather than on higher hair weight.


Wilt resistance in G. arboreum and G. herbaceum is controlled by two dominant complementary genes, \( A \) and \( B \), and a third one, \( C \), with a dominant inhibitory action.


For the improvement of yield, staple and ginning outturn of the Dharwar-American type Gadag-1, the use of Co. 4 and Co. 2 as parents is recommended.

KESAVA AYYANGAR, N. 1947. See BALASUBRAMANYAN, R. and KESAVA AYYANGAR, N.


A mutant female sterile type behaved as a simple recessive. The factor pair has been designated \( D-d \).


Jarila (ginning outturn 35%) was crossed with NR 5 (ginning outturn 45%) and three strains were bred from the hybrid having 2-4% higher ginning outturn and an increased yield, but otherwise similar to Jarila.


A graphical indication of the trend in economic characters of the cotton strains developed in Khandesh is provided. Notes are also given on the morphological characters of the strains concerned, which comprise the local cottons, Banilla, Jarila, NR 6 and 197-3.


A survey of breeding work on Khandesh cottons from 1932-1948.

KHAMBANONDA, L. 1929. See CAPINPIN, J. M. and KHAMBANONDA, L.

At Lyallpur 2% of natural crossing takes place between cotton plants grown in contiguous holes and rows. Under field conditions the figures are only about 0.05% for desi and American cotton. Maximum natural crossing took place within 15 ft. from the marker plants and wind direction had no effect on it. Natural crossing was entirely entomophilous, Anthophora conjusa, Apis dorsata and Elis thoracica being the most active agents.

40 ft. barriers of the variety itself were most effective, as compared with barriers of other types and open space and sorghum barriers. Sorghum was the worst barrier.


The chief agents bringing about natural cross pollination of cotton at Lyallpur are Apis dorsata, Anthophora conjusa and Elis thoracica; wind pollination does not occur.

KHAN, A. H. 1950 a, b & c. See AFZAL, M. and KHAN, A. H.


Deals with the variety 124F.


Jassid is one of the major pests attacking Punjab-American cottons, and in years of abundant rainfall in the summer causes considerable losses. The work of evolving varieties entirely immune or highly tolerant to the pest, is in progress in Lyallpur. The existing Punjab-American varieties are being crossed with types reputed to be jassid-resistant, such as Tangüis and Cambodia. Crosses with Tangüis have shown high resistance in the initial stages, but later this resistance has gradually been reduced. Crosses with Cambodia have yielded very promising progenies which have not only maintained resistance throughout, but have also given new types which possess superior fibre. It is hoped that the problem of jassid resistance in the Punjab may be solved by these Cambodia crosses.

KHARGONKER, S. A. 1949. See PANSE, V. G. and KHARGONKER, S. A.


A discussion of the general principles involved in breeding improved cottons.


The requirements are: earliness; a short fruiting period; large storm-resistant bolls; and a minimum of vegetation. Breeding work carried out for five seasons is described.


Virescent yellow cotton is described. This is a simple recessive to green, the genes concerned being V (green) and v (virescent yellow).

It is confirmed that red leaf R is a simple dominant to green leaf r.

Genes R and v are inherited independently.

The combination of R with v produces a new type named bronze.


Hybrid strains which have recently been developed, and which show promise in harvesting trials, include Western Early, Ducona x Lone Star and Ducona x Half-and-Half.


The desirable type of plant for mechanical harvesting should be characterized by medium height, relatively short-noded fruiting branches, not more than one minor vegetative branch, open-type growth, light foliage with small leaves that shed early and a medium-sized, strong, storm-resistant boll, borne singly on a peduncle that snaps easily under tension. In addition, the fibre should be relatively harsh bodied, dense on the seed, of medium staple length, and have sufficient interseed drag to keep the locules relatively compact for best results in cleaning mechanically harvested cotton. Several promising hybrids bred at College Station and Lubbock appear relatively uniform for the desired characteristics: Half-and-Half x Acala, Ducona x Mebane 140, Clark x Acala and Half-and-Half x Lone Star, all of which are characterized by a high mechanical harvesting efficiency, good yield, good cleaning qualities, desirable staple length and relatively high percentage of lint. The improved strains are being increased.


"In the breeding work to combine in synthetic types those characteristics found to be best suited to mechanical harvesting, the coarser-bodied, medium-staple varieties such as Gorhams, Lone Star, Western Mebane 140, Western Early and Mebane 504-50 were used as parents. In cleaning mechanically-harvested varieties and hybrid strains prior to ginning, it was found that the
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coarser-bodied medium-staple types with compact locks and fibres dense on the seed graded from one to three commercial grades higher than the softer, finer-bodied, longer-staple types, representing an increase in value of $3-10 a bale. In order to further increase the yield of the present hybrid strains these have been crossed with two new high-yielding varieties, Deltapine 14 (44-51) and Half-and-Half Selection 25. Four of the hybrid strains, Gorhams Lone Star x Dccona 112, Mebane 140 x Ducona 30-31, Western Early x Ducona 17 strain 1, and Western Early x Ducona 17 strain 10, gave yields 11, 12, 15 and 24% higher, respectively, than the average yield of the selected high-yielding commercial varieties used as standards or checks.

KILLOUGH, D. T. 1942. See SMITH, H. P. and KILLOUGH, D. T.


New varieties of cotton of good spinning performance have been developed for different parts of Texas. At Denton Station, Suntex and Dentex have been developed by inbreeding and selection from Sunshine Rowden, and are being released for commercial production. These varieties produce high yields and are storm proof. The Chillicothe Station has developed Lockett 140 (Mebane 140) and Western Prolific (Mebane 141), which give high yields of medium length staple. The Lubbock Station has evolved a new variety called Stormproof, which gives yields of cotton with good cleaning and spinning properties, and is essentially adapted to machine harvesting. At the Beeville Station, Mebane 804-50, a high-yielding cotton with a medium staple length, has been developed.


Deals with a variety of aspects of cotton culture. After three years' work the author states he believes a variety of cotton immune to anthracnose can be produced.


Literature on hybrid vigour in interspecific and intraspecific crosses of cotton is reviewed. Hybrid vigour was studied during a three-year period in crosses between inbred lines selected from the Coker 100, Stoneville and Deltapine 11A varieties of Upland cotton (G. hirsutum); Coker 100 and Stoneville are related cottons. On the basis of a comparison with the parent possessing the higher value for a given character, $F_1$ hybrid vigour was shown in yield of seed cotton, lint yield, lint index, earliness and rate of blooming. No heterotic increase was, however, observed in the weight of the plants after harvesting, plant height, seed index (weight of 100 seeds), boll size, and fibre strength and length. It appears that hybrid vigour in Upland cotton is expressed in the characters contributing to greater yield rather than in an increased growth of the plant parts. Both the $F_1$ and $F_2$ generations showed considerable hybrid vigour in comparison with the parental
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mean values, the F₂ showing a decrease in hybrid vigour approaching 50%, when compared with the F₁. In the F₃ generation hybrid vigour showed a still greater reduction. The practical application of these results is discussed.

King, C. J. 1943. See Presley, J. T. and King, C. J.

King, H. E. 1949. See Parnell, F. R., King, H. E. and Ruston, D. P.


By the procedure used, leaves of a definite internode are cut off and placed in a beaker of water; the temperature of the water is gradually raised to 55°C, and the leaves are kept at 55°-60°C for ten minutes. After this they are transferred to containers of cold water; which is replaced by 0.2 N HCl. The appearance of yellow spots under the influence of the acid is considered an index of the heat resistance; the earlier they appear, the lower the resistance of the leaves tested. Experiments with different concentrations of HCl into which the petioles of cotton leaves were dipped for 2-5 hr. indicated that the decrease in heat resistance paralleled the concentration of the salt in the medium. The heat resistance of leaves on different internodes proved of considerable significance; the maximum resistance occurred in leaves of the middle internodes; the minimum in the lowest and uppermost leaves.


Gives details of the method of selfing by means of gum used in the Sudan.


Varying degrees of resistance to blackarm (Bact. malvacearum Sm.) were found in American cottons and complete immunity obtained in some, though not in all, of the Old World types. All Sakels tested showed the same susceptibility.

"Resistance" is used in the sense of resistance of the leaf. Leaf and stem resistance are positively correlated. It is assessed on a scale in which 0 represents immunity and 12 full susceptibility. This scale is defined.

The resistance of the Upland type, Uganda B 31, depends on two dominant cumulative genes, B₁ and B₂, the former being weak and the latter a strong factor. Minor genes are present also. B₁ and B₂ have been transferred to Sudan Sakel.

647. Knight, R. L. and Clouston, T. W. 1941. The genetics of blackarm resistance. II. Classification, on their resistance, of cotton types and strains. III. Inheritance in crosses within the Gossypium hirsutum group. J. Genet., 41, pp. 391-409.

Part II of this series gives a classification, based on blackarm resistance, of over 160 varieties and strains of cotton. Complete immunity was not found in New World types, but exists in some of the Old World species.

Part III shows the type of blackarm resistance inheritance
obtaining in the crosses Uganda B 31 x 514 and B 31 x 513 (all are American Upland types), the latter results being further clarified by crosses between 513 and Sakel.

It is shown that 513, a selection from a Punjab American Upland importation, carries B 3 together with minor resistance genes.


BAR 3, a strain of G. punctatum, carries two linked blackarm resistance genes, B 2 and B 3. B 3 is the gene responsible for resistance in G. hirsutum varieties, B 3 is a new, semi-dominant factor. Neither minor nor modifying factors are present in BAR 3 in sufficient strength to have any marked effect. B 1, B 2 and B 3 are all additive.

B 2 and B 3 showed 32.4% cross-over in the first four Sakel backcrosses. Later backcrosses and later backcross F 2 's showed a loss of linkage attributed to replacement of the punctatum segment of chromosome between B 2 and B 3 by barbadense, thus permitting greater freedom of crossing-over and making the recombination value approach 50%.

The resistance of Gambia Native, another G. punctatum strain, is also due to B 3 and B 3, but Gambia possesses, in addition, a number of minor factors, and crosses between Gambia and Sakel showed blending inheritance in the F 2.


Darfur Local, a cultivated G. punctatum from the Western Sudan, was heterogeneous for resistance but gave evidence of the presence of B 3 and, assumingly, of B 3 also.

Kadugli Local, a semiwild G. punctatum from Kordofan Province, Sudan, showed marked resistance but no genetical analysis has as yet been made.

The system of grading for resistance is defined and illustrated in detail.


Backcrossing, though successful in other crops, has in the main failed to produce economic results in cotton. The use of the technique discussed in this paper has produced several commercially successful interspecific gene transferences. The following suggestions are made:

1. The hybrid should be the male parent.

2. The latest substrain of the backcross parent variety should be used each season as female parent to keep the crossing programme up to date.

3. Where a large number of visible differences exist between the original parents, these provide a valuable basis for selection. In such a case, large early backcross progenies should be grown and severe selection in the field utilized to accelerate the removal of the donor parent genotype. With few visible differences between the parents it is advisable to grow small backcross progenies and to concentrate on the elimination of the donor genotype by
making as many backcrosses per year as possible.

4. Selection of hybrid plants for further backcrossing should be made solely on (a) presence of transferred gene and (b) vegetative similarity to the backcross parent. All characters likely to be due to heterosis should be avoided.

5. An arbitrary end-point in backcrossing should be avoided. The criterion should be a replicated test of bulk seed from heterozygotes from the backcross, against bottom recessives from the backcross, using the backcross parent as control. When the heterozygous bulk is qualitatively and quantitatively equal to the backcross parent, bulk propagation and large scale testing should be started.

6. Cumulative factors with only slight additive effect should be separated in backcrossing and recombined later.

7. Linked factors are best separated to facilitate the elimination of the donor parent chromosomal segment between them.

8. Blending inheritance in a first backcross need not discourage a plant breeder since inheritance of the character may still be mainly due to one or two major genes and clear-cut ratios may appear in later backcrosses.

9. A method of bulk propagation from a backcross progeny, via an out of season backcross F₂, to an F₃ homozygous propagation plot in the following season, is discussed.

10. A technique is suggested for transferring genes to a strain showing moderate heterogeneity.

The only resistance to blackarm disease (B. malvacearum) of any importance found in American Upland types is dependent on a single fully dominant gene, B₂. Sometimes a weak gene B₁ may also be present. Some varieties of G. hirsutum var. punctatum carry a second partially dominant gene, B₃. B₂ and B₃ are linked, having a 32% crossover value, and are additive in effect.

A resistance classification is given on a genetic basis for a number of Upland strains and details are given of a method of obtaining even infection on which classification for resistance is based.

Only one blackarm resistant pure G. barbadense type has so far been found, viz. Grenadines White Pollen.

The genes B₁, B₂, and B₃ have all been transferred to Sudan varieties of G. barbadense. In this work, B₃ is the most important gene, followed closely by B₂; B₁ in only of minor importance. Breeding methods are described for transferring these genes from resistant to susceptible varieties, and for selection within varieties for resistance.


In the F₂ of a cross between two American Upland (G. hirsutum) types, Uganda B₃1 and the Sudan variety 514, a number of markedly dwarfed bunched plants appeared. Investigation showed that normality as opposed to dwarf-bunched depends on the presence of either of two duplicate genes; one dominant and the other giving an intermediate heterozygote. These genes have been called D₂ and
Db, the former deriving from 514 and the latter from Uganda B 31.

The gene db occurs in Gambia Native (G. hirsutum var. punctatum) and in the American Upland varieties Uganda SP 84, XA 129 and Deltapine, but it was not present in all Upland varieties examined.

The gene da is closely linked with (or possibly identical with) the blackarm resistance gene B1. Since G. barbadense types are of DaDaDbDb composition, B1 can be utilized in conferring blackarm resistance on this group.


It is considered that preadaptation is not uncommon in economic characters. Notable examples are the resistance of many wild xerophytic species of Gossypium to the rain-borne disease Bact. malvaeearum, the resistance of several cottons of non-African origin to the virus disease leafcurl, a disease unknown outside the Sudan and Nigeria, and the marked resistance of certain New World species to the Egyptian and pink bollworms.

It is argued that preadaptational characters involving major differences will typically be found to be controlled by one or a few large genes, whereas adaptations which arise in 'response' to an existing selection pressure may be controlled either by major or minor genes, or both, according to the strength of the genes available.

Preadaptation is thought to have played a major part in the evolution of disease and pest resistance and to this is attributed the predominance of major gene control in resistance.

Major gene control is shown to be of considerable importance in a large number of economic characters other than disease resistance. It is suggested that major genes are more common in the control of economic characters than is commonly supposed. For breeding purposes an attempt should be made to reduce complex characters to their integral components to facilitate genetic analysis.


A strong, partially dominant gene governing resistance to blackarm disease (Bact. malvaeearum) has been transferred from G. arboreum to G. barbadense (Domains Sakel). The new gene, B4, segregates independently of B1, B2 and B3 and it shows additive effect in conjunction with B2 and with B3.

Three cytogenetically distinct techniques for transferring genes from Old World diploid to New World allopolyploid cottons are described and their relative merits discussed.


The immunity of Multani cotton (a variety of G. arboreum race bengalense) to Bact. malvaeearum is shown to depend on a major gene, B4, accompanied by a strong complex of minor genes. No such strong complex has ever been found in cottons of immediate New World origin. From this and other data, it is argued that the cottons of India
have undergone a strong selection pressure from *Bact. malvacearum* for longer than the cottons of the New World, and it is suggested that this disease originated in the Old World, probably in India.


*Gossypium somalense* race *soudanense* Knight is illustrated and described and *G. anomalum* is illustrated. These two species occur sporadically in a broad belt across the Sudan between the 5 in. and 20 in. isohyets. The northern more arid fringe of this belt runs from one rocky hill top to another. Southward, with increasing rainfall, these species occur on fixed low dunes or grit ridges and still further south on mature sand plains.


Summarizes the author's work on blackarm resistance up to 1949, and outlines the reaction of 20 species of *Gossypium* to the disease. The synthesis of resistance under the impact of blackarm is dealt with and breeding techniques are outlined.


Two forms of resistance occur in *Gossypium barbadense*: weak resistance, due to leaf hardening, is found in the Sea Islands, and strong resistance, due to the gene *B₅* fortified by minor genes, occurs in the perennial variety Grenadines White Pollen. *B₅* is variable in expression but, in general, the homozygotes show stronger resistance than the heterozygotes. *B₅* is additive in conjunction with *B₁, B₂, B₃* and *B₄* respectively.


India is the major centre of blackarm resistance. The Indian races of *G. arboreum* and *G. herbaceum* are, almost without exception, immune. Immunity and high resistance predominate in the commercial Asiatic cottons of the surrounding countries but the general level of resistance is lower in the more peripheral areas and in perennial types.

In the New World, resistance occurs in variable material at the centre of origin in Central America and in the *punctatums* of the Bahamas region, but only two resistant strains have been discovered in the main bulk of the commercial Uplands. In the *hirsutum* acclimatized in the Old World, marked resistance is common in the Uplands and *punctatums* of India and Africa. The highest degree of resistance so far recorded in New World cottons is to be found among the *punctatums* of the West African savannahs.

Resistance is rare in *G. barbadense*. Minor gene resistance occurs in Sea Island, but apart from cases directly attributable to introgressive hybridization, major gene resistance has only been recorded once in the species.

Two types of resistance genes have been recognized: those
which have no demonstrable effect on the plant apart from conferring resistance, and those which affect the plant in other ways and only incidentally confer or enhance blackarm resistance. All the worthwhile major resistance genes belong to the former group.

There have been two great waves of spread of resistance in the commercial cottons, one in the Asiatic species, and one in those of the New World. The Asiatic species acquired resistance first, and it was built up in India by the establishment of $B_4$ throughout the crop, and the accumulation of minor genes around it. In New World cottons, resistance genes have spread from extremely limited sources. Every case of effective resistance that has been studied save one, can be traced to $B_3$ or $B_5$ from *G. hirsutum* var. *punctatum*, sometimes fortified by minor genes. In addition the gene $B_5$ has been recorded once in *G. barbadense*.

The Upland crops of India and Africa were established on susceptible types from the US Cotton Belt, but in India and West Africa, resistance was acquired, by introgressive hybridization, from *G. punctatum*. The resistance which occurs in other parts of Africa probably traces its origin to chance hybridization with an early importation of acclimatized Indian Upland.

The foundation of effective resistance has proved to be a major gene in all the cottons tested. The value of minor genes alone is strictly limited, but wherever there has been prolonged selection under epidemic attack, the main gene has been fortified by lesser genes. Effective resistance can, in fact, only be built around a main gene.

**Knight, R. L. 1950.** See **Hutchinson, J. B. and Knight, R. L.**


The only successful way to use hybridization in the production of new cotton varieties is to limit the number of parental combinations to the minimum whilst growing the largest possible number of families of each. For crosses differing in many characters, backcrossing is recommended to reduce the number of types segregating.

The main commercial varieties are intermediate in ginning out-turn, lint length, earliness and size of boll. Each of these characters could if necessary be increased.

The size of bolls was studied in a cross between two American cottons, Schroeder (bolls 3–3.5 grm.) and Triumph Navrotskii (8–9 grm.). The $F_2$ was intermediate with a boll weight of 6.5 grm. An $F_3$ of over 3000 individuals was grown and contained all types from the largest to the smallest bolls, the distribution being in the form of a regular unimodal curve. The $F_3$ showed several of the intermediate forms to be homozygous. The experiment thus shows that boll size is dependent on a number of factors and that desired types can be obtained among the segregates only by growing at least two to three thousand $F_2$ seedlings.

The Schroeder parent was considerably earlier than the other,
but some of the homozygous F<sub>4</sub> families combined an earliness almost equal to Schroeder with a much greater boll size, which exceeded Schroeder by up to 2·2 grm., producing a difference of up to 22% in yield.

In crosses between the local (G. herbaceum) cottons the F<sub>1</sub> was generally intermediate in boll size, with occasional dominance of small boll (this was never observed in the American crosses). Similar polymeric segregation occurred in the F<sub>2</sub>, though again with a tendency towards the dominance of small bolls in certain combinations. Thus a cross was made between the smallest form obtainable (boll weight 3·5 grm.) and an Afghan form with bolls of 5 grm. The F<sub>1</sub> was intermediate and the F<sub>2</sub>, consisting of 194 plants, contained two groups, 102 plants all small and 92 plants intermediate in boll size. No form with large bolls was obtained, certain other combinations however showed an increase in boll size both in the F<sub>1</sub> and F<sub>2</sub>, these being the cases when one parent contributed large number of locks per boll and the other parent large weight of seed per lock. Thus the cross between a line (3280) with bolls of 4·1 grm. and a line of 5·49 grm. gave an F<sub>1</sub> with bolls of 5·8 grm., whilst 3280 crossed by a line with bolls weighing 3·7 grm. gave an F<sub>1</sub> with bolls of 5·1 grm.

Observations were made on the components of ginning outturn, namely weight and number of fibres, and weight of seed. The number of fibres per seed calculated in seven varieties of American cotton varied from 7800 to 14700 and in the two varieties of G. herbaceum from 3600 to 9200; the weight of a thousand fibres in American cottons varied from 4·4 to 7·6 mgmr. and in G. herbaceum from 3·4 to 5·8 mgmr.; the seed weight varied from 97·0 to 167·2 mgmr. in American and from 69·7 to 111·8 mgmr. in the local cottons. Variations were observed in the way in which the ginning outturn is made up, some varieties having a small number of fibres but of a high individual fibre weight, others with a large number of light fibres. Crosses were made between these two types in the attempt to combine the characters fibre number and fibre weight. In the F<sub>2</sub> of such a cross between two G. herbaceum lines there appeared plants with ginning outturns higher than the better parent by 7 to 13%. Lines homozygous for this combination were obtained, an F<sub>4</sub> line constant for a ginning outturn of 8% more than the better parent being quoted. The same effect was observed in similar crosses of American cottons: a cross between Triumph, having a ginning outturn of 34–35% and a naked-seeded Transvaal cotton ginning 4–5%, gave hybrids in the F<sub>2</sub> ginning 40, 41 and 42% and almost constant lines ginning 39·1% in the F<sub>4</sub> with every indication of giving constancy in the F<sub>5</sub> or F<sub>6</sub>: A line of G. hirsutum, with petal spot, was crossed with others without petal spot. The F<sub>2</sub> contained 585 plants with petal spot and 201 without, and this monohybrid inheritance was confirmed by backcrosses. Spot intensity showed a wide range of variation. The behaviour in the crosses with other spotless varieties was exactly similar, and in three crosses in G. herbaceum monohybrid ratios for petal spot were obtained.

Pollen colour was studied in crosses within G. hirsutum.
Yellow pollen proved dominant in crosses with four different varieties with white pollen, giving monohybrid ratios in the F2. In crosses between American cottons with yellow corolla and varieties with cream or white corolla, the yellow colour was 

majority or partially dominant, with monohybrid segregation in the F2. The behaviour in crosses in G. herbaceum was exactly similar.

The boll type in G. herbaceum is much more variable than in the other species. The closed boll, a type desired for purposes of mechanical harvesting, proved to be a simple recessive to the open or semiopen type.

Anthocyanin pigmentation in the plant and sometimes the flowers gave simple 1:2:1 ratios in the F2. Similar 1:2:1 ratios were obtained in crosses between forms with brown and white lint in American cottons. The intermediate forms appearing in the F2 varied in shade but all segregated in later generations and gave 1:1 ratios in backcrosses; the variations in shade are possibly due to modifying factors. Crosses in G. herbaceum on the other hand showed lint colour to be dependent on two or three factors. No homozygous lines of intermediate coloration were obtained in the F3 of the dihybrid crosses, though this is probably due to the insufficiently large size of the populations studied.


Transgressive segregation occurred in F2 of crosses between varieties with differing ginning outturns.


Four naked-seeded cottons were crossed with a number of forms with normal fuzz. Two of the four varieties gave F1 plants bearing naked seeds, one gave an F1 with intermediate pubescence and the fourth an F1 varying from intermediate to full fuzz. The ratio of naked to pubescent seeds in the F2 varied in different crosses, being 63:1 in some and in others as much as 253:1.

The naked seeded parent had a ginning outturn of only 4-6% and transgressive inheritance occurred in the F2, forms without lint occurring together with others superior to the normal parent. Although there was a general association between naked seeds and low ginning outturn some of the naked seeded segregates were not inferior to the normal parent in ginning outturn.


In an F2 consisting of 786 plants from a cross of two varieties of American cotton, 585 had petal spot and 201 were without; in another F2 of 549 individuals there were 417 with and 132 without petal spot. In G. herbaceum, 187 with and 56 without this character were obtained and the latter bred
true. Monofactorial inheritance was found also in respect of pollen coloration, petal coloration and leaf pigmentation. Brown versus white lint gave mono-, bi- and trifactorial ratios.


Schroeder (boll wt. 3.0–3.5 grm.) x Triumph Navrotskii (8–9 grm.) gave a 6.5 grm. F₁ and a unimodal distribution in the F₂ with a range from 1.6 to 9.3 grm. Pure breeding segregates were obtained in the F₄, combining large bolls with earliness.


Studies of the morphological and photoperiodic characters of the wild species of Gossypium and their behaviour on crossing have led to the following conclusions:

G. davidsonii should be retained in the genus Gossypium; it has no morphological feature justifying its exclusion and has given a partially fertile hybrid with G. hirsutum in which the characters of the latter species were largely dominant; the F₂ gave segregates varying from exceptionally early to perennial and a wide range of morphological characters.

G. anomalum gave one boll in crosses with G. arboreum and the F₁ was backcrossed successfully with G. arboreum; G. anomalum should therefore be retained in the genus Gossypium.

G. lanceaeforme was crossed with G. davidsonii and G. peruviunum and though the bolls were abnormal in form there is no reason for excluding the species from the genus.

Observations are also being made on G. stocksii, G. kirki, G. harknessii and G. sturtii.


The perennial cottons, when grown under curtailed illumination, display an unexpected range of variation in type. Some of these forms are considered useful for hybridization, e.g. forms of G. peruviunum possessed of unusually large bolls. Some of these have also very long lint (up to 40 mm.) and are being crossed with Egyptian cottons to increase the boll size of the latter.

Some of the perennial forms are highly disease resistant and one species at least, G. lanceaeforme, is frost resistant.


Recent studies of G. herbaceum have revealed extremely valuable types for breeding. Among those mentioned are forms from western China (Turfan region) earlier than any other known cottons,
reaching maturity in 90–95 days, which is 15–20 days before the earliest Upland varieties. Early cottons were also found in various countries in Asia Minor. The form from Turfan (var. kuldjanum of Zaitsev) in spite of its great earliness, is slow in the period from bud formation to flowering. By crossing it with varieties that are rapid in this period still earlier forms should be attained.

Some of the forms collected in Afghanistan, Iran and central Asia have bolls weighing up to 5.5 gm. Others had lint up to 32 mm. in length, and some had ginning outturns up to 37%; these latter types are late in maturing.

Special interest is attached to the forms with nondehiscent bolls for breeding cottons resistant to wind damage and suitable for mechanical harvesting.

Most of the forms are more drought resistant than the American and Egyptian cottons, some being quite exceptionally tolerant of unfavourable conditions.

These various desirable characters occur separately in different individuals but could no doubt be combined by hybridization, whereby unexpectedly valuable forms of this species might be produced, especially in connexion with new or unfavourable cotton areas. Some of the forms might also be used with advantage in interspecific crosses.


From the crossing behaviour of G. lanceaforme (Thurberia thespesioides) with G. barbadense, G. peruvianum, G. hirsutum and G. arboreum it is concluded that T. thespesioides should be included in Gossypium.


Late maturing varieties have been grafted at the cotyledon stage on to the following stocks: (1) an arborescent type incapable of natural blooming under the conditions of long day at Tashkent, (2) an extremely early annual cotton and (3) F₁ hybrids from the cross G. hirsutum x G. barbadense. With the exception of the first all the stocks had reached the reproductive period at the time of grafting. Rate of development of the scion, reproduction capacity and general appearance were markedly influenced by those of the stock.

670. Koshal, R. S., Gulati, A. N. and Ahmad, N. 1940. The inheritance of mean fibre-length,
COTTON BREEDING AND GENETICS

A statistical treatment of the subject.

Varieties of cotton have been evolved which are early ripening, have good staple and yield well. Prominent among these are strains 8517, 8196, C460, 35-1, 18819 and 246. New types have also been evolved with a coarse woolly fibre, and several that produce brown-coloured lint. The research workers at the Turkmenian Experimental Station are engaged in developing coloured cottons of the following shades: light and dark blue, green, pink and smoke colour.
Kottur, G. L. 1915. See Kulkarni, K. D. and Kottur, G. L.


Describes the use of thin wire rings, slipped over fully developed buds.


The objective was to combine the 35-1% ginning outturn of the G. neglectum var. rosea parent with the good staple of Kumpta herbaceum (ginning outturn 28%).
In the F2 a 9 : 3 : 3 : 1 ratio was obtained of high ginning outturn + long staple: high ginning outturn + short staple: low ginning outturn + long staple: low ginning outturn + short staple.
F3 and F4 results appear to bear out the interpretation that in this cross, high ginning outturn and long staple are controlled in the main by single genes inherited independently.


Records the sudden appearance of a glabrous plant in a variety of Wagale (G. neglectum) which had been self-bred for seven years. The mutant type was lintless and bred true for lintlessness and glabrousness.


Crosses were made between white-flowered and yellow- and red-flowered cotton plants.

Yellow-flowered and red-flowered plants gave 3 : 1 ratios in the F₂. White-flowered x red-flowered gave 9 : 3 : 3 : 1 ratios.

F₃ segregation confirmed these ratios.


Almost all Asiatic cottons are highly susceptible to *Fusarium vasinfectum*. Some commercial varieties, though susceptible, contain some degree of resistance and on selection yield resistant strains. Such varieties, if grown on wilt infected soils, show rapid improvement owing to the early elimination of susceptible individuals.


In Russian experiments with several varieties of cotton, direct relation was established between the bactericidal properties of the cell juice of the different varieties and the resistance of the varieties to gummosis, caused by *Bact. malvacearum*.

The hybrid cottons OD-1, bred at the USSR Institute for Breeding and Genetics, and 4943, developed at the Ukrainian Cotton Station, were the least susceptible varieties. The bactericidal properties of the cell juice of all varieties increased with the age of the plants.


Data are presented to show that the quality of the plants produced from any seed is influenced by the conditions of growth of the plants producing that seed.


Seed from plants of a number of varieties of *G. hirsutum* that had been artificially self-pollinated for a number of years was compared with seed from the same varieties open-pollinated.
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The plants of the control were taller, flowered 2–3 days earlier and ripened sooner; they had a greater number of bolls per plant and of seeds per boll, especially in comparison with the varieties that had been selfed for longer periods.


Descriptions are given of various off-types found in elite material of a number of cotton varieties. Many of them were sterile or of reduced fertility. The elites were grown under conditions designed to preclude out-crossing and the degeneration is ascribed to the fact that the elites are produced from the progenies of two or three single plants which has reduced their range of adaptability. A much larger number of plants is now taken as the basis for elite production so as to avoid this danger, and the application of intravarietal crosses is recommended.


Descriptions are given of the varieties Acala Blue Tag and the local Chaco type and of the local selections Tucumán C1 and selected Lightning Express. Tucumán C1 is exceedingly vigorous, yields over 2 tons of raw cotton per hectare, and has silky fibre of excellent colour and drag, 30/32 mm. in length. Selected Lightning Express is early, yields 1½ tons of raw cotton per hectare, produces silky fibre with good drag, 30/32 mm. in length, with a ginning percentage of 32.

KUBERSINGH, 1936. See Hutchinson, J. B. and KUBERSINGH.


Records the production (in the F₃ of a cross between two Ashmouni selections with short internodes) of plants with bolls formed directly in the leaf axils on the main stem. These plants produced no sympodia.


With the object of producing large-belled cottons yielding coarse lint but capable of being used as a wool substitute, crosses were made between Egyptian cottons (G. barbadense) and perennial Peruvian cottons (G. peruvianum), which were induced to flower by treatment with a 10 hour day.

The F₁ plants behaved as perennials, giving seed only when grown under curtailed illumination. The F₂ generation segregated into annuals and perennials and showed great variations in fertility, lint length and other characters. Segregation was also observed in the F₃ generation. Several plants of the annual Egyptian type of habit, with coarse, woolly lint, were selected; they were all later than Pima in maturity. Some of the hybrids have bolls weighing 5–7 grm.
and their lint is considered quite suitable for mixing with wool.


From 1931-1939 the Turkmenistan Cotton and Lucerne Experiment Station has produced a number of promising, relatively high yielding and high quality varieties of cotton of the Egyptian type with long lint. Particulars are given of their origin and their characteristics and performance in various trials and in spinning tests.

Economic conditions in the USSR have created a demand for cottons with coarser lints, but of good quality, for admixture with wool in manufacture, or for use as a substitute. In these types high yield, large bolls and disease resistance must also be combined. Some large-bollled types with coarse lint have been bred from lines of G. barbadense x G. peruvianum, the final selections from this cross being 4844 I and 4848 I.


Gives lists and descriptions of some 300 varieties of native and 300 varieties of introduced cotton and their hybrids grown in various parts of Bombay Presidency since 1905, with brief notes regarding the performances of some of the selections and hybrids.


Describes hybrids between Gadag I, an Upland with a mean lock number of 4·0, and Sea Island with a mean of 3·1. The F₁, F₂, F₃ and F₄ generations are described. High locule number showed partial dominance in the F₁. No clear segregation was obtained in the F₂ but the author succeeded in obtaining types breeding true for the parental lock numbers in later generations. He also obtained new types, with lock numbers intermediate between the parental types, which bred true.


Covers: (i) The history of the introduction of American cotton into India; (ii) improvement of Dharwar-American cotton by selection; (iii) attempts to produce improved cottons for the Dharwar-American tract by hybridization; (iv) parents of the cross; (v) the method of selecting and making the cross; (vi) the characters of the hybrid plants: hairiness of the plants, colour of the spot on the pulvinus, number of teeth in the bracts, colour of the flower petals, presence of petal spot or “eye,” length of the flower petal, colour of bolls, surface and glandulation of bolls, number of loculi in the bolls, length of staple of lint, ginning percentage and lint index, amount of fuzz on the seed and colour of the seed fuzz; and (vii) correlation studies: correlation between length of stigma and staple and correlation between
ginning percentage and staple of lint.

The appendices comprise (1) correlation tables between the length of stigma and that of fibre; and (2) correlation tables between ginning percentage and length of staple.

Kulkarni, Y. S. 1940. See Uppal, B. N., Kulkarni, Y. S. and Ranadive, J. D.

Kulkarni, Y. S. 1941. See Patel, P. L. and Kulkarni, Y. S.

Kulkarni, Y. S. 1948. See Patel, M. K. and Kulkarni, Y. S.

Kulkarni, Y. S. 1950. See Patel, M. K. and Kulkarni, Y. S.


Deals in detail with a case of complete sterility in *G. herbaceum*.


An account of the origin, breeding and characteristics of this cotton. It has c. 1 in. staple, lint index 5 grm., ginning out-turn 35–42%, matures early and has large bolls and high yield, but the lint is coarse and the variety has very low resistance to leaf roll disease.


Part of the bulletin deals with varietal resistance to *Bact. malvacceum*. Resistance, but not immunity, was noted in some Uplands, notably varieties 1306, 2013 and 182. *Herbaceum* cottons as a group showed greater resistance, some of them being immune.


Experiments on the correlation of hair density and resistance to *Empoasca devastans*, at Lyallpur, showed that resistant varieties had short hairs with high density. There is some evidence that jassid resistance is due to some peculiarity in the leaf veins that prevents oviposition.

Lal, K. B. 1940. See Husain, M. A. and Lal, K. B.


Jassid resistant hairy varieties are resistant because the insect cannot oviposit: attention should
therefore be focused on leaf veins, the site of oviposition.


An account of the origin and breeding of X 1530, X 1730 and Lecret.


A general account covering the breeding potentialities of the existing types and outlining a scheme for improvement.

The problem is to isolate sympodial forms with the staple of the monopodial types.


715. LEAKE, H. M. 1914. A preliminary note on the factors controlling the ginning per cent of Indian cottons. J. Genet., 4, pp. 41–47.


This publication has a considerable section on the inheritance of anthocyanin pigmentation, illustrated with coloured plates.


The causes of recurrent deterioration, which is more prominent in Egyptian cotton than in any other type, are reviewed, and the methods of elimination now being pursued are examined. The conclusion is reached that deterioration in the past has not arisen from deliberate adulteration, but from the inherent
nature of the cotton plant. It is pointed out that in a plant of such complex genetic constitution as cotton, purity can only be relative; few characters are controlled by a single gene, and this is particularly so for those characters which concern quality, or which are subject to large variations as the result of environmental influences. Inbreeding by self fertilization does not lead to sterility. It is possible, therefore, to carry on, indefinitely, single lines, each derived from a single plant, judging the purity of each successive parent by the variation found in its offspring. The process is described in detail.


This report describes the experiment which led to the selection of the variety Stoneville for distribution throughout the Uele region of the Belgian Congo in the place of Triumph. Particulars of the methods of multiplication and selection are given and the report includes a description of the seed control and distribution system whereby it is hoped that the strain will be kept pure and will not suffer deterioration.


A short account of cotton improvement work is included.


"In any event the embryological situation herein described represents a rare case of polyembryony in the cotton plant."


The methods of breeding used in selecting improved types of Ishan (G. vitifolium) cotton are detailed and pedigrees of Ishan A, B, C, D, E, F and G are tabulated.


The results of using the following methods of pollination are reported: (1) normal open pollination; (2) normal self pollination; (3) normal cross pollination with foreign pollen; (4) emasculation with foreign pollen applied at 5 a.m. on day of anthesis; (5) as in treatment (4) but pollen applied at 5 p.m. on the day previous to anthesis; (6) no emasculation, corolla opened and foreign pollen applied at 5 a.m. on the day of anthesis; and (7) as in (6) but pollen applied at 5 p.m. on the day previous to anthesis. Application of foreign
pollen to the stigma of non-emasculated flowers before normal receptivity resulted in a significant increase in mean number of seeds per boll when compared with methods in which pollen was applied at the time of anthesis; it is thought that this increase is due to the stimulation of a substance or substances aiding fertilization.

   An illustrated description of G. irenaeum.

   An illustrated description of G. hopi.


   It is noted, inter alia, that Pima 32, Amsak and S x P are less susceptible than Upland types, and that of the Uplands 1517WR, Mesilla Acala, and 1517B show some tolerance.


   This stem blight pathogen, believed to be A. macrospora, causes heavy losses in G. arboreum varieties in Szechuan Province, China. The main part of this paper deals with the disease itself and its epidemiology. It is noted that in inoculation experiments, Upland (G. hirsutum) cottons proved equally susceptible with G. arboreum in early stages of growth but gradually acquired some degree of resistance.

   LOCKWOOD, E. K. 1929. See HARRIS, J. A., HARRISON, G. J. and LOCKWOOD, E. K.

   The presence of cryptic structural differences between the species G. hirsutum and G. barbadense has been observed in genetic tests. The linkage between the loci R1 (red plant colour) and cl (cluster fruiting habit) was studied in both interspecific and intraspecific backcrosses. Results of the intraspecific backcross indicated approximately 16% crossing-over, whereas, only approximately 8% of the cross-over types were observed in the interspecific backcross population. Since previous investigations indicate complete
homology for all chromosomes in crosses of *G. hirsutum* x *G. barbadense*, the absence of cross-over individuals in the expected numbers in interspecific backcrosses has been attributed to cryptic cytological differences. In view of the fact that disturbance of linkage was observed for the loci tested, no other linkage group being available for testing in the species studied, it was concluded that cryptic differences exist between other chromosomes and that this mechanism has been important in the development of the species.


The substance of this paper has already been summarized. See Lewis, C. F. and Loden, H. D. 1950.


A brief account of what is being done at Sahel and Kogoni in breeding for resistance. A range of crosses are being made and these include Sudan material carrying the genes B$_2$ and B$_3$.


An outline is given of the introduction of cottons suitable for selection work in the Niger Colony.

Details are given of an extensive hybridization programme to increase the fibre length of Allen cottons while preserving their climatic adaptation to the Niongo region. Egyptian cottons, e.g. Maarad, Sakel, X 1530 and Giza, have been crossed with lines of American types such as Allen and N’Kourala. In attacking the problem of blackarm resistance, backcrossing has been adopted and lists are given of 1946 crosses backcrossed in 1947 and of 1948 crosses in which Egyptian selections of genetically known content as regards black-arm resistance were used.

Interspecific hybridization has also been tried, using the Budi cottons, *G. arboreum* var. *cernuum* x *G. arboreum* var. *neglectum* derivatives, and amphidiploid cottons as parents. In 1948 one plant from Budi x Egyptian was obtained but remained sterile in spite of colchicine treatment. A number of selections of Allen and N’Kourala have been isolated, differing in morphology, earliness, length of flowering and harvest periods but resembling each other closely in fibre quality.


A study of pollen mother cells of a number of *Gossypium* species, in which the author also surveys and incorporates previous work. Observations are also recorded on the pollen mother cells of an Asiatic x American F$_1$ plant. Chromosome numbers are given for a limited number of plants of other genera.

738. LOVE, H. H. 1934. Directions
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In the section on varietal variation it is shown that the square period for Upland is consistently lower than that for Egyptian cottons; the period for Sea Island is still higher. The order of the varieties with regard to boll period was also rather constant, the Uplands being again the earliest. From this it is concluded that time of maturity is an inherited character and breeding for earliness should be possible.


Hairiness of the leaf is associated with insect resistance. The Punjab American types have longer hairs and thicker leaves than indigenous types but the latter have more hairs per square cm. Among the American types 1, 43, 4-F and 4-F (S) are the hairiest.


Breeding for improved quality in G. neglectum and for resistance to Fusarium has been in progress since 1923. Verum 262, developed from a cross of G. indicum x G. cernuum shows wilt resistance (inherited from G. cernuum) and improved quality.

Work on improving buri cotton (G. hirsutum) and bani cotton (G. indicum) is also dealt with.

Tinged lint in Chandra Jari (G. indicum) is due to a single gene which is almost fully recessive.


Covers the period 1846–1906.


Out of 2,000 families of hybrids examined in the autumn of 1939, only 24 plants, resulting from four interspecific combinations were found to carry bolls with fibre tinted green. Three of the combinations bore evidence that G. purpurascens was included in their ancestry; the ancestors of the fourth combination included Pima, G. hirsutum and G. barbadense. The purpose of the investigations described was to breed cottons of various colours. During successive generations originating from the 24 plants mentioned above, shades of blue, buff, yellow and pinkish-yellow, as well as green, emerged in some
of the cotton bolls. These and other characters came into being from time to time, and the author could not account for them on Mendelian principles. A decrease in vigour occurred in the F2 generation, but under the influence of external conditions and unrestricted pollination a recovery was effected. Strains of cotton then emerged in which the colours became faster and deeper, and the technological quality of the fibres approached normal standards. The chemical properties of the colours are being investigated.


Cotton cytology and genetics are reviewed. "Cyclic crossing" is recommended: for earliness all possible combinations between early, medium and late should be made in the American cottons (18 crosses), plus all combinations of two types of Egyptian (8 crosses) and of Asiatic cottons (8 crosses), thus involving 34 crosses in all. A number of other characters which should be treated on similar lines are specified.

It is noted that Olshanskii, by using high voltage X rays on germinating seeds, obtained one plant whose bolls dehisced a month earlier than the controls.


The average cross pollination for all the Upland varieties was 4·62%, 2·87% of the progeny being hybrids with plants of the adjacent row and 1·84% with other plants.


MANKAD, D. P. 1926. See PATEL, M. L. and MANKAD, D. P.

MANN, H. H. 1928. See PATEL, M. L. and MANN, H. H.


Maintenance and Improvement of V 135.—In 1926 seed from a representative plant of V 135 was taken to Trinidad, where it has been propagated by graft since 1928. This season ten V 135 progenies were grown in a family block layout with ten selections from seed of this graft. Results indicated substantial increase in seed cotton and lint per boll, lint length, and seed cotton per plot in favour of the new V 135 strain.

Sea Island Hybrids.—The randomized progeny row technique was employed for the first time with the V 135 Montserrat hybrids, and the results showed large increases over V 135 in seed cotton characters often combined with a superfine lint length.

MANNING, H. L. 1943. See HUTCHINSON, J. B. and MANNING, H. L.

MANNING, H. L. 1945. See HUTCHINSON, J. B. and MANNING, H. L.

MARALIHALLI, S. S. 1931. See KOTTUR, G. L., MUNDKUR, B. B. and MARALIHALLI, S. S.
COTTON BREEDING AND GENETICS

A correlation between hairiness and jassid resistance is recognized, but not all hairy plants were resistant. Even glabrous plants withstand attack under certain conditions. Mass and individual plant selection have yielded the strains 41J and Miller respectively. Hybridization of U4 with Queensland cottons has produced promising material.

An account of the diversity of characters in the perjugate (second generation) hybrids of Hindi x Egyptian.

Differences of pollen grain size are characteristic of different varieties of cotton.
No correlation apparently exists between chromosome number and size of pollen grains.
The F1 hybrid shows the pollen dimensions of the large pollen parent.
The variation in the size of pollen from different varieties is continuous, from 108 to 135 microns.


Deals with selection work in São Paulo, mainly in stocks of Express and Texas Big Boll. Piratininga 086 was derived from Texas Big Boll and the variety 21077 came from Express.

Descriptions and origins are given of a number of varieties produced at the institute. The breeding methods used are described.

The technique of artificial selection used in cotton breeding is described. Earliness, vigour, yield and disease resistance are the characters on which field selection is based, boll size and weight, lint percentage, length and index, and seed weight being determined in the laboratory. Selection is always carried out in the locality for which the new varieties are designed.

759. MASON, T. G. 1922 a. Growth and abscission in Sea Island
COTTON BREEDING AND GENETICS


760. **MASON, T. G.** 1924. See **MARTIN, R. F.** and **MASON, T. G.**

760. **MASON, T. G.** 1925. See **LEWIN, C. J.** and **MASON, T. G.**


Emphasis is placed on primary selection, and the possibility of increasing the variability of the initial stock is discussed.


A short note on the early history of cotton in Egypt and the Sudan. The earliest literary reference to the use of cotton for textiles, known to the author, is given by Herodotus, *450 BC*. The first good description of the plant is given by Theophrastus, and literary evidence is sufficient to show that cotton was well known in antiquity in India, the Persian Gulf and Ethiopia.


Describes *G. paolii* and *G. benadirense*.


The author reaches the conclusion that the tetraploid cottons originated at a very distant period, probably long before being taken into cultivation. The extreme genetic differences that exist between the individual species of the tetraploid group suggest that they arose independently from crosses between the South American group (*G. barbadense* L.) and the Central American group (*G. hirsutum* L.).
COTTON BREEDING AND GENETICS

different diploid species; their geographical distribution supports this view. None of the existing diploid species has chromosomes that are homologous with those of any tetraploids and it seems clear that at the time when the tetraploid species arose the whole specific composition and distribution was quite different from those of the present day, and that the original parent species no longer exist.

In an attempt to throw light on the subject various crosses were made as follows: (1) F₁ G. arboreum x G. thurberi was crossed with G. arboreum and selfed in the hope of producing triploids and amphidiploids: the resulting hybrids were also crossed with G. barbadense; (2) F₁ G. barbadense x G. thurberi was crossed with G. arboreum and G. herbaceum; (3) F₁ G. barbadense x G. armouri-anum and F₁ G. hirsutum x G. armouri-anum were crossed with G. herbaceum and G. arboreum.

In the cross (G. barbadense x G. thurberi) x G. arboreum six hybrids were obtained, three being highly fertile and three partially so. One plant was particularly fertile, vigorous and abundant in flower and fruit production; its flowers strongly resembled those of G. barbadense in colour and size, except that the stamen filaments were somewhat longer. The pollen was copious, large, yellow in colour and almost all perfect as judged by acetocarmine. The plant itself also resembled G. barbadense, the leaves being somewhat more dissected, and the bolls were almost identical with those of the wild forms of that species. The seeds were small, very slightly pubescent, with fine soft lint, very strong and up to 45 mm. in length. Meiosis in the hybrid was regular and 26 closed bivalents were present; it had clearly arisen from an unreduced egg cell of the female parent and contains the full genomes of all three species, thus \( (G. \text{ barbadense} + G. \text{ thurberi} + G. \text{ arboreum}) = 26_1 \). In the first metaphase 13 small and 13 slightly larger bivalents could be distinguished; it thus supports Skovsted's conclusion that G. barbadense consists of one chromosome set of G. thurberi and one of G. arboreum, or at least species of which these are the nearest surviving relatives. This view is supported too by the genetic behaviour of the hybrid G. thurberi x G. arboreum e.g. the dominance of the glabrous stem and leaf, the extrafloral nectaries and absence of fused bracts, all characters of G. thurberi, and of the wide cordate leaf, dentate bracts, internal nectaries, yellow petals, stamens and pollen, clearly defined petal spot, pitted and glandular nature of the bolls characteristic of G. arboreum.

This combination of characters is strongly reminiscent of G. barbadense. It is possible that the original form differed from the present day G. thurberi in having yellow flowers and less dissected leaves with broader lobes, in these respects being somewhat more similar to G. armouri-anum or G. harknessii, and may in fact have been the forbear of these three species, which are undoubtedly altered in both distribution and genetic constitution. It is to be expected that amphidiploids of G. arboreum x G. thurberi if obtained would fit into the existing species G. barbadense and serve to extend its range of variation; they might hence be of great practical breeding value, for instance the introduction of characters such as
the earliness, resistance to gummosis, and tolerance of *G. arboresum*, and the cold resistance, resistance to wilt and gummosis, vigorous root system and prolific fruiting of *G. thurberi* into *G. barbadense* would create immense possibilities in the improvement of this species.

Other triple hybrids of the type referred to above are expected to have a similar practical interest.


Reference is made to the possibility of obtaining jassid resistant strains of cotton in Queensland by selection from varieties already being cultivated, in addition to the initiation of a breeding programme to develop resistant varieties.

MAYANDI PILLAI, S. 1949. See BALASUBRAHMANYAN, R., SANTHANAM, V. and MAYANDI PILLAI, S.


768. McCLELLAND, C. K. 1930. The genetics, breeding and improvement of corn and cotton. (Published by the compiler).

There are 24 pages of cotton references covering the period 1863-1929.


Pollen of Half-and-Half cotton was X-irradiated overnight then used on Half-and-Half. The number of seeds set was markedly reduced. Of the 21 plants raised only 10 were fertile, 3 of these had abnormally large seeds, others had naked or partially naked seeds.


Summaries of investigations conducted in Egypt prior to 1918 are given under the topics of methods of investigation, origin and history of Egyptian cotton, descriptions of modern Egyptian cottons, heredity, cross fertilization, selection, physiology, cytology, mycology and general accounts. The second part deals with papers omitted from the first list.


McLACHLAN, A. 1909. See COOK, O. F., McLACHLAN, A. and MEADE, R. M.


1.94% of natural crossing occurred in rows of red-leaved Upland alternated with green-leaved; none where plants were netted.

The following F2 ratios were obtained:—

Leaf colour: Red Upland x green Upland gave 963 red : 2615 intermediate : 1036 green. Three green plants bred true in the F3, eight intermediate plants

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showed segregation in the F₃ and three red plants bred true.

Leaf segments: Sea Island (narrow) x Upland (broad) gave 319 narrow : 622 intermediate : 283 broad.

Red-leaved Upland x okra-leaved Upland gave 268 reddish and narrow or intermediate : 81 red and broad : 111 green and narrow or intermediate : 38 green and broad.

Petal spot: Upland (no spot) x Sea Island (red spot) gave 736 spotted : 413 spotless.

Petal colour: Sea Island (yellow) x Upland (white) gave 986 yellow and intermediate : 160 white. Red Upland x green Upland gave 281 reddish : 66 white.

Boll shape: Big-bolled Upland x Sea Island gave 301 long and narrow + intermediates : 129 short and wide. Toole (Peterkin small-bolled group) x Sea Island gave 217 long and narrow + intermediates : 53 short and wide.

Boll surface: Sea Island (pitted) x Upland (smooth) gave 1047 pitted + intermediates : 114 smooth.

Seed fuzziness: Sea Island (smooth) x Upland (fuzzy) gave 663 fuzzy : 376 smooth.


Three semilethal abnormalities, designated HA 1, 2 and 3 are described and illustrated in Upland cotton. Each comprises a mixture of dwarfing and malformation and each depends on a single gene with partial dominance. The genes controlling H.A. 1 and 2 are nonhomologous. HA 1 and 3 are inherited independently of red plant colour and okra leaves.

MEADE, R. M. 1909. See COOK, O. F., McLACHLAN, A. and MEADE, R. M.


Records the occurrence of long whitish bodies in the centre of bolls between the placentae. In some cases these contained rudimentary seeds with fibre attached.


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Treatment of buds of cotton plants with mixtures of lanoline and colchicine was unsatisfactory. The most effective treatment consisted of immersing cotton seeds in 0.15% colchicine solution for 16 hours. In this way a doubled herbaceum \( (2n = 52) \) and a doubled \( G. hirsutum \) \( (2n = 104) \) were obtained.


The most effective treatment for bringing about chromosome duplication consisted in soaking delinted seeds in a 0.15% colchicine solution for about 16 hours. Octoploid plants \( (2n = 104) \) of \( G. hirsutum \) formed quadrivalents at division I but anaphase I was regular, 52 chromosomes going to each pole. Anaphase II was also regular.


Immersion of delinted seeds in a 0.15% solution for 16 hours was the most effective treatment and although plants of \( G. hirsutum \) sometimes failed to react, in \( G. herbaceum \) all plants reacted equally. Roots of the abnormal looking plants of \( G. hirsutum \) often contained a mixture of \( 2n = 52 \) and \( 2n = 104 \) tissues; flowers with mixed tetraploid and octoploid tissue were also encountered.

At anaphase I in the octoploids 52 chromosomes generally went to each pole but deviations were occasionally observed. Secondary association was frequent. Pollen formation was more or less normal, but the anthers mostly failed to dehisce. The pollen was larger and more variable in size than in normal plants. No seed was obtained either from self pollination or from cross pollination with either octoploids or tetraploids. Occasional fruits were formed from open pollination; the seeds obtained, which were usually abnormally large, could often be induced to germinate only by incision of the testa. The plants produced frequently had \( 2n = 52 \) chromosomes.

MENZEL, M. Y. 1950. See BROWN, M. S. and MENZEL, M. Y.


Gives a detailed historical account of breeding in Algeria, Tunisia and Morocco.


The beneficial effect of intra-varietal hybridization was most marked when varieties of different origins were used in the crosses. These effects included: a greater number of bolls per plant, more seed per boll, longer lint and a higher lint yield. Natural cross pollination gave better results than hybridization of emasculated plants.

MIKHAILOVA, K. A. 1936. (The morphology of cotton chromosomes). Résumé Results Objects
COTTON BREEDING AND GENETICS

(Abst. from Plant Breed. Abstr., 8, p. 50).

The karyotype of all the Old World cottons examined was substantially the same. The 52-chromosome cottons contained 26 larger and 26 smaller chromosomes, though no such clear difference as was observed by Skovsted could be detected; moreover in G. barbadense and G. hirsutum the satellites characteristic of the Old World group were absent, though they were found in G. hodi. The variety Navrotskii was different from other members of the species G. hirsutum examined in having two large satellites with a constriction.


The chromosome morphology of the 52-chromosome New World cottons agrees approximately but not exactly with the hypothesis that they are amphidiploids derived from the Old World cottons and the 26-chromosome wild American species. Skovsted's division of the New World cotton chromosomes into 26 larger and thicker and 26 smaller and thinner is confirmed, though it is stated that the distinction is not absolute and that the difference in thickness cannot be measured.

786. MILES, L. E. 1939. Some tests of varietal susceptibility to a combination of root-knot nematode (Heterodera marioni) and wilt (Fusarium vasinfectum) at the Mississippi Agricultural Experiment Station, the highest degree of resistance to both organisms was shown by Cleve-wilt 6, Cook 144-68, Cook 307, Dixie Triumph 55-85, Toole (Perry), Sykes WR, Dixie 14-5 and Dixie Triumph 12, the average percentage of fungal infection amounting to 18-53 as against 30-61 and 79-92 in the intermediate and susceptible groups respectively. Of 14 exotic varieties and hybrids, one strain of Sea Island (13B3) remained free from wilt throughout the experiment, while another (Andrews) showed 9-61% infection. Similarly, one strain of Hopi (Sacaton 6, No. 2) contracted only 9-73% infection, while another (M-34-6-2, No. 6) was 100% diseased. The average incidence of wilt in the resistant group of exotic varieties was 13-20 as against 87-18 in the susceptible. Except for Sea Island 13B3 all the foreign varieties were liable to nematode infestation, which was particularly severe in the wilt susceptible group.


A detailed account of the methods used and of the results obtained. Cross pollination ranged from 2-10% over the years studied.


Various degrees of jassid resistance were noted in work at.
Barberton, ranging from the full susceptibility of Watts Long Staple to the complete immunity of Cambodia.

Resistance was found to be hereditary and closely correlated with plant hairiness.

MOGFORD, J. S. 1927. See HUMBERT, E. P. and MOGFORD, J. S.


One section of this deals with the effect of X rays on Sea Island cotton: fasciation, failure of terminal bud to develop, changes in leaf form and dwarfing were the main effects produced.

MOORE, E. J. 1941. See GOLDSMITH, G. W. and MOORE, E. J.


A comparison of mass-selfed with open pollinated (in isolation) Upland cotton over a period of 3 years showed no difference between the two. It is concluded that registered varieties do not “run out” as regards lint length unless contaminated.


A popular account of laboratory methods for measuring dimensions, strength, maturity and uniformity of raw cotton in connection with the work of the plant breeder. Staple lengths and fibre diameters are recorded for various strains of Acala, Rowden, Farm Relief and Coker-Cleveland cottons of the 1943 and 1944 crops to show the differences due to inbreeding. Two strains of Acala cotton, 1943 crop, are compared for fibre diameter, staple length, fibre weight per inch, and percentage thin-walled fibre.

MORELAND, C. C. 1916. See EDGERTON, C. W. and MORELAND, C. C.


Comparative trials of resistance of *Gossypium hirsutum* varieties to gummosis and *Verticillium* wilt at the Azerbaijan Scientific Research Institute of Agriculture are reported. The varieties tested were 8517, S–3173, 1306–DV and 108–F, all being obtained from both Uzbekistan and Azerbaijan.

The trials showed that the plants of the same variety grown from seed originating from Uzbekistan were less susceptible to gummosis but more susceptible to wilt than cotton from seed reproduced in Azerbaijan. Reference is made to similar but more striking results with *G. barbadense*.

The experiments showed that the Uzbekistan varieties in the first and second seed generations had acquired a higher degree of resistance to wilt, but had become more susceptible to gummosis.
The effect of external conditions upon varietal seed properties is illustrated by the example of 108 F, which had a higher seed weight when grown under Tashkent conditions than when it was grown at Kirovobad.


Deterioration is attributed to indiscriminate mixing. The isolation of superior strains and dissemination of pure seed, with safeguards against contamination, are recommended.


Mudaliar, V. R. 1947. See Balasubrahmanyan, R., Mudaliar, V. R. and Jagannatha Rao, C.

Mudaliar, V. R. 1948. See Dharmarajulu, K., Seshadri Ayyangar, G., Mudaliar, V. R. and Balasubrahmanyan, R.

Mudaliar, V. R. 1950. See Balasubrahmanyan, R., Mudaliar, V. R. and Santhanam, V.

Mundkur, B. B. 1931. See Kottur, G. L., Mundkur, B. B. and Maralihalli, S. S.


Homozygous lines representing extremes of lint length and consisting of two lines of Half-and-Half, two of Wilds, one strain of Ambassador and one of Meade were crossed in all possible combinations. The following conclusions were reached from a study of the $F_1$, $F_2$, $F_3$ and backcross progenies. The degree of dominance varied from below intermediacy to approximately an intermediate condition. Heterosis was not an important factor in expression of lint length. Differences between direct and reciprocal crosses were of little or no significance. The two strains of Half-and-Half possessed the same factor for lint length. Ambassador may have had an extra minor factor for lint length. The three long-linted parental types, viz. the two lines of Wilds and the Meade line, appeared to have the same primary genes for length of lint. Four or possibly five genes seemed to be involved in lint length, of which two or three may have major effects. The smoothness of the fibre length curves for the $F_2$ generations and the absence of any marked skewness indicated that the major factors for lint length were approximately equal in their effect. The tendency towards negative skewness suggested, however, that some of the genes for lint length may have interacted in a cumulative manner.
NADKERNY, N. T. 1947. See GADHAR, P. D., DEO, K. G. and NADKERNY, N. T.
NAGAI, T. 1942. See ENOMOTO, N. and NAGAI, T.


Cross pollination was 5.22% in rows of green-leaved cotton adjacent to a strip of red Upland. This diminished rapidly with increased distance. Spatial isolation is calculated to be thoroughly reliable at 1 km, though isolation of 15 m has given practically satisfactory results.


Vicinism ranged from 4% to 9%, being least in varieties with spreading, branching habit.


Experiments on hybridization between G. herbaceum and New World cottons (G. hirsutum and G. barbadense) are described. Crosses were obtained using a New World cotton as the female parent. The F₁ hybrids showed marked heterosis but were sterile (both self and backcross). Cytological studies of pollen mother cells showed that the chromosome behaviour in meiotic division was quite irregular. The perfect sterility of the F₁ hybrids was found to depend on the formation of abortive germ cells.


By line selection of an early maturing Upland cotton, King's Improved, at Kanto-syu Agricultural Experiment Station, the new line, Upland Cotton Kanno l, was obtained. It matures much earlier and is more productive than the parent type. It was thought most promising for southern Manchuria.


The selected strains obtained from a cross between a Manchurian cotton and a variety from southern China are illustrated. They mature early like the native cotton, which they surpass in ginning percentage and staple length.


An F₁ plant from the Egyptian Asimouni (n = 26) x a Manchurian variety (G. herbaceum, n =...
bore no seed when selfed, but on being pollinated by King's Improved (G. hirsutum, \( n = 26 \)) gave a few seeds. A plant raised from among these flowered abundantly and was partly fertile when selfed or crossed. It has \( n = 26 \) chromosomes.


After seven years the author obtained six \( F_1 \) plants from the cross King's Improved (New World) x Manchurian Black (Old World), and one \( F_1 \) from Egyptian x Manchurian Black. On pollinating the latter with King's Improved, two seeds were obtained, one of which developed, the plant flowering and setting fruit. Its chromosome number was \( n = 26 \), and it was partially fertile, with about 10% fertility on self pollination and about 20% when pollinated with King's Improved. Nineteen offspring were obtained in all, six from self pollination and 13 from the backcross. The plants varied a great deal in all characters.


A detailed account of experiments on colchicine treatment of seeds and seedlings of Asiatic and Upland varieties of cotton to produce polyploids. The cytological behaviour of one polyploid plant (\( n = 26 \)) is described.


Under cotton, pronounced varietal differences in resistance to anthracnose are noted.


A full description of cotton wilt (*Fusarium vasinfectum*) is given, with a review of the literature on this subject. The disease is said to cause an average annual loss to the United States cotton crop of over 350,000 bales.

Tests of wilt resistance have been carried on for a number of years at the Mississippi Agricultural Experiment Station. In 1926, the most promising long staple varieties were found to be Lightning Express, Watson and Super Seven, while among the short staples Rhyne's Cook, Dixie Triumph, Cleveland 54, and Solomon's and Oates' Big Boll gave encouraging results.

811. Neal, D. C. 1935. Wilt-resistant cottons adapted to the Gulf
Survey the resistance to Fusarium of a large number of Upland strains; Pima and Sea Island proved immune.

Deals with Delfos 2323-965-425.

The maximum degree of resistance to cotton wilt (Fusarium vasinfectum) in the Louisiana trials of 1939 were (in the order named) Delfos 925-425 (with only 0-4% infection), Dixie Triumph 66-366, Deltapine 12, Dixie Triumph 85, Dixie Triumph 62 x D and PL 10-44-531-62 and Miller 610, of which Deltapine 12 was the highest yielder and Dixie Triumph 85 the lowest; the highly susceptible Half-and-Half showed 87% infection. Stoneville 3-68, though moderately susceptible (25-5% infection), ranked third in the production of seed cotton.

The percentage infection by Fusarium vasinfectum and the yield of seed cotton are shown for eight new strains and three F1 hybrid lines grown in a wilt resistance test in comparison with the susceptible variety Half-and-Half. The infection ranged from 0-4% for Delfos 925-425 to 87% for Half-and-Half. Deltapine 12 gave the highest yield, while ranking third in resistance.

A cleistogamous mutant occurred in the F2 of a G. hirsutum x G. barbadense cross.


Gives confirmation that red (R10) and cluster (cl) are controlled by single genes with a cross-over value of about 18-5%.

The monofactorial nature of green lint is confirmed and green lint and low lint index are shown to be very closely associated. This reduction of lint index by
the green lint gene is regarded as
spurious pleiotropy: the green
gene affects the pigment of the
fibre wall and in turn the pig­
mentation prevents proper devel­
opment of the fibres so that they
have thin walls.

Neely, J. W. 1943. See Conrad,
C. M. and Neely, J. W.

821. Newcombe, H. B. 1939. A
note on the relation of Gossypium
raimondii Ulbrich to other Ameri­
On morphological grounds, the
author considers G. raimondii to
be nearer to G. hiltzschiamum and
G. davidsonii than to G. aridum
and G. harknessii.

on cotton (Gossypium species),
with special reference to cotton
as a crop in Peru. Inst. Inter­
Amer. Affairs, Peru, 58 pp.
(Mimeographed). (Condensed
from Plant Breed. Abstr., 19,
p. 345).

Part I reviews the classification
of world cottons and the origin
and distribution of wild and
cultivated cottons. Part II pro­
vides an account of the Gossypium
barbadense cottons and the
Peruvian cottons, including the
wild species G. raimondii and the
cultivated cottons Pais and
Tangüis (G. barbadense); litera­
ture on the origin of Tangüis is
summarized. Part III deals
with the history and present
status of cotton growing in
Peru. An account of the improve­
ment of Tangüis and Pima is
included.

823. Novikov, V. A. 1936. (Germi­
nation of cotton in salt solutions
of different concentrations).
Résumé Objects Res. Wk. Cent.
Br. Sta. Soutznikh Tashkent,
p. 72. [Russian]. (Abst. from

The cotton plant is most
sensitive to salts at the time of
germination and by germinating
in van't Hoff-Richter solutions
of varying concentration it was
possible to find salt resistant
forms in all the main cotton
species.

824. Novikov, V. A. 1941. Causes
underlying bud and boll shedding
in cotton and means to control
it. C.R. (Doklady) Acad. Sci.,
In discussing the breeding
aspect of the problem, the author
suggests that in breeding for non­
shedding, special attention should
be paid to forms in which trans­
piration, rate of photosynthesis
and the formation of vitamins
are high, and the selected forms
must also be characterized by
high suction pressure of the bud
and bolls, and by a well developed
root system such as is found in
the Egyptian varieties.

825. Novikov, V. A. 1943. (Investi­
gations on the salt resistance of
307–331. [Russian]. (Abst. from
Plant Breed. Abstr., 15, pp. 149–
150).

Cotton plants belonging to
several varieties were grown in
soils of different degrees of
salinity. The physiological and
other reactions of the plants
were observed. The yield and
general condition of the plants
deteriorated as the salinity of the
soil increased, but the plants
acquired succulent characters and
showed a certain capacity to
adapt themselves. During the
germinating stage they were least
immune to the ill-effects of
salinity; therefore breeders who
seek to adapt cotton to saline
soil must produce varieties which
can withstand salinity at this
particular stage of growth; higher degrees of salinity can be tolerated as the plants grow; those which withstand it best when seedlings withstand it best when fully grown.

The following varieties proved to be capable of surviving high degrees of salinity: *Gossypium barbadense* 670, the germination of which was 74% at 0·4 normal salinity; and the local Asiatic (*G. herbaceum*) and Indian (*G. neglectum*) cottons. These may be of use for hybridization. Only 7 of the 37 American cottons (*G. hirsutum*) were found to withstand salinity up to 0·4 normal.


Salt tolerance was reduced by short day length. This reduction in salt resistance was associated with lowered organic substances within the plant. It is suggested that salt resistance should increase with increased photosynthesis of the plant.


On the genetic side, significant correlations were obtained between ginning outturn of parent and progeny, and also of lint length of parent and progeny. The correlation for yield, though positive, was not significant. Naked seed, from a short-stapled variety was dominant, giving 3 : 1 segregation in the F₂. The factor for naked seed, if brought in by a Sea Island parent, was recessive.


Where segregation was sufficiently clear cut to give definite indications, it appeared that lint percentage was controlled by a single factor pair.

In crosses between species and crosses between Upland strains where the percentage differences were narrow, it was not possible to determine definitely the nature of the segregation. Where segregation was definitely evident, high percentage was partially or entirely dominant.


No significant correlation was found between yield of parent and yield of progeny, nor between parent yield and progeny ginning outturn. Parent yield seemed slightly negatively correlated with progeny staple length. Parent ginning outturn showed weak positive correlation with progeny yield, and weak negative correlation with progeny staple length. Parent and progeny ginning outturn showed strong correlation. Parent staple length seemed to be slightly negatively correlated with progeny yield and somewhat more strongly negatively correlated with progeny ginning outturn. Parent staple length was strongly correlated with progeny staple length.

Thus it is justifiable to discard, without planting, those selections which are undesirable in lint percentage or staple length.
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Deals with the varieties Empire and Lankari-57.

In 1934, lint length measured in 42 F4 plants from the cross Pioneer 915 x Schroeder 1306 varied from 20.0 to 26.0 mm. Selection was repeated each year and raised the mean lint length to 31 mm., with variations from 28 to 35 mm., by 1940.


Classifications of Gossypium are reviewed, and that of Harland is said to accord best with the author’s experience of cotton in Persia, India, Burma, Siam, Cochin China, Korea and Japan.


As a result of continued selection of wilt resistant varieties, Sea Island is now grown in regions which had been practically abandoned owing to wilt. In general, Uplands seem less resistant to wilt than Sea Island, and Egyptians are more resistant than any of the others.

Includes a popular account of work in progress in breeding for resistance to Neocosmospora vasinfecta.


Deals with wilt resistance in cotton.


Successful breeding depends on the wealth of diversity of the original material. For this reason a collection has been built up
embracing all the diversity of all cotton growing countries
Among the material collected are varieties which under the conditions of Central Asia show no boll production until advanced autumn. Over 500 specimens of these are under investigation and they possess a great number of very valuable characters. Some of these individuals have large bolls weighing up to 8 grn. Early ripening Egyptian types with bolls weighing 3–3.5 grn. have appeared. Many of the late types have proved highly drought resistant, suitable for poor soils and resistant to a variety of diseases. A number of methods of inducing flowering in late types have been tried.

Grafts were made of Gossypium hirsutum (Upland) and G. herbaceum. Alterations were observed in both scion and stock, in vegetative characters, fruit characters and in the type of lint. Three flowers of the scion were pollinated with pollen of the stock and two normally developed bolls were obtained, both containing normally developed seeds. Three flowers of the reverse cross produced one boll. All the bolls contained a number of unfertilized ovules.


Resistance to root rot (Macrophomina sp.) is associated with a long tap root, few laterals in the first 15 cm of soil and profuse branching below 15 cm.

A statistical study of quantitative inheritance of staple length relating to F2 and F3 progenies of interstrain G. arboreum crosses.

A statistical method for the study of quantitative inheritance is described. [The experimental material consisted of staple lengths in the F2 and F3 of interstrain G. arboreum crosses]. On the basis of information obtained from F2 and F3 progenies, hypothetical genetic models are set up to represent the genetic constitution of the character concerned. The statistical consequences in the population corresponding to these models are then worked out with the help of cumulant and moment functions for the joint distribution of three variates, the F2 phenotypic value, the mean value of the F3 progeny and the genotypic variance within the F3 progeny. These functions provide the materials for expressing certain properties of F3 progenies in terms of F2 phenotypic values. The properties studied are (1) the mean value, (2) the genotypic variance, (3)
the covariance between (1) and (2), (4) the variance between means of progenies and (5) the variance of genotypic variance within progenies. Their mean values for progenies of a selected set of F2 phenotypes can be calculated by integrating the expressions for these properties over the F2 distribution, between the limits determined by the degree of selection applied.

Some further applications of the method are discussed.


The questions arising in the effort to secure progressive improvement by selection are closely linked with the study of the genetics of quantitative characters. The paper deals with some of the simpler consequences of Mendelian inheritance applied to quantitative characters, as very little is known about the more complex ones. Heritable variability can be considered as made up of two components, one arising from the additive action of the genes, and the other from other nonadditive interactions, and it is the former that is most relevant to selection work. Methods are discussed for separating heritable from nonheritable variance. Crosses between parents differing only slightly may give as much variability as between those with a large difference.


A discussion of the application of statistical principles to the layout of field tests and the examination of results in progeny row breeding. This involves a considerable amount of labour, but is amply repaid by providing an objective procedure for selection thereby increasing its effectiveness.


A discussion of the problem from the statistical angle in relation to work on G. arboreum.


It is concluded that the discriminant function, as studied here, does not provide a method of making more efficient selection for yield than the plant yield itself. Attention of breeders is drawn to the suggestion that in so far as replicated progeny row trials are concerned, selection of plants should be made from all replications on the basis of deviations of individual plant values from the respective plot means.


The distribution of these types
in northeastern India is given and the Lushai Hills are shown to be the region of greatest variability.

PARNJAPE, V. N. 1944. See RAMIAH, K. and PARNJPE [PARNJAPE], V. N.


A survey of hairiness in the varietal collection at Indore.

PARNJPE, V. N. See PARNJAPE.

PARNELL, F. R. 1917. See HILSON, G. R. and PARNELL, F. R.


Gives information on jassid resistance of cotton varieties in South Africa.


Work was started in 1924-25 on the following material: (1) the chief varieties being grown in the Union, (2) several types from USA and one from India, (3) several strains of Improved Bancroft and Meade, and (4) some 50 single plant selections from Zululand Hybrid.

Both Zululand Hybrid and Improved Bancroft, the two varieties most widely grown in the Union, were found to vary enormously, "good, bad, and indifferent plants being hopelessly mixed."

Attention is drawn to the connexion between jassid resistance and hairiness. The types grown are arranged in descending order of jassid resistance as follows: Cambodia (immune), Z1, Uganda, Improved Bancroft, Zululand Hybrid, Griffin, Watt's Long Staple (fully susceptible).

"It may be noted that all the resistant plants are distinctly hairy, though all hairy plants are not necessarily highly resistant."


The original U.4 plant was selected in 1924-25 season from a type called Uganda, the origin of which was obscure, but which was very mixed.


A general account of the subject. Pest avoidance is exemplified by the use of long duration varieties to avoid an early American bollworm attack; of early varieties where late crop is normally attacked by stainer (plateau area of South Africa) or of late varieties to avoid an early stainer attack (e.g. Ishan in southern Nigeria).

True resistance is exemplified by jassid resistance and it is noted that Gwynn in Uganda has recorded differences in varietal susceptibility to Helopeltis and Lygus.


A close and consistent relationship has been found between degree of hairiness of the under
surface of the leaf, and degree of resistance to jassid (*Em*poasca fa*ci*alis). Without exception, all thoroughly hairy types have been found highly resistant, and all nonhairy types fully susceptible. Intermediate degrees of hairiness are associated with intermediate degrees of resistance.

The relationship has been found to hold good between varieties and between plants within varieties, of the species *G. hirsutum*; also between plants of *G. barbadense*, and in segregating progenies of hybrids between these two species.

The hairiness of resistant strains of cotton has been found to develop gradually with the growth of the plants; the first few leaves on the seedlings being virtually nonhairy. This lack of hairiness in the early stages of growth is associated with a lack of resistance. Hairiness and resistance to jassid develop concurrently.

Length of hairs is shown to be of prime importance, and high densities without adequate length are ineffective.

The relative importance of hairs on lamina and midrib has not been conclusively determined. Both have an influence on resistance but a high degree of midrib hairiness is not essential if the lamina is hairy.

Hairs on stem and petiole are shown to be of very little direct importance.

Parr, A. E. 1911. See Leake, H. M. and Parr, A. E.

Patel, A. F. 1937. See Panse, V. G. and Patel, A. F.


At the cotton-breeding station at Jalgaon in Bombay Province, selection work in the Verum strains has resulted in a wilt resistant strain, Jarila, which is far superior to the local NR cotton. It has white, shining lint of 4 in. staple, and spins 30 counts against 7 counts for NR.


Apart from two areas which grow varieties of *G. arboreum*, Gujarat is all under *G. herbaceum* var. *frutescens*, the principal varieties being Surtre-Broach, Goghari and Wagad. The steps taken to isolate and improve types of superior merit are reviewed. Recent importations have been made of *G. herbaceum* from Russia and Iran to form additional sources of variability.


The following characters were shown to be monogenic recessives: (1) yellow/white flower, (2) 3–4 boll loculi/4–5 loculi, (3) linted
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Ghost spot and cluster are linked, the cross-over value being 30%. The lintless naked and lintless fuzzy genes are complementary, giving linted fuzzy in the F₁, and the F₂ linted fuzzy (9): lintless fuzzy (3): lintless naked (4); the double recessive is phenotypically indistinguishable from lintless naked.


Autopolyploids from diploids and amphidiploids are generally sterile. Doubling sterile allotriploids of cultivated New World x cultivated Asiatic cottons gives fairly fertile hexaploids which, though not economically useful by themselves, are of value for the synthesis of an allotetraploid of the genomic constitution of New World cottons.

The fact that some of the first backcrosses of (cultivated New World x cultivated Asiatic) x cultivated New World cottons are of the genomic constitution of the New World cottons, and are also chromosomally balanced, gives scope for combining desirable characters of the two groups of species.


Some of the backcross plants of \(G. \text{ hirsutum} \times G. \text{ arboreum}\) or \(G. \text{ herbeaceum}\) x \(G. \text{ hirsutum}\) are fully fertile and chromosomally balanced, with the genomic constitution of American cotton. Breeding from these backcrosses has resulted in the synthesis of types, possessing staple length or/and ginning outturn surpassing the original parents. Some of the backcrosses have responded well to selection for yield, so that they have come up to the level of locally adapted Asiatic cotton.

Further crossing to American cottons has given types with very high ginning outturn (41%) or extra long staple (1.15 in.), the latter showing better growth than the ill-adapted, unhealthy and poorly growing long-stapled American cottons. Derivatives from certain backcrosses show better thrip resistance than the American cottons.

Under Sural conditions, American cottons, as also most of the derivatives from the backcrosses of (American x Asiatic) x American, are very susceptible to thrip attack. There are indications of the possibility of getting types with healthy foliage (including thrip resistance) and with normal economic characters, from the derivatives of the synthetic tetraploid obtained from the cross of \((\text{Co.2} \times 1027 \text{ AL1})\) doubled x \(G. \text{ armatorianum}\), or from crossing it with American cottons. Such a possibility is also indicated in crosses involving \(G. \text{ anomalum}\).

Transferring the leaf hairiness of \(G. \text{ tomentosum}\) to \(G. \text{ hirsutum}\) (Co.2) background by backcrossing gives derivatives which are much more hairy than Co.2 (the hairs being not so short as in \(G. \text{ tomentosum}\)), showing good jassid resistance and possessing characters conducive to drought resistance. The staple length, however, is adversely affected.

Exotic cottons belonging to *G. barbadense*, *G. purpurascens*, *G. hirsutum* and *G. thurberi* are susceptible (in descending order) whereas some Indian cottons of the *G. herbaceum* and *G. arboreum* groups are highly resistant.


In the Gujarat Section, selection BD 8 has shown high wilt resistance, but its ginning percentage is comparatively low and it has been replaced by Vijay. Recently (BD 8 x Ghogari) x BD 8 and Vijay x 1027 ALF, with desirable agronomic characters and wilt resistance, have been developed.

Jarila was obtained by field selection in the Khandesh Section and crossed with 197-3; the cross shows great promise. Dokras and Verum selections have been crossed with 197-3, to combine their wilt resistance and desirable agronomic characters. The high wilt resistance of New Million Dollar appears to be linked with its unfavourable agronomic characters.

At Poona, the highly wilt resistant selections Gaorani (6838-2-6-10 and 6107-11-4-5-7 have been evolved.


All foreign cultivated cottons proved susceptible to *Xanthomonas malvacearum*, *G. barba-

dense* varieties being most susceptible of all. Sudan BAR 7/8 (*B₂ B₃* Upland) retained its resistance. Russian, Persian and Baluchistan varieties of *G. herbaceum* were susceptible. Indian cottons with very few exceptions showed high resistance.


In Part I, the various types of cotton grown in Gujarat are described and especially Goghari—a *G. herbaceum* characterized by its roughness, short staple and high ginning outturn.

Part II deals with the *G. herbaceum* variety, Broach-Desi or Lali. A critical consideration of the environment, mainly climatic, of Gujarat cottons is included.


Covers history and characteristics of Wagad (*G. herbaceum*) and gives an account of inheritance studies in plant, boll, seed and lint characters.

In crosses between Broach-Desi and Goghari (both G. herbaceum) the nodal position of the first sympodium, boll diameter, boll shape, staple length, seed weight and lint index all appeared to be inherited in a complex manner. Factors determining boll shape seemed to be closely linked. In some cases ginning outturn was negatively correlated with lint length.


The three important factors influencing the expression of wilt are rainfall, soil temperature and the degree of soil infestation by the wilt pathogen. It is possible, to a large extent, to create a uniform spread of the wilt fungus by continuous growth of a 100% susceptible variety on the same field for a number of years, and also by adding wilt compost. Even so, varying rainfall and soil temperature give an uneven expression of wilt from season to season. Strains tested in fields under fluctuating seasonal conditions are likely to carry on temporary resistance. Hence the necessity of finally testing them under standard conditions of soil moisture and soil temperature in pots. One backcross of the hybrid to the resistant parent appears to be a fairly reliable method of obtaining material of better resistance than the straight cross.


A detailed description of a hybrid of Bourbon ♂ (G. pulcherrima) x Wagad 12 ♀ (G. herbaceum) composition.


Owing to the general tendency for the flower buds to shed so long as environmental conditions favour vegetative growth, foreign cottons, which are constitutionally early, fail to show early flowering under Gujarati conditions. Under these conditions extra early maturity, which allows the crop to escape frost damage and to grow well under deficient rainfall, may be obtained by evolving quick-flowering strains with shorter bud and
boll maturation periods, and by controlling bollworm attacks.


A survey of work done on this variety of *G. herbaceum*.


Covers the evolution of the Jayawant and Gadag I varieties, and their distribution in the Bombay Karnatak.

Pearson, E. O. 1950. See Hutchinson, J. B. and Knight, R. L.


Work in Southern Rhodesia on reselection in U 4 is cited as evidence of the value of reselection. Mason's (1938) emphasis on primary selection is questioned.

Peebles, R. H. 1926. See Kearney, T. H. and Peebles, R. H.

Peebles, R. H. 1927. See Kearney, T. H. and Peebles, R. H.


Crosses between okra-leaved Acala and normal Acala gave clear 1:2:1 segregation for leaf shape in the F_2_.


A plant appeared in the F_3_ of Pima x College (Upland) having dense woolly pubescence on the margins of the floral nectaries, conspicuous hairiness of the outer surface of the bolls and marked development of intracarpellary hairs. This plant bred true for hairy bolls and pronounced intracarpellary hairs in the F_3_. It is suggested that Pima carries a factor for boll hairiness and that College carries a modifier enabling the development of the character in the mature boll.

In some of the F_3_ segregates of a Pima x Acala cross the development of intracarpellary hairs was found to be more pronounced than in Pima. Classifying these F_3_ progenies into "hairs present" and "hairs absent or nearly so" gave 113:6 against an expectation of 111:6:7:4 on a 15:1 basis.

Peebles, R. H. 1940. See Kearney, T. H., Peebles, R. H. and Smith, E. G.


Smooth boll surface and three oil gland characters (delayed development of the boll glands, small and deeply embedded stem glands and small calyx glands) characterize a family of Pima cotton (*G. barbadense*) known as P Hope. The contrasting characters (pitted boll surface, early development of the boll glands, large and shallowly embedded stem glands and large calyx glands) are found in PH 8, a family of normal Pima cotton.

The characters mentioned above do not segregate independently. This association of the
characters is tentatively accounted for as an instance of pleiotropy of a single pair of genes, rather than as complete linkage.

Ratios obtained in F₁ and backcross populations agree fairly well with expectation based on the assumption of a single-factor difference. Pitted boll surface and smooth boll surface, for which the symbols are respectively Bₚ and Bₛ, show mono-hybrid inheritance. All the above-mentioned characters are intermediate in the F₁.

A remarkable increase in number of boll glands occurs in the F₁ and in the heterozygous class in F₂ and backcross populations. This is explained by assuming that the genes Bₚ and Bₛ are additive in respect to number of boll glands.


Notes the improvements required in the crop and describes the breeding methods in use.


The varieties of cotton grown in Queensland are all of the American Upland type. All these cottons, with their large bolls and coarse fibre, can be picked and ginned much more cheaply than the forms with small bolls, fine fibre and long staple. Brief accounts are given of the most successful cottons: Lone Star, Miller, Triumph, New Mexico Acala and Farm Relief.

Peters, W. A. 1908. See Kearney, T. H. and Petersen, W. A.

Petersen, W. A. 1909. See Kearney, T. H. and Petersen, W. A.


Points out that Thurberia therspesoides is the host of a variety of boll weevil, Anthomonas grandis thurberiae.

Pillai, R. C. 1925. See Hilson, G. R., Ramanathia Ayyar, V. and Pillai, R. C.


0·1% of red-leaved plants sown in a green-leaved variety gave 0·14% red plants in the green progeny. When the percentage of red-leaved plants was raised to 10% the proportion of hybrid seed produced by the green plants rose to 3·18%. Seed from the red plants showed 92% outcrossing. In two other cases where rows of red were surrounded by green plants, the proportion of outcrossing in the seed of the red plants was 40·8% and 58·0%. In another case, using a plant with brachytic fruiting branches, 42% of outcrossing occurred. N. F. Zulinov reports an average set of 54% in flowers of Schroeder left exposed after emasculation. Natural hybrids with Old World cottons are not uncommon.


Corn barriers reduced the amount of natural crossing. The reduction tended toward linearity for the different barrier widths used in the experiment.

The results show that the barrier widths of corn used did not afford sufficient protection,
under the conditions of this experiment, for the multiplication of selfed seed stocks. The minimum amount of natural crossing found would, in a few generations of multiplication, reduce the homozygosity to a point where the seed stocks would be too badly mixed for continued production.

Small-block plantings of red-leaved cotton, made at distances ranging from 700 to 4,200 ft. from green-leaved cotton established the occurrence of natural crossing at distances up to 0.8 mile. It therefore seems clear that distances of 1 mile or more will be required to provide complete isolation, under the conditions prevailing in this study.


PORTER, D. D. 1926. See KEARNEY, T. H. and PORTER, D. D.


PRASAD, RAM. 1912 a and b. See LEAKE, H. M. and PRASAD, RAM.

PRASAD, RAM. 1914. See LEAKE, H. M. and PRASAD, RAM.


894. PRASAD, RAM. 1926. Length of fibre and ginning percentage in Indian cottons. Agric. J. India, 21, pp. 431-446.

The author finds that plants combining high ginning outturn with long staple can be obtained by selection, but that subsequent generations from such plants tend to revert, although some improvement can be brought about by straight selection. He considers that hybridization followed by selection gives a better chance of combining the two characters.


Describes an attempt to combine high ginning outturn with good quality in Asiatic types.


An account of work designed to improve the staple and ginning outturn of Khandesh cotton.


The Bombay Karnatak is divided commercially into two cotton belts, viz. Kumpta-Dharwar and Dharwar-American, the average area under each being 968,797 and 253,711 acres respectively. By a process of unit selection in local Kumpta (G. herbaceum, var. frutescens) a type suitable to the belt was isolated in 1918 and named Dharwar 1. This strain
was superior in ginning outturn, staple length and spinning quality to the local cotton, but the ginning outturn was still inadequate. Further experiments were carried out and two types, 15-9-9 and 1A-14-3 were evolved by hybridization of Dharwar 1 with Rosea (G. arboreum var. neglectum). The strain 15-9-9, known as New Cross, spread on account of its superior ginning outturn but its cultivation is being suppressed because of its high susceptibility to wilt. Search for a wilt resistant cotton led to the evolution of the Dharwar 2 strain in 1921, but it was found unsuitable for cultivation. By crossing the two pure strains Dharwar 1 and Dharwar 2, a strain called Jayawant (Triumphant) was evolved in 1928. This cotton is superior to Dharwar 1 in ginning outturn, staple length, and wilt resistance, and 700,000 acres are under cultivation. Jayawant was further hybridized with 15-9-9, and the two new strains evolved, New Jayawant and Early Jayawant, spin almost equal to Jayawant and possess ginning outturns of 31% and 33% respectively, compared with 28% for Jayawant. By continued selection, cotton strains have been isolated which though showing leaf mottling in the initial stage of growth are highly resistant to wilt. One of these, KFT 12-2-5, in addition to wilt resistance, has high yield and quality and is capable of spinning 44s compared with 40s for Jayawant, but unfortunately its ginning outturn is only 24%. American cotton has been grown in the Gadag tract, Bombay Province, since 1842. The New Orleans cotton acclimatized in Dharwar district is called Dharwar-American. In 1910, pure line culture experiments were started and Gadag 1 was isolated in 1914. This strain gives 26% more lint per acre than Dharwar-American, and its staple is longer by \frac{1}{2} in. During certain seasons, however, Gadag 1 is late in maturing and suffers from red leaf blight. To eliminate these defects it has been crossed with Co.2 and two segregates, 9-7-6-6 and 4-4-1-1, have been evolved. Segregate 9-7-6-6 is characterized by high yield, higher ginning outturn and better staple quality than Gadag 1, and has so far proved remarkably resistant to red leaf blight. The segregate 4-4-1-1 is earlier than Gadag 1 by at least three weeks, and gives a much higher yield. Its resistance to red leaf blight is also outstanding.

PRENTICE, A. N. 1938. See PRAT, J. E. and PRENTICE, A. N.


All American varieties of cotton tested proved equally susceptible to *Puccinia submunis* (Accidium gossypii) but resistance was found in some varieties of *G. arboreum*.


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The botanical classification of the cotton varieties grown in Mozambique is outlined, followed by an account of the distribution of the varieties and details as to their fibre quality.

QUINTANILHA, L. 1947. See QUINTANILHA, A., CABRAL, A. and QUINTANILHA, L.

RAJA, G. G. 1945. See BOZA BARDucci, T., RAJA, G. G. and WILHE, J.

RAFIQUE, M. 1939. See VASeLEVA, R. S. and RAFIQUE, M.

RAgHAYAN, A. 1950. See BALASUBRAHMANYAN, R. and RAgHAYAN, A.


Continuous and well marked changes in chemical composition occur during the development of the cotton boll. These are discussed in relation to the alterations, during its development, in susceptibility to NeNlatoceporida (transmitted by Dysdercus), to Dysdercus itself and to Holothis, Platypedra, Earias and Dipsopsis.

RAJ, L. D. 1938. See SINGH, S. C. and RAJ, L. D.

RAMACHANDRAN, C. K. 1943. See RAo, M. V. and RAMACHANDRAN, C. K.

RAMANATHA AYYAR, V. 1925. See HILSON, G. R., RAMANATHA AYYAR, V. and PILLAI, R. C.


The proportion of 5-locked bolls on a plant is normally greater at the beginning of the season but 5-locked bolls show a higher rate of shedding. There is a positive correlation between the number of 5-locked bolls and the remaining number of bolls produced by a plant. A negative correlation exists between number of ovules per lock and number of locks per boll, but the total number of ovules is greater in a 5 than in a 4-locked boll. The 5-locked bolls show more variation in the number of ovules than 4-locked bolls. There is more variation in the number of seeds set than in the number of ovules per loc. The 4- and 5-lock bolls have a similar maturation period. The kapas weight per seed is least in 5-lock and highest in 3-lock bolls.


Segregation of the colour of pollen was studied in both inter-varietal and interspecific crosses in G. obtusifolium and G. herba­ceum. Segregation was clear cut and yellow colour was mono-factorial. Modifying factors were not evident even in interspecific crosses.


From ratios obtained in £2 and £3 progenies of interspecific crosses of G. obtusifolium, G. indicum and G. herba­ceum, a trifactorial basis for lint colour in these cottons is postulated. A basic gene X, essential for colour but producing pigmentation only
in the presence of either \( K_1 \) or \( K_2 \) or both, is regarded as the probable factor relationship. The factor \( X \), with either \( K_1 \) or \( K_2 \) gives cream; \( X \), with \( K_1 \) and \( K_2 \) gives brown. Further work is in progress.


Two kinds of petalody were found: (1) wherein the stamens on the lower three-fourths of the staminal column were completely metamorphosed into petaloid structures, those at the top being only partially so and a few being normal; (2) wherein many of the stamens on the lower half of the staminal column were transformed into petals, but were less distinct, smaller in size and paler in colour. The anthers at the top were whitish and contabescent, and produced no pollen.

An \( F_1 \), raised from seeds from the few bolls which were obtained when pollen from the first kind of flower was applied to stigmas of emasculated normal flowers, consisted of all normal plants, while in the \( F_2 \) a simple segregation into normal and petaloid types on a 3:1 ratio was obtained.


In view of the low potentialities of the Asiatic cottons in their capacity for combining quality with yield, the author suggests that the possibility of evolving suitable Upland types should be re-explored on a wide basis.


By exposing dry seeds of Asiatic cotton to X rays, three new recessive types of mutants comprising two chlorophyll deficient and one meristic variant, were obtained in the second generation.


A paper by Ramanathan is reported in which it is shown that the position of the first fruiting node is governed by multiple factors.


Genetical studies on pollen colour, seed and lint weights, boll locule number, boll opening, hybrid vigour, vicinism and X-ray-induced mutations are recorded. American cotton showed
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less attack of *Pempherulus affinis* (stem weevil) than *desi* cottons. Co.2 was the most susceptible of the Uplands.

**Ramiah, K. 1938.** See Hutchinson, J. B. and Ramiah, K.


A general discussion of methods of breeding and improvement in breeding technique, deterioration of strains, limits of selection, application of genetics and cytology to plant breeding, etc. The author recommends the carrying out of more extensive trials with new crop strains in every tract on a well-thought-out plan; improvement in the prevalent technique of selection in hybrid material; study of the genetical variance in quantitative characters; and the collection of a wide range of material for utilization in breeding.


The topics discussed in this short review are selection, quantitative inheritance, breeding for quality, choice of parents for crossing, discriminant function, correlation and linkage, breeding for wilt resistance, species relationship, collection of breeding material and maintenance of purity of strains. Suggestions are made for future genetical and breeding work with cotton in India. The author emphasizes the interrelationship of genetical and plant breeding work.


The subject is treated more fully by Ramiah and Nath, 1943, q.v.


Reports a further member of the *R₂* series.


The sterility due to gene *stp* has been found to be caused by asynapsis.

This gene assorts freely with the genes controlling corolla colour, anthocyanin, and leaf shape in Asiatic cottons.


The gene $\text{Li}_c$ affects viability and growth and disturbs leaf shape segregation.


The action of the Punjab hairy lintless (G. arboreum) mutant gene $\text{Li}_c$ on the plant carrying it has been studied. The lintless type has a lower growth rate, and fewer and shorter internodes giving the plant a stubby appearance.

Studies on fibre development in $\text{Li}_c \text{Li}_c$, $\text{Li}_c \text{li}_c$ and $\text{li}_c \text{li}_c$ plants show that the differences among the three are mainly brought about by the action of the gene in arresting the growth of the fibre, more particularly in the homozygous condition.

The gene affects boll size, fertility, number of ovules per locule and also viability of the seed, the lintless seed showing the lowest viability. All these effects are pleiotropic.

924. RAMIAH, K. and BHOLA NATH. 1943. Genetics of single lobe leaf mutant in cotton. *Indian J. Genet.*, 3, pp. 89-98. (From Authors' summary).

The inheritance of a gene $s$ which arose as a mutant in G. arboreum at Nagpur and which makes the normal palmately lobed leaf into one with an entire lamina, is described. The locus of this gene is different from that of the multiple alleles controlling leaf shape.

The $F_2$ and $F_3$ results of crosses between the mutant and the leaf shape series show an abnormal segregation of 10 palamate : 1 entire and this has been explained as possibly due to the production of 70% and 30% of functional palmate and entire lamina gametes respectively in the heterozygous plant instead of the usual 50 : 50.

The mutant has a low vigour and viability and shows fusion of petal lobes and cotyledons.

The abnormal $S-s$ segregation is not the result of aborted embryos produced in the heterozygous plant.

There is no linkage between $S$ and $Y$, petal colour gene, nor between $S$ and $Lc_1$ for khaki lint.


Red leaf, distinguishable from the reddening due to jassid, behaves as a Mendelian character and may be of value because it causes extra earliness.


Two new anthocyanin alleles of the $R_s$ series in Asiatic cottons are described: $R_{s_{1\alpha}}$, weak thumbnail red-spotted; and $R_{s_{1\beta}}$ green spotless-2.


The gene $H_{1\alpha}$ controls a new type of stellate hair, having 20-30 short rays, found in Viramgam lintless cotton.


A detailed review is given of knowledge of the anthocyanin genetics of cotton. The 16
alleles at the $R_2$ (Old World) locus are tabulated and described in detail and information is also given about the alleles at the $R_1$ and $R_9$ loci.


Tabulated data are given for 23 cotton research stations showing soil types, temperatures, rainfall, humidity, sowing date and spacing.

Very detailed tabular descriptions are given of the following varieties:

- **G. arboreum**: Jarila (NY 54–3), Banilla (Dhulia 1), NR improved, Verum 434, Late Verum, Malvi 9, Malvi 9–20, C 520, 39 Mollisoni, 60A2, 119 Sanguineum, Gaorani 6, N 14, N 23, K 1, 171, X 20, CN 86, CN 4–5, Strain 199, Strain 260–61, and H 190.

- **G. herbaceum**: Wagad 8, Wagotar, BD 8, Vijay, Broach, 1027 ALF, Suyog, Kumpta, Jaywant, Selection 69, 29H1 and Hagari 7.

The geographic distribution of these strains is illustrated by maps.


A single gene difference forming the genetic basis for the distinction between tufted and fuzzy seed in *G. hirsutum* varieties is confirmed. The tufted condition is usually partially dominant.

The expression of the gene is subject to considerable modification by modifier genes present in the Indian varieties of *G. hirsutum*. While the simple dominance of tufted over fuzzy condition and 3:1 $F_2$ segregation holds good in crosses between related varieties having the same modifier background, in crosses with unrelated varieties having different modifier backgrounds the segregation of fuzz becomes complicated.

The modifying genes affect the dominance mechanism and it is possible to isolate in the $F_3$ families which give 3 fuzzy : 1 tufted and thus demonstrate the reversal of dominance analogous to the similar phenomenon demonstrated by Harland for the crinkled dwarf gene in interspecific crosses.

The partial association of low grades of fuzz with sparse lint in *G. hirsutum* has been indicated, and the importance of maintaining a high level of homozygosity with regard to seed fuzz character in established commercial varieties is discussed.


Daloda (a Malvi form of *G. arboreum*) showed a variation of 3.0–3.7 in the mean number of locules per boll in individual plants but progenies from the extremes showed this to be chance fluctuation, not genetic.

A mutant *G. arboreum* having a fasciated stem apex, 4–5 lock bolls, 4 bracts (occasionally 3) and 5–7 petals is recorded. The 4–5 locked condition proved to be a monogenic recessive. Repeated selection gave a 5-lock type free from fasciation.

A correlation is noted in *G. arboreum* between narrow leaves and long bolls.

932. Ramiah, K. and Bhola Nath. 1947 b. Seed fuzz in Upland
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In Upland, selection forces favour the more fuzzy types of seed, whereas in G. barbadense selection pressure is in favour of tufted or naked seeds. Results obtained in Upland show "that while there may be a single gene difference between tufted and fuzzy condition, its action is subject to modification by the modifier background which may be different in different varieties of G. hirsutum."


Breeding for wilt resistance is described, selection being based mainly on duplicated replicated progeny trials: one in wilt infected and the other in wilt free land. It is noted that in the cross Dhar 43 x Chinese Red Spotless, the red spotless condition and wilt resistance were inherited together.

RANADIVE, J. D. 1940. See UPPAL, B. N., KULKARNI, Y. S. and RANADIVE, J. D.


A report on selection work carried out in Mysore Province with three varieties of Sannahatti cotton, with a view to effecting improvement in the colour, yield and ginning outturn.


Records the production of a new strain, H 190, with good agricultural characters from a cross between G. herbaceum (Kumpta 69) and G. arboreum.


Concerns two new strains of cotton, possessing red flowers and green seed, developed from interspecific hybridization between G. arboreum and G. herbaceum.


By selection from the cross G. hirsutum (local Doddahatti) x G. peruvianum, two strains of Mysore-American cotton with a very high percentage of 5-lock bolls were developed. The results clearly indicate that loculus number in cotton is heritable. It was shown that the amount of seed cotton per loculus is not significantly different in 4-lock and 5-lock bolls, the 5-lock therefore yielding considerably more cotton per boll.


The hybrid G. arboreum x G. herbaceum was crossed with G. cernuum x G. obtusifolium and from this, types have been
obtained combining the long, silky staple of *G. arboreum* with long big bolls and high ginning outturn.


A recessive mutant in *G. herbaceum* with short internodes and numerous basal monopodia is controlled by a single gene, *Db*.


There are marked differences in oil content between varieties, and between single plants within varieties. Rexall, Hite, Willet Perfection, Cook and Willet Ideal showed the highest oil content ranging from 23.3% in the first to 21.78% in the last.


Forty-eight varieties were examined and showed a range in oil content from 17.64 to 23.8%. The highest was Mexican.


In the work carried out at Lyallpur, for the improvement of Punjab-American cottons, reselection of 289F/43 and LSS varieties figures prominently. From 289F/43 three strains, 233F, 234F and 238F, have been evolved, in which the original fibre length of the mother strain has been fully maintained, but yield and ginning outturn have been considerably increased. From LSS, five strains resembling the original strain in habit of growth, nakedness of seeds, fibre length and ginning outturn, but earlier in ripening, have been built up.


Records the result of testing a range of Upland cottons for resistance in the seedling stage. Stoneville 20, Stoneville 62-1, Stoneville 462 and Oklahoma Triumph 92-I showed considerable resistance.


Even with no bottom heat a fair proportion of cuttings of cotton strike; when optimum conditions are established this proportion could probably be much increased.


A study of the locks of Anton and Belton cottons showed a progressive increase in motes from the apex to the base of the lock, the percentage range being from 6.5 to 25.3 for the 9-seeded locks of Anton, 11.1 to 38.3 for the 11-seeded locks of Belton (1925), and 17.2 to 83.3 for the 11-seeded locks of Belton (1926). Five-locked bolls averaged 19.2% of motes in Belton in 1925 and 4-locked bolls 16.8%, while in
1926 the respective percentages were 27.5 and 20.5. The differences are suggested as nutritional or possibly due to incomplete fertilization.


Points out that Brown and Cotton's (1937) results fit expectation on the basis of a single factor \( r_1 \) for round-leaf interacting with Harland's \( O_n \) (okra) and \( O_n \) (normal). Okra is thus \( O_n O_n r_1 r_1 \) and round-leaf is \( O_n O_n r_1 r_1 \).


On the basis of \( F_2 \) and backcross data, it appears that the characters brown lint and green lint in Upland cotton, are independently inherited. Each is due to a single incompletely dominant gene.

The factor \( K \) for brown lint also gives brown seed fuzz, the heterozygote \( Kk \) having intermediate brown fuzz. The factor \( G_1 \) for green lint gives green fuzz, whether it is in the homozygous or heterozygous condition.

In addition, there is a third factor \( G_f \) which has no effect on lint colour, but which gives green fuzz when in the homozygous recessive condition. The effect of this factor is masked in the presence of the factor \( G_1 \).


Classification of over 2,000 progenies of crosses of lintless \( x \) normal stocks has led to the conclusion that a single gene, \( N \), controls both lint and seed fuzz. \( NN \) plants are devoid of seed fuzz, and when modifiers for lint are absent they are also devoid of lint. \( Nn \) plants carry a trace of fuzz and produce lint approaching in abundance that of the normal \( nn \) types. The production of lint in \( NN \) types appears to be conditioned by the presence of plus modifiers. Practical application of the use of modifiers for lint production is being made by combining as many as possible into one genotype, which will then be combined with some of the better stocks carrying the major gene for lint production. An investigation is being made of the possibility of utilizing \( F_1 \) hybrids of \( G. \) barbadense \( \times G. \) hirsutum for the commercial production of cotton with a staple 1\( \frac{1}{2} \) in. or longer. Small quantities of Upland and \( G. \) barbadense seed were planted in two localities known to have large populations of certain species of Hymenoptera. The average amount of natural crossing obtained was 95%. Numerous interspecies crosses were made to study the practicability of transferring desirable economic characters from \( G. \) barbadense, \( G. \) purpureascens and
other closely related species to Upland. This study will parallel a similar one, just initiated, in which desirable characters from new species produced synthetically from Asiatic and wild species will be transferred to Upland.

Richmond, T. R. 1939. See Beasley, J. O. and Richmond, T. R.


Experiments in the accumulation of lint production modifiers in smooth-seeded lines were continued. Of the 86 progenies grown from the three most promising families last year, 77 bred true for smooth seed, 20 of which were uniformly high in ginning outturn, averaging over 20%. Several of the better lines will be crossed with high yielding, covered-seeded, normal lines to test the possibility of increasing the lint production in normal stocks with the modifying genes accumulated in the smooth-seeded stocks. The characters hirsute and petal gland were recovered from first backcross generation, indicating at least partial dominance. Selfed progeny of these crosses threw individuals in which the expression of both characters was greatly intensified.

Richmond, T. R. 1940. See Beasley, J. O. and Richmond, T. R.

Richmond, T. R. 1941. See Beasley, J. O. and Richmond, T. R.


The genetical behaviour of lint pigmentation has been studied, using the following varieties: Texas Green Lint, Nankeen (dark brown lint), Texas Rust (light brown lint), Higginbotham (light brown lint) and a normal white-linted variety. Pigmentation of the first three varieties is conditioned by a single gene which is incompletely dominant to white. The genes for Texas Rust and Nankeen are allelic and appear to be independent of Texas Green Lint and Higginbotham which are also independent of each other. An association was observed between the green and brown lint genes and a reduction in the weight of fibre per unit length.


Using methods involving colchicine, a genetic study of the taxonomic relationships of cotton species is well on its way to completion. Studies of plants with more than the basic number of chromosomes afford a direct method of determining the effects on American Upland cotton of chromosome balance and the effects of genes introduced from wild or distantly related species. Four plants with an extra pair of chromosomes were recovered in 1943. Since fertile hybrids between 26-chromosome cottons and 13-chromosome cottons can be made almost at will, it is now possible to utilize genetic characters carried in the latter types. One of these characters, fibre strength, is of particular importance at present; and while
average Upland cotton gives a breaking strength of approximately 80,000 lb. per square inch, lines which break at 100,000 to 110,000 lb. have been recovered from species hybrids.


Data were obtained on the quantity of lint of four strains of American Upland cotton, *Gossypium hirsutum*, Lintless (glabrous seed coat and no lint), High-Smooth (glabrous seed coat and linted), Missel (covered seed coat and low lint quantity), Half-and-Half (covered seed coat and high lint quantity), and their hybrids.

Two genetic systems, which control lint quantity in American Upland cottons, were identified. In one system, a single pair of alleles, \( F_n F_n \), has a major effect on lint quantity. The homozygous phase of this gene, \( F_n F_n \), produces covered (fuzzy) seed coat and also conditions the production of lint. In the homozygous condition, \( F_n F_n \), no seed fuzz is produced; the amount of lint is greatly reduced, any lint produced being due to the action of modifiers. In the heterozygous state, \( F_n f_n \), the seed coat is glabrous and an intermediate quantity of lint is produced.

The other system is composed of a complex of modifiers or genes which independently have minor effects in the production of lint but which may have a considerable effect as a group. These modifiers act to produce varying quantities of lint even in the presence of \( F_n F_n \) in the homozygous condition and, are, therefore, epistatic to it. When modifiers are absent, the \( F_n F_n \) phenotype is glabrous and completely lintless. Apparently these epistatic modifiers also have a positive effect when acting in the presence of the linting phase of the major gene.

The interpretation just given differs radically from that of Thadani who concluded that the so-called "sparse lint" gene was completely linked with another gene which was responsible for glabrous seed coat. In all of the \( F_2 \) material involving glabrous and covered seed coat hybrids classified by other workers, and in more than 5,000 \( F_2 \) plants examined by the writer, in addition to the 916 plants in this study, there has not been a single authentic case of a plant with covered (fuzzy) seeds and no lint. Therefore, rather than postulate two completely linked genes, the most logical genetic interpretation is that glabrousness and lintlessness, and covered seed coat and lint production, are pleiotropic effects of a single pair of alleles. It should be emphasized that the interpretation just given hypothesizes a pleiotropic effect of a single gene in the homozygous state which conditions glabrousness and lintlessness, not glabrousness and sparse lint as reported by Griffee and Ligon (1929).


954. Roberty, G. 1938. (Hypotheses on the origin and migrations of cultivated cottons and notes on


These notes, compiled from 1933-39, give an analysis of the successive stages in the improvement of lines, followed by an alphabetical list of common names, an index arranged systematically, and a table of the distribution of the cultivated cottons in French West Africa.


The Anglo-Saxon classification of cotton is considered to be insufficiently precise. It is suggested that Old World cottons be divided into the sections *arborea*, comprising the three species *G. obtusifolium*, *G. arboreum* and *G. eglandulosum*, and the section *herbacea*, comprising *G. herbaceum*. The New World cottons are divided into three sections: the *fructicosa*, comprising *G. hirsutum* and *G. latifolium*, the *insculpta*, comprising *G. barbadense* and *G. peruvianum* and the coarctata constituted by the single species *G. lapidum*. Each of these nine species corresponds to relatively precise agricultural and industrial, biogeographic, genetic and morphological data. Tables are presented illustrating this statement.


Two *Gossypium* spp., *G. anomalum* and *G. somalense* [G. somaliense] are stated to grow on the high plateau of Djebel Markhiyat. There is no sign of hybridization between them. The author is of the opinion that *G. somaliense* should, perhaps, be excluded from the genus *Gossypium* because of its united stigmas. The two species are described. They have been crossed artificially with several other species at Shambat, near Khartoum.


The following new cotton genera and species are defined and described: *Neogossypium*, cottons with 52 somatic chromosomes; *N. roseum* (= *Gossypium arboreum* var. roseum); *N. barbadense* var. rubrence *f. knightii*, a form with purple leaf venation, pinkish-yellow petals and trifid style; *Ultragosyppium*, cottons with 78 somatic chromosomes; *U. armadense* (*G. lutarum* subsp. *armourianum* x *G. barbadense*); *Hemifultragossypium*, cottons with 39 chromosomes; and *H. harknum* (*G. harknessii* subsp. *armourianum* x *G. hirsutum*).


Cotton breeding work is covered.


In crosses between New and Old World cottons, sterility is not caused by failure of the pollen tube to reach the ovary.

The heavy soils of the San Joaquin Valley, California, have become extensively (and in places totally) permeated by Verticillium albo-atrum, the selection of strains resistant to which has been successful in Cooke 307–6, Mexican Big Boll, Kekchi, Tuxtla and Missel. Strains of Stoneville and Acala, while not resistant, are prolific under heavy infection. The American Egyptian types are highly resistant to V. albo-atrum, and an attempt is in progress to transfer the resistance of Pima to Acala by means of backcrossing.


The salt concentration in the first 10 cm. of the soil is of primary importance during the process of germination; 1-5% salt concentration was found to be injurious, but up to 0-9% concentration no injury was noted. For the normal growth of cotton the salt concentration of the first 50 cm. of soil is a determining factor. The sulphates of sodium and magnesium were found to be just as injurious as the chlorides. Gypsum, at the rate of 0-4%, does not depress the growth of the cotton plant but reduces the yield. Egyptian cotton was found to be more sensitive to salt concentration than American cotton.

The following early varieties of cotton were recently selected at the Fergana Research Station of the USSR Cotton Institute: 689, 690, 692 and 693. The last was a natural hybrid between 113F and 1115. A character common to these new varieties is the production of supplementary sympodial branches, bearing up to three bolls which reach maturity at the same time as the bolls on the rest of the plant. The varieties are productive and about 15 days earlier than S-460.
Varieties 692 and 693 yielded more fibre than S-460, although the latter variety produced a heavier boll, weighing 1.5 to 2 grm. This was due to their higher ginning outturn. The bolls of 692 and 693 weighed 1 to 1.5 grm. more than those of 1306 and S-3210.
Breeding for the multibranched
habit, including Michurinitic training upon fertile soil, is advocated. The varieties 692
and 693 are still inferior in quality to 108F and S-460.

RUSTON, D. F. 1949. See
PARNELL, F. R., KING, H. E. and
RUSTON, D. F.

RZAEEV, M. M. 1940. See
ZIEBRAK, A. R. and
RZAEV, M. M.

SAMSON, S. 1947. See
SETHI, B. L., ANSARI, M. A. A. and
SAMSON, S.


In experiments with Sea Island cotton the author succeeded in increasing the number of 4- and 5-locked bolls by selection.

SANKARAN, R. 1934. See
RAMANATHA AYYAR, V. and
SANKARAN, R.


SANTHANAM, V. 1949. See
BALASUBRAHMANYAN, R., SAN
THANAM, V. and MAYANDI PILLAI, S.

SANTHANAM, V. 1950 a and b. See
BALASUBRAHMANYAN, R. and
SANTHANAM, V.

SANThANAM, V. 1950. See
BALASUBRAHMANYAN, R., MUDA
LIAR, V. R. and SANTHANAM, V.


Covers cultivation, botanical classification and recommendations for future breeding work.

973. SAWHNEY, K. 1941. Growing better cotton in Hyderabad. Indian Fmg., p. 22.

Deals with Gaonari 6, which in 1939-40 was sown on some 240,000 acres.


The results of an intensive analysis of the genetics of carpel number in G. herbaceum, carried out at the Cotton Breeding and Experiment Station, Adena, Turkey, during the period 1941 to 1949, are presented in considerable detail. On the basis of these results the author presents the hypothesis of multigenic inheritance for this character and for quantitative variation in general. The term monogene or intrachromosomal gene is applied to single genes arranged linearly in the chromosomes. The term multigene or extra-chromosomal gene is used for
another class of genes, organized in groups outside the linear file, each group being called a set. In *G. herbaceum*, the carpel number depends upon four multigenic sets in two pairs, each set comprising 16 genes. The number of genes in each of such sets is regarded as constant. It is suggested that multigenes are held together by some form of bond or attachment, that each set is connected with the linear file through one of its members, which behaves as a monogene, and thus each set has a particular position on the chromosome. The distinction between monogenes and multigenes is purely one of organization.

In the case of the genes conditioning carpel number, the data are interpreted as providing evidence that allelomorphic sets of multigenes conjugate and exchange genes during mitosis and meiosis. Such exchanges are not limited to one or two genes but may involve all the multigenes concerned. It is thought that such exchanges are usually non-random processes in this case.

A description of this variety and its origin by selection from Pima.

In the USSR *B. malvacearum* is most severe in Transcaucasia and Russian Central Asia, chiefly in the areas where Egyptian cotton is grown. While local varieties are less susceptible, no truly resistant strain has so far been found. Under Central Asian conditions plants affected with stem blackarm show a reduction in yield of 60%.

977. Sethi, B. L. 1941. A note on the cultivation of improved varieties of cotton in the United Provinces. *Bull. Dep. Agric. Unit. Prov.*, No. 84, 5 pp. Accounts are given of the two improved cotton varieties, C 520 (*G. arboreum*) and Perso-American, which have been produced by the Department.

Plant breeding operations carried out by the Department of Agriculture since 1905 have resulted in the evolution of a number of improved types which have passed into general cultivation in varying extent. Among the most important are C 402, A 19, JN 1, CA 9 (American cotton), C 520 and Perso-American. Of these, the last two have proved particularly hardy, high yielding and superior in quality in the cotton-growing areas of the United Provinces. C 520 is an early hardy variety with white flowers and narrow leaves. Perso-American is a single line selection from exotic material (*G. hirsutum*) imported from Persia and acclimatized in the United Provinces. It is a high-yielding and early variety. The plants have broad, three-lobed
leaves and large, widely expanding pale yellow flowers. The seeds are large and fuzzy, and the seed coat varies from brown to black in colour.


Covers selection of new varieties and seed multiplication.


Four distinct types of perennial cotton found by the author at Kaiyung, Yunnan Province, China, are described. All these types were superior to annual cottons in vigour, yield and quality. It is therefore suggested that in breeding new cottons for subtropical conditions in south-western China, stress should be laid on developing perennial types of Egyptian, Sea Island and American Upland cottons rather than annual types.


Of 62 varieties of cotton, only Pima and Sea Island appeared practically immune to *Verticillium* wilt.


Somatic chromosomes of 24 types belonging to *G. arboreum* and *G. herbaceum*, five wild diploid species, and two types of *G. hirsutum* were studied with special reference to the number of satellites and nucleoli.

All the diploid varieties, except the wild species and two Russian varieties of *G. herbaceum* (Russian 25 and Russian 20) in which six satellites and six nucleoli were seen, showed two pairs of nucleolar chromosomes, which is indicative of their allotetraploid nature.
The Punjab-American tetraploid varieties, LSS and 280F/43, have shown only six nucleolar chromosomes in their somatic complement and it appears that they have lost some nucleolar organisers during the course of evolution.

The complement of nucleolar chromosomes in some Asiatic cultivated species consists of one chromosome pair with secondary constrictions and another with satellites, as reported by Jacob, while in others both pairs of nucleolar chromosomes are clearly satellited, though one of them possesses slightly thicker satellitic knobs than the second.

The presence of secondary constrictions in the primitive africanum variety, and their transition into progressively thin satellites in the highly evolved frutescens and typicum varieties, has led to the conclusion that the satellite is a higher evolutionary type than the secondary constriction.

Shortening of the chromosomes and a tendency towards the attainment of subterminal primary constrictions with advance in evolution, have been observed in the varieties grouped under G. herbaceum.

The somatic complement of G. hirsutum could be clearly divided into two groups, one consisting of thick chromosomes, such as occur in the Asiatic cultivated species, and the second comprising thin chromosomes of the type found in the wild American diploids. This fact could be correlated with the allopolyploid nature of G. hirsutum.

The length and morphology of chromosomes of arboreum types classified within the same group have shown wide variations, but the structure of nucleolar chromosomes within the same group is constant and bears greater association with the geographical distribution than with the branching habit of different types. On the basis of the latter similarity, it seems more appropriate to give the geographical trends the higher varietal status now assigned to habit of growth by Hutchinson and Ghose.

The general morphology of nucleolar chromosomes of the sanguineum cotton of the Punjab bears greater resemblance to that of Karunganni and Gaoran cottons than to the roseum types. It, therefore, appears more appropriate to classify this type in the indicum group than in the bengalensis group, as done by Hutchinson and Ghose.

The nucleolar chromosomes of Comilla bear greater similarity with the ones occurring in forma bengalensis of G. arboreum, one pair having thick secondary constrictions and the other having thin satellites. It is consequently more appropriate to classify Comilla cotton in the bengalensis group than with cernuum, which has two pairs of well differentiated satellites.


Two further members of the leaf shape allelomorphic series in the cultivated Old World cottons, G. arboreum and G. herbaceum, are described. One, L³, was found in a strain of G. arboreum. The other, L⁴, is confined to the wild species G. anomalum.

The method of action of leaf shape genes is considered in
COTTON BREEDING AND GENETICS detail. It is postulated that the gene is a compound one, with two gene centres controlling laciniation and lobe width respectively.

Dominance is regarded as a function of allele interaction, dependent upon the magnitude of effect of the gene relative to the possible range in expression of the character affected, and upon other genes working towards the same result. The bearing of this conception on some current evolutionary theories is discussed, and it is concluded that the acquisition of dominance may be regarded as a subsidiary feature of the primary action of natural selection upon the genotype as a whole.


It has been possible to recognize particular members of the gene complex controlling the number of lint hairs on the cotton seed by their effect on the glabrous lintless mutation. The latter was used as an analyser to separate the genes controlling lint development into two series, those hypostatic to it, and those epistatic to it and acting as modifiers. The basic lint percentage effect of a single epistatic gene in the heterozygous phase is about 6–10% on the lintless genotype. The epistatic genes show a reductive interaction with other genes working towards the same effect, so that in the fully linted genotype their effect is less than one-fifth of their basic value.

The epistatic genes are shown to have a clearly defined varietal and specific distribution, not associated with the ginning capacity of the strains in which they occur, showing that in different taxonomic groups a typical quantitative character may be controlled by quite distinct complexes of genes.

SILOW, R. A. 1939. See HUTCHINSON, J. B. and SILOW, R. A.


Very different degrees of specific divergence are represented within the Asiatic diploid section of the genus *Gossypium*. Hybrids between *G. arboreum* and *G. herbaceum* are fully fertile in the F1 and only show breakdown in viability and fertility in the F2, but hybrids between these species and *G. anomalum* are almost sterile.

This paper deals with the inheritance of eight characters in hybrids obtained by backcrossing to the cultivated species. The genetic structure of the three species is compared in terms of the fifteen main loci involved, and their associated minor genes. The same main loci are represented in all three species, but different alleles may enter into the construction of homologous characters. A particular and unusual instance is afforded by the anthocyanin petal spot common in this genus. In the cultivated Asiatic cottons its characteristics are determined by a single allele; in *G. anomalum* they are the result of genes, situated in duplicate loci, which act as complementaries, a conception not to be confused with that involved in the more usual interpretation of complementary factors. Genetic support is given
to the contention, hitherto based on cytological grounds, that the diploid species are themselves derived from polyploids. The closely related species *G. arboreum* and *G. herbaceum* differ hardly at all in their main loci, but their modifier systems are quite distinct. *G. anomalum* shows a much wider divergence in main loci, and whilst in some characters the minor genotype is near that of either one or other of the cultivated species, in others it is very distinct from both.


Seven additional types of anthocyanin in cotton are described and shown to be controlled by members of an extensive allelomorphic system of which fourteen members are now known in *G. arboreum* and *G. herbaceum*. All seven types were found in China, six in field material, and the seventh as an anomaly in experimental cultures. The information relating to the genetical behaviour of this and similar series, whose manifold expressions do not conform to a single simple seriation, is reviewed from the stand-point of deciding between the alternative interpretations of close linkage and multiple allelomorphism with pleiotropy.


Three loci *Lc*<sub>1</sub>, *Lc*<sub>2</sub>, and *Lc*<sub>3</sub> carry the major genes determining lint colour in *G. arboreum* and *G. herbaceum*. Only one colour gene *Lc*<sub>1</sub><sup>k</sup> is known at the *Lc*<sub>1</sub> locus and this induces khaki coloration. At *Lc*<sub>2</sub>, a multiple allelomorphic series occurs, viz. *Lc*<sub>2</sub><sup>a</sup>, *Lc*<sub>2</sub><sup>b</sup>, *Lc*<sub>2</sub><sup>c</sup> and *Lc*<sub>2</sub><sup>d</sup>, the colours produced being khaki, medium brown, light brown and white respectively. *Lc*<sub>3</sub><sup>b</sup> is the only colour gene at the third locus and causes a light brown coloration similar to that produced by *Lc*<sub>3</sub><sup>b</sup>. The various genes react cumulatively and the resultant modes of expression are indicated.

*Lc*<sub>1</sub> is linked with *L*, the cross-over value being 28.7% within *G. arboreum* and 24.5% in *G. arboreum* × *G. herbaceum*. *Cu* lies approximately midway between *Lc*<sub>1</sub> and *L. Lc*<sub>2</sub> is linked with *Ha* (7% cross-over) and *Lc*<sub>3</sub> with *Ya* (24% cross-over).

In general, colour is associated with a decrease in lint length, a relation more likely physiological than a case of true gene pleiotropy. Seed size and lint quantity are less constantly associated with pigmentation, and here linkage with quantitative genes is assumed.

Lint pigmentation tends to be more frequent in the presumed centres of origin of the species and is regarded as a primitive feature. The modifier complexes are particularly important and appear to have been built up, in part, by the action of human selection. Part of the distinction between high and low level modifying complexes appears to be due to the presence or absence of factors on the *Pa* chromosome. The data on the distribution of colour genes are compared with those elucidated for tetraploid New World cottons.


All of the several taxonomic distinctions which have been
analysed in Gossypium up to the complete sterility level associated with full specific status, but below the level at which chromosomal rearrangements become important, can be accounted for entirely by the cumulative effects of many gene differences. Of any macro-evolutionary hiatus, in the orderly progression from geographic race to full species, there is no evidence whatsoever.

Twinning is much more common in Sea Island than in other cultivated cottons. Most Sea Island twins are diploid/haploid. Twins in Asiatic cottons are usually diploid/diploid. One case of twinning (diploid/haploid) has been reported in G. sturtii by Webber (1940).

A fourth main locus has been recognized in a strain of G. arboreum, viz. $Lc_4$ giving white lint and $Lc_4^k$ giving khaki. Further multiple allelomorphism at the $Lc_3$ locus has been demonstrated with the addition of $Lc_3^r$ to the series, this gives very light brown lint. Considerable modifier variability has been found in G. arboreum race indicum.
SILOW, R. A. 1945. See HUTCHINSON, J. B., SILOW, R. A. and STEPHENS, S. G.


Anthocyanin pigmentation in G. arboreum and G. herbaceum is determined by an extensive series of multiple alleles with pleiotropic effect upon several organs of the plant; 22 alternative anthocyanin patterns, behaving as unit complexes in inheritance, are now recognized. It is considered that anthocyanin development is controlled by a single gene of a complex nature, rather than by an allelic system of distinct genes.

A newly identified linkage involving anthocyanin ($R_a$) and a habit character (short branch) in the New World tetraploid cottons shows about 10% crossing-over. This linkage group is a duplicate of one previously reported by other workers, and its recognition as such gives further genetic support to the hypothesis of the amphidiploid origin of the New World cultivated cottons.
It is frequently maintained that in a polyploid variability is buffered by extensive masking between duplicates, so that the evolutionary potentialities of the organism are much reduced. The fact that the amphidiploid cottons are at least as variable as the diploid species has led to an examination of the theoretical concepts underlying this situation. Although certain characters in known allopolyploids do give duplicate or triplicate factor segregation, with respect to many other characters such organisms behave as diploids. Identical gene duplication in the sub-genomes of an amphidiploid is likely to be the exception rather
than the rule, as much on account of specific divergence which precedes hybridization, as on account of evolutionary changes which follow the induction of amphidiploidy.

There are no indications of any fundamental divergence between the anthocyanin loci, either in the respective presumptive parental diploid groups of species, or in the amphidiploid, but there are some indications of its early stages at the speciation level. In the case of the habit character, reduced fruiting branch, genes in the recessive phase at either of the two duplicated loci concerned can gain expression even when, as in nature, normal genes exist at the other locus. Here masking is completely absent. In cotton, subsidiary considerations make it possible to recognize the two habit characters as duplicates, even though diploidization has been carried almost to completion in this case. Examples are discussed of the type of functional divergence between alleles which, when translated from the diploid to the tetraploid condition, might lead to functional divergence between the genes at duplicated loci, so that masking would not occur. It is concluded that there is no reason to believe that amphidiploidy adversely affects the evolutionary prospects of an organism.


Evidence is insufficient to determine whether the lethal or semi-lethal crumpled abnormality is controlled by complementary alleles at a single locus or by complementary genes at different loci. $C_{Pa}$ is independent of $R_2$, $Y_a$ and $Ne$ and $C_{Pb}$ is independent of $L$. A table is given of the distribution of the crumpling genes amongst the Asiatic cottons, based upon a survey of the Trinidad Type Collection.


Covers the evolution and domestication of cotton.


SIMLOTE, K. M. 1949 a and b. See GADKARI, P. D. and SIMLOTE, K. M.

SIMPSON, D. M. 1923. See MARTIN, R. D., BALLARD, W. W. and SIMPSON, D. M.

SIMPSON, D. M. 1944. See POPE, O. A., SIMPSON, D. M. and DUNCAN, E. N.


A strain of Upland (Stoneville 20), highly resistant to bacterial blight under conditions of natural and artificial infection has been isolated. Resistance has been transmitted to selections from hybrids of Stoneville 20 and susceptible varieties and to their backcrosses, suggesting that the resistance factors can be introduced into varieties adapted to production in the various sections.
of the Cotton Belt. The Stoneville 20 strain, therefore, may be valuable for cotton breeders in areas where bacterial blight causes serious loss.


An extremely pilose Upland cotton, apparently a mutant, is described. The simple mendelian inheritance of the pilose condition indicates control by a single gene allelic to the glabrous condition, with the heterozygote definitely intermediate in pilosity. The pilose condition and short lint are considered to be pleiotropic effects of a single gene.


Relatively pure seed of seven varieties of cotton was planted at Knoxville, Tenn., for comparison with seed of the same varieties that had been produced by open pollination in a previous variety test comprising 25 varieties of Upland cotton. The excess yield of the crossed seed over that of the pure varieties ranged from 5.7 to 44.2%, with an average of 15.4%. The crossed seed also produced plants with larger bolls, larger seeds and higher lint indices.

Other seed and fibre characters were not significantly affected; in general, no deleterious effects from crossing were observed.

Two possible methods of the commercial utilization of partially hybrid seed are suggested. Experiments at Knoxville have shown that natural crossing among plants may normally reach 50%.


Deals with 110–Sanguineum.


Sparse lint is due to a single recessive gene.


Hybrids between Old World 
\(n = 13\) and New World \(n = 26\) cottons are rare and are usually sterile. They have 39 chromosomes. The 13 chromosomes of the Old World forms pair with half the chromosomes of the New World forms, the remainder are left as univalents. The evidence indicates that pairing takes place with the 13 chromosomes of the New World forms which remained as univalents in
the cross with the Old World forms. Both hybrids are slightly fertile. The same is the case with *G. thurberi*.

*G. aridum*, *G. harknessii* and *G. thurberi* offer the possibility of introducing into the New World cottons a xerophytic habit and resistance to disease.


Of two interspecific hybrids between Asiatic and New World cottons studied, one had $2n = 39$ and the other $2n = 52$. For the latter the inference is that a diploid egg from Asiatic cotton had functioned.

In a study of the somatic chromosomes of New World cotton it has been found that half of the chromosomes are small and the other half larger, the latter being comparable in size to the chromosomes of Asiatic cotton. The small chromosomes of New World cotton are of the same size as those in diploid wild species from North America. Species from the Old World and from Australia are all characterized by the larger size of their chromosomes.

In the first meiotic division it was seen that (1) at least 13 univalent chromosomes are present in both hybrids, and (2) the hybrid with 52 chromosomes shows the same chromosome conjugation as in a triploid Asiatic cotton, but with the addition of an extra set of 13 non-homologous chromosomes.

The conclusion was drawn that New World cottons are allopolyploid species. It is thought that these probably originated from a cross between two species of *Gossypium* both with $n = 13$ but possessing morphologically dissimilar and nonhomologous sets of chromosomes. The inference is that one of the parental species was an Asiatic cotton, or a very closely allied type, while the other was probably a New World species characterized by its smaller chromosomes.


*G. davidsonii* ($n = 13$), a wild species from California, has smaller chromosomes than *G. sturtii* ($n = 13$), a wild species from Australia. This difference in chromosome size is maintained in the hybrid, and enables a distinction between the paternal and the maternal chromosomes to be made.

The chromosome pairing in the hybrid is incomplete, but allo-syndesis takes place about nine times more often than auto-syndesis. Univalents are just as frequent between the small chromosomes from *G. davidsonii* as between the larger chromosomes from *G. sturtii*.

The chiasma frequency is the same in the pure species despite the difference in chromosome size. Contrasted with the pure species, the chiasma frequency in the hybrid is significantly smaller in the bivalents containing a *davidsonii* and a *sturtii* chromosome.


Hybridization experiments have been carried out between
the following groups with the exception of (h) and (i): (a) *G. aridum* (*Erioxylum*); (b) *G. armourianum*; (c) *G. davidsonii*; (d) *G. trilobum*; (e) *G. sturtii*; (f) *G. stocksii*; (g) *G. anomalum*; (h) Asiatic cottons; and (i) New World cottons.

Of the 85 possible combinations, one has not been tried and 6 have so far been unsuccessful. The results include empty seeds (9 combinations), hybrids dying in the cotyledon stage (3 combinations), partly fertile hybrids (4 combinations) and sterile hybrids (12 combinations).

Within the species with 13 chromosomes, Asiatic cottons, *G. anomalum* and *G. stocksii* form one group, and *G. armourianum* and *G. aridum* another, *G. trilobum* probably occupying an intermediate position. Apparently *G. davidsonii* and *G. sturtii* represent two separate side groups.

Hybrids between New World cottons (*n* = 26) and the species with *n* = 13 are usually much easier to produce than hybrids between the species with *n* = 13. So far, only three of the hybrids from the present study have been sufficiently fertile to afford material of use to the practical plant breeder. These all have 2*n* = 39, the parental species being New World cottons (*n* = 26) and the wild species *G. aridum*, *G. armourianum* and *G. trilobum* with *n* = 13 from America.

A haploid *G. davidsonii* was obtained in hybridization experiments with *G. trilobum*.

Further reasons for the inclusion of the genera *Thurberia* and *Erioxylum* in the genus *Gossypium* have been advanced. On cytological, genetical and morphological grounds it is considered that all the species and groups mentioned form a natural genus.


The chromosome numbers of about 120 species representing 25 genera of the family Malvaceae are described. The following chromosome numbers were found: 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 21, 22, 25, 26, 28, 33, 35, 36, 38, 39, 42, 46, 56 and 65.

Evidence is presented in favour of the following chromosome series: (a) a five series (5, 10, 15, 25); (b) a six series (12, 18, 36); (c) a seven series (7, 14, 21, 28, 35, 42, 56); (d) an eleven series (11, 22, 33); and (e) a thirteen series (13, 26, 39, 65).

In most genera, all species examined are members of the same chromosome series. Some genera, however, contain different chromosome series.


The following new interspecific hybrids were recorded: *G. armourianum* x *G. aridum*, *G. armourianum* x *G. trilobum*, *G. sturtii* x *G. armourianum*, *G. anomalum* x *G. trilobum*, and New World cottons x *G. anomalum*. The two first-mentioned hybrids are partly fertile.

Chromosome conjugation was studied in these hybrids and in those described earlier. Results obtained from the average chromosome conjugation in about twenty pollen mother cells in each hybrid are summarized.

Subdivision of the genus *Gossypium* in the following three cytological groups was confirmed: (A) species with 2*n* = 26 from
America and the neighbouring Pacific Islands, (B) species with $2n = 26$ from Africa, Asia and Australia, and (C) New World cottons with $2n = 52$ from America and Islands in the Pacific Ocean.

Secondary pairing in American wild species indicates that 6 is the basic chromosome number.


Hybridization and grafting experiments have been carried out involving 26 species of Hibiscus, 18 species of Gossypium, and 1 species of each of the following genera, Kosteletzya, Cienfuegosia, Thebesia, and Gossypioides. No intergeneric hybrids were obtained. The classification of the genus Hibiscus is discussed in the light of the various relationships indicated by the data of the hybridization and grafting experiments.

The hybrids obtained by crossing G. klotzschianum with G. davidsonii, G. stocksii, G. anomalum and the F₁ hybrid G. barbadense x G. arboreum, are described, and the result of all the hybridization work with the 18 species of Gossypium are summarized diagrammatically. The interrelationship of the different Old and New World species is discussed, and a diagram is presented illustrating the probable course of their evolution.


Studies of a number of varieties of cotton showed that in most cases increased oil content of the seeds is accompanied by increased gossypol content. As a preliminary to the identification of forms with a low gossypol content, a study of varietal differences in this characteristic was made and a positive correlation was observed between the number of glands present in histological sections of seeds and the percentage content of gossypol in the different varieties. This finding could, it is suggested, be used as a method of selecting plants with a low gossypol content.

The gossypol and oil content of individual plants of a variety differed little; but plants of the same variety, grown in different localities, exhibited variation in their chemical composition. As regards species differences, figures are cited showing that varieties of G. herbaceum contain the least gossypol, a low oil content and a high percentage of protein, while forms of G. barbadense apparently have a high oil content.


Cotton varieties of the southeastern United States vary widely in root knot (Heterodera marioni) resistance. Resistance to root knot appears to be associated with wilt (Fusarium) resistance, but this association does not always hold.

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The variety Empire covers a wide range in wilt resistance, showing that resistant lines can be obtained.


A method of assessing root knot (*Heterodera marioni*) attack is given and it is shown that Coker 4 in 1–5 evinced significant root knot resistance at three sites, compared with five other cotton varieties.


It is noted, *inter alia*, that of 25 cotton varieties tested, all proved susceptible to *Ascochyta gossypii* in the seedling stage. Empire has mature plant resistance and this variety appeared somewhat less susceptible in the seedling stage than the other varieties.

Smith, E. G. 1940. See Kearney, T. H., Peebles, R. H. and Smith, E. G.


Crosses between a smooth-budded variant and normal Pima (*G. barbadense*) gave intermediate bolls in the *F*₁ and 1 pitted *BB* : 2 intermediate *BbBb* : 1 smooth *BbBb* in the *F*₂. In backcrosses 1 : 1 segregation obtained. *Bb* and *Bb* are allelo-morphic.

Smith, E. G. 1943. See Peebles, R. H. and Smith, E. G.


The ideal type for mechanical harvesting appears to be a plant with relatively short but numerous fruiting branches with short nodes, no vegetative branches, an open type of growth, light foliage, moderate storm resistance and large strong bolls borne singly, with a peduncle which will snap easily under tension, but which will stand considerable plant agitation.


Basic requirements of a mechanical cotton harvester are outlined, and various plant characteristics that affect machine operation are listed. It is pointed out that an ideal plant type for all methods of harvesting is one having relatively short-noded fruiting branches 8 to 10 inches long, no vegetative branches, an open type of growth, light foliage, storm resistance and a medium to large strong boll borne singly on a peduncle that will snap easily under tension but will withstand plant agitation. Reference is made to suitable strains recently developed by cotton breeders at the Texas Station and to tests with the Texas Station harvester, which is of the stripper type.

1022. Soyer, L. 1933. (Note on the progress achieved in the methods of selection of cotton in the
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Colchicine treatment was given to (1) newly germinated seeds, (2) plumules in the cotyledon stage, (3) apical buds of the main stem, (4) flower buds and (5) young bolls. Success was obtained with (1) using seeds on the second day after germination, immersing from 1–2 days in aqueous 0.025% colchicine, washing and planting out. Treatment (2) was also successful and the best concentration was found to be 0.5–1.0% colchicine, applied with a small brush to the plumule just as the first leaf was on the point of unfolding. 10–25 drops were applied singly allowing time to dry between each drop.

A tetraploid *G. arboreum* was made, also a hexaploid cotton from a hybrid of *G. barbadense* x *G. raimondii*.


Meiotic studies of a colchicine-produced tetraploid, *G. arboreum* var. *neglectum* (4n = 52), gave further support to the hypothesis that diploid *Gossypium* species are secondary polyploids.

Female gametes of the tetraploid were 40–50% fertile. This figure is in agreement with the expected fertility of the male gametes as calculated from the proportion of 26 chromosome plates found at metaphase II. Pollen fertility was lower than this owing to poor germination, or slow pollen-tube growth of many apparently viable grains.

The tetraploid, when used as female parent, crossed readily with several wild diploid and New World (n = 26) species.
Their compatibility relations are discussed.

Studies of metaphase I in the triploid hybrids, tetraploid x G. armourianum, tetraploid x G. raimondii and tetraploid x G. sturtii, showed that on the average less than one trivalent was formed per pollen mother cell. Homologies between Asiatic and wild diploid species are therefore very low. Furthermore, G. sturtii chromosomes are not closely homologous with either Asiatic or American diploid chromosomes.


An autotetraploid specimen of G. arboreum (genom AAAA) has been crossed with G. sturtii (CC) and a triploid (AAC) produced. The latter was treated with colchicine and the pollen of the resultant flowers applied to G. barbadense (AADD). One completely sterile 52-chromosome hybrid was obtained which is believed to have received the AC genom from the pollen parent. Its chromosome complement is therefore presumed to be Aacd. At meiosis, the hybrid exhibited an average of 11.8 ± 0.8 univalents per pollen mother cell and it is concluded that the A genomes pair, but that a very low degree of association exists between the C and D genomes. This result would suggest that G. sturtii is not the American ancestor of the New World tetraploid cottons.


The possible phylogenetic origin of American tetraploid cottons is discussed. It has been found that the leaf morphology and developmental tracks of the F1 hybrids, G. arboreum x G. raimondii and G. herbaceum x G. raimondii, correspond closely to those of tetraploid American types. Consequently, the author suggests that the latter forms have probably arisen by chromosome doubling in crosses between diploid American and Asiatic species. In this case, the genes L and l of the tetraploid forms would be identical with the gene complexes L + X and l + X respectively, where L and l are the alleles of the Asiatic species and X a presumed entire leaf gene of the diploid American ancestor. General morphological considerations indicate that either G. klotschianum or G. raimondii might produce hybrids resembling the present-day tetraploid cottons.


Leaf shape in Gossypium is controlled by series of multiple alleles.

By plotting logarithmically the dimensions of fully expanded leaves at successive nodes on the main stem, characteristic 'developmental tracks' are constructed for each allele. Developmental tracks of all lobed-leaved types in the genus can probably be
induced to pass through three phases:

A. A linear phase, in which leaf length, sinus length and lobe width develop at equal rates \((K = 1)\). During this phase the leaf is entire.

B. A transition phase in which development of leaf length and sinus length show nonlinear relationship. During this phase sinus fields, i.e. localized areas of restricted growth, are established in the leaf primordia \((K \text{ values vary continuously})\). As a result the entire is converted into a lobed pattern.

C. A second linear phase in which leaf length, sinus length and lobe width develop allometrically \((K \text{ stabilized at } <1)\). In this phase each allele has its characteristic \(K\) value.

Entire-leaved types remain in phase A during their normal developmental \((\text{preflowering})\) period. In the New World amphidiploids and in \(G. \text{ thurberi}\) and \(G. \text{ anomalum}\) development is normally arrested during phase B. In the Asiatic cultivated types phases A and B are completed in the early seedling stages and development continues in phase C.

A mathematical relationship between leaf growth and leaf development is demonstrated. The latter may be regarded as a recapitulation of the former; complete recapitulation in the case of entire-leaved types, modified recapitulation in lobed leaved types.

The alleles which control this growth and developmental mechanism do so by varying the rate and extent of change in leaf pattern, and also by varying the timing of the pattern change initiation in relation to the general developmental processes of the plant. An evolutionary sequence is suggested.

**Stephens, S. G. 1944.** See Hutchinson, J. B. and Stephens, S. G.

**Stephens, S. G. 1944.** See Silow, R. A. and Stephens, S. G.


The compatibility of tetraploid \(G. \text{ arboreum}\) with other Old World species, and the cytology of two resulting triploid hybrids is reported.

Crosses within the Old World group and within the American group may be considered potentially compatible. Crosses between Old World and American species are easily obtained but the hybrid zygote nearly always fails to develop.

The degrees of metaphase I pairing found in synthesized triploid hybrids form a quantitative series, ranging from Skovsted’s Asiatic autotriploid to the allotriploid, tetraploid Asiatic \(\times G. \text{ armouriannum}\). This suggests that the gradual quantitative change shown by Silow (1944) to be responsible for speciation in the \(arboreum-\text{herbaceum-anomalum}\) group is a process which has been continued throughout the genus, and that gross structural changes have been superimposed on the basic mechanism.

The relationship between \(G. \text{ stocksi}\) and other Old World species is still obscure, since the cytological evidence conflicts with other sources of information.

Evidence is presented which suggests that \(G. \text{ anomalum}\) may be regarded as a species bridging
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the Old World and American groups.


An extensive genetic survey of New World cations has shown that leaf shape is controlled by a single multiple allelomorphic series having a minimum of four members, L^b, L^o, L^c and I.

The interspecific distribution of the four distinct alleles is considered in relation to the evolution of New World cations.


On transference from a late to an early flowering background, the action of the leaf shape alleles is accelerated, but as a compensatory effect, the period of development is reduced. If compensation were exact the shape of the climax leaf would be unaffected by change in flowering habit. In the cases studied, however, overcompensation and undercompensation occur, so that the shape of the climax leaf is ‘shifted.’

In interspecific crosses involving different leaf shape alleles, transgressive segregation of genes controlling flowering habit in the *F_2* is associated with transgressive segregation in rate of leaf shape development. Consequently measurements of climax leaves show increased variability, frequently leading to intergradation of the main leaf shape classes.

The fact that flowering habit has been a character of undoubted selective value during the evolution of cotton under domestication, whereas any selective value of leaf shape *per se* has yet to be proved, shows that modifiers are not necessarily genes of minor importance, their modification of the expression of another gene being only one of several possible pleiotropic effects. Neither is there any a priori reason to suppose, in the absence of any understanding of the physiological processes which they control, that modifiers have individually small effects.

1036. STEPHENS, S. G. 1945 d. Canalization of gene action in the *Gossypium* leaf-shape system and its bearing on certain evolutionary mechanisms. *J. Genet.*, 46, pp. 345–357. (Condensed from Author’s summary).

A phenogenetic analysis of leaf shape expression in the genus *Gossypium* suggests that the leaf shape alleles are members of a single canalized system. The system appears to be composed of five alternative developmental tracks, the courses of which are but slightly affected by changes either in environment or in the rest of the genotype. The final phenotypic expression attained, however, may be considerably modified by such changes. The chief modifying mechanism appears to be retardation or acceleration of the actions of these alleles in relation to development of the plant.

Characters dependent on a canalized system of development may be expected to show a restricted capacity for modification, though the number of phenotypic variants possible may still be considerable. The effects of such restriction are considered in relation to two evolutionary
phenomena: (a) the expression of dominance, (b) the occurrence of nonadaptive trends. Both phenomena would be expected as a result of natural selection acting on characters controlled by canalized systems.

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**STEPHENS, S. G. 1945.** See **HUTCHINSON, J. B., SILOW, R. A. and STEPHENS, S. G.**

**STEPHENS, S. G. 1945.** See **HUTCHINSON, J. B., STEPHENS, S. G. and DODDS, K. S.**

**1037. STEPHENS, S. G. 1946.** The genetics of 'corky.' I. The New World alleles and their possible role as an interspecific isolating mechanism. *J. Genet.*, **47**, pp. 150–161.

Corky symptoms depend on the interaction of complementary alleles, *ckx* carried by *G. hirsutum* var. *marie-galante*, and *ckY* carried by the *G. barbadense* parent. True breeding corky types cannot therefore be isolated.

A geographic survey of the two species shows that the corky complementary alleles are most common in types occurring in, or originating from, areas where the geographical ranges of var. *marie-galante* and *G. barbadense* overlap and where the two species have been grown in mixed cultivation. It is suggested that this association is the result of seed selection by man in a partially outcrossed population.


Crossing between *G. arboreum* and *G. davidsonii* produced only inviable embryos. Partially fertile allotetraploids were synthesized from *G. arboreum* x *G. anomalum*, *G. herbaceum* x *G. anomalum*, *G. arboreum* x *G. stocksii* and *G. herbaceum* x *G. stocksii*. The article also deals with chemical studies of the anthocyanin alleles in Asiatic cotton, and with possible pseudo-allelism in the crinkle-contorta series.


Covers breeding and genetical work in Texas, Mississippi and North Carolina.

**STEPHENS, S. G. 1947.** See **HUTCHINSON, J. B., SILOW, R. A. and STEPHENS, S. G.**


The table (p. 207) summarizes the present cytological classification of *Gossypium*.

This table has been adapted from the work of Skovsted (1937) and Beasley (1942) and follows the classification of Hutchinson (1947).

Harland (1935) considered that the New World allotetraploids originated in Polynesia before the establishment of the Pacific Ocean in its present form. Hutchinson and Silow (1947) consider South America to be the most likely centre of origin of the amphidiploids. Hutchinson and Stephens (1947) suggest that cultivated Asiatic cottons were carried by an early civilization across the Southern Pacific to the New World in prehistoric times and that natural hybridization between this cultivated crop and a wild American species gave rise to the first amphidiploid.
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<table>
<thead>
<tr>
<th>Primary group</th>
<th>Location</th>
<th>Genome class</th>
<th>Chromosome size</th>
<th>Gametic chromosome number</th>
<th>Species</th>
</tr>
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<tbody>
<tr>
<td>Old World</td>
<td>Asia</td>
<td>A₁</td>
<td>large</td>
<td>13</td>
<td><em>G. herbaceum L.</em> (Cultivated)</td>
</tr>
<tr>
<td></td>
<td>Asia</td>
<td>A₂</td>
<td>large</td>
<td>13</td>
<td><em>G. arboreum L.</em> (Cultivated)</td>
</tr>
<tr>
<td></td>
<td>Africa</td>
<td>B₁</td>
<td>medium</td>
<td>13</td>
<td><em>G. anomalum</em> Wawr. and Peyr.</td>
</tr>
<tr>
<td></td>
<td>Australia</td>
<td>C₁</td>
<td>very large</td>
<td>13</td>
<td><em>G. sturtii</em> F. Muell.</td>
</tr>
<tr>
<td></td>
<td>Indo-Arabia</td>
<td>E₁</td>
<td>large</td>
<td>13</td>
<td><em>G. stocksii</em> Tod.</td>
</tr>
<tr>
<td>American</td>
<td>N. America</td>
<td>D₁</td>
<td>small</td>
<td>13</td>
<td><em>G. armourianum</em> Kearney</td>
</tr>
<tr>
<td></td>
<td>N. America</td>
<td>D₂</td>
<td>small</td>
<td>13</td>
<td><em>G. karknessii</em> Brand.</td>
</tr>
<tr>
<td></td>
<td>Galapagos and</td>
<td>D₃</td>
<td>small</td>
<td>13</td>
<td><em>G. hiotachinianum</em> Anders.</td>
</tr>
<tr>
<td></td>
<td>N. America</td>
<td>D₄</td>
<td>small</td>
<td>13</td>
<td><em>G. aridum</em> (R. &amp; S.) Skovsted</td>
</tr>
<tr>
<td></td>
<td>S. America</td>
<td>D₅</td>
<td>small</td>
<td>13</td>
<td><em>G. ramosi</em> Ulb.</td>
</tr>
<tr>
<td>New World</td>
<td>N. America</td>
<td>(AD)₁</td>
<td>13 large:</td>
<td>26</td>
<td><em>G. hirsutum</em> L. (Cultivated)</td>
</tr>
<tr>
<td>and Polynesia</td>
<td>S. America</td>
<td>(AD)₂</td>
<td>13 small:</td>
<td>26</td>
<td><em>G. barbadense</em> L. (Cultivated)</td>
</tr>
<tr>
<td></td>
<td>Hawaii</td>
<td>(AD)₃</td>
<td>13 large:</td>
<td>26</td>
<td><em>G. lomentosum</em> Nutt.</td>
</tr>
</tbody>
</table>


The pseudallelic anthocyanin series in Asiatic cottons depends on the interaction of at least three neighbouring loci, two of which (*G* and *S*) govern the presence or absence of a spot at the base of the petal and its pigmentation when present. When both *G* and *S* genes are present, there is a red spot at the base of the petal; when *G* alone is present the spot is white; when *G* is absent the petal is spotless.

Studies of pigment development in the petal favour the hypothesis that *G* converts a yellow pigment to a leuco substance, and that *S* further converts the leuco substance to a red pigment.

Chemical studies of the flower pigments show that the primary yellow pigment in the flower is the anthoxanthin, quercetin, and the primary red pigment is the structurally analogous anthocyanin, cyanidin. The leuco substance can be converted *in vitro* by reduction to cyanidin, and furthermore the naturally occurring anthoxanthin can be reduced *in vitro* to cyanidin via an intermediate leuco substance.

Genetic and chemical evidence combined therefore suggest that the leuco substance is an intermediate stage and a probable common precursor in the natural syntheses of both anthoxanthin and anthocyanin in the petal.
If this interpretation is correct the following situation is indicated:—two genes, \( G \) and \( S \), situated in neighbouring loci control similar reductional processes and act on very similar though not identical substrates (leuco substance and anthoxanthin). This would suggest that the loci arose by duplication from a common ancestral locus, and that in the process of duplication, or as a direct result of it, specificity was developed, so that the daughter loci lost both their cytological and biochemical homology and became qualitatively new loci.

The possible evolutionary significance of these studies is briefly discussed.


Spectrophotometric evidence is presented which suggests that the leuco substance present in the petals of Asiatic cottons is identical with the colorless intermediate product obtained in the reduction of quercetin to cyanidin *in vitro*. This agrees with genetic and developmental evidence, reported previously (1948 \( a \)), that the leuco substance, present in young flower-buds, is a common precursor of both anthoxanthin and anthocyan pigments in the flower petals and convertible to either quercetin or cyanidin by a single, genetically controlled chemical step.


Neighbouring loci concerned with anthocyanin pigmentation of the cotton flower control similar chemical processes but act on slightly different substrates. This suggests they originated as repeats accompanied by divergence in function (Stephens 1948 \( a \), 1948 \( b \)). A study of a second, genetically independent system controlling anthoxanthin pigmentation can be interpreted similarly, although cytological support is still lacking. A pseudallelic basis is probable, however, as two genes apparently control the production of isomeric pigments, and in combination, produce a third pigment which structurally may be regarded as an internally compensated “hybrid” of the two isomers. The “hybrid” pigment is also produced independently by a third, dominant, member of the pseudallelic series. Divergence in function of loci has apparently accompanied speciation.


There is considerable selective elimination of the donor parent genotype in interspecific backcrosses involving *G. hirsutum* and *G. barbadense*. In the first backcross the elimination, primarily gametic, is operative both in pollen and ovules.

The selective elimination can be detected by the significant skewness of specific monofactorial segregations and also by the cumulative tendency for the recurrent parent genotype to be recovered more rapidly than expected as a result of random segregation and recombination.
Of four loci which showed selective elimination, two are suspected on independent grounds to be carried on structurally differentiated chromosomes.

The results are not explicable by interspecific differentiation based on freely assorting modifier systems, but require some form of internally balanced polygenic complexes.

It is considered that the so-called polygenic complexes may be structurally differentiated chromosome segments.


Suggests using marked Asiatic stocks crossed with New World wild diploids in the formation of synthetic amphidiploids. These marked amphidiploids should then be crossed with multiple dominant and multiple recessive New World (AD) stocks for first cross and backcross respectively. By this means it should be possible to allocate several New World genetic loci to their correct (A or D) subgenoms.

1046. STEPHENS, S. G. 1950 a. The genetics of 'Corky.' II. Further studies on its genetic basis in relation to the general problem of interspecific isolating mechanisms. J. Genet., 50, pp. 9-20. (From Author's summary).

Further data are presented in support of the writer's previous finding (1946) that the corky complementary genes in New World cottons are not located at independent loci. Comparison with analogous, more critically analysed cases suggests that the complementary genes are pseudoalleles.

The corky complex is located on the same chromosome in the D genome as the crinkle/contorta series, and no critical evidence of crossing-over between them has yet been obtained. It is suggested that the crinkle/contorta series may also have a pseudoallelic basis.

A reexamination of the complementary crumpled mechanism in Asiatic cottons (A genom) shows striking genetic and phenotypic similarity to the corky mechanism, and suggests that the two complexes have a similar pseudoallelic basis. In spite of their close similarity there is, as yet, no critical evidence that crumpled and corky are duplicates.

A survey of similar complementary mechanisms in Crepis and Triticum/Aegilops hybrids in comparison with crumpled and corky suggests that they all may have a similar basis, and may have played a part in interspecific isolation during one phase of their respective evolutionary histories. Reasons are given for the opinion that complementary isolating mechanisms are more likely to be built up from pseudoallelic complexes than from independent loci.


The literature concerning speciation in Gossypium is critically reviewed. It is concluded that both multiple gene substitution and cryptic structural differentiation of the chromosomes have determined the building of species. Methods of testing for cryptic structural differentiation are suggested. The success to be expected in transferring potentially valuable characters
from one species to another will be inversely proportional to the frequency of small scale structural differences in the breeding material.


The most common causal organisms are *Nematospora coryli* and *Ashbya gossypii*. By using a method of artificial inoculation of the bolls, it has been possible to select successfully for resistance in Upland types.


Gives descriptions with illustrations of twenty types of cotton.


Reference is made to the adaptation of cotton plants to saline conditions which is expressed externally by the bleaching of the chlorophyll in the isolated leaves treated with salt solutions, this test being a useful indication of the adaptation of different varieties.

A study is reported of the influence of this adaptation upon the seeds, i.e. upon the next generation. Cotton varieties grown on soils of varying salinity were used in the experiments. It is concluded from the results that seeds from plants grown under saline conditions and the plants which develop from these seeds do not show increased salt resistance.


A study of sixteen Texas varieties of cotton which ranged in ginning outturn from 42.8 to 29.7%, and in length from 14 in. downwards. 5-lock bolls outweighed 4-lock bolls in almost all cases. All the types showed a positive correlation between yield and the proportion of 5-lock bolls.


Two factor pairs, $Y_1Y_2$ and $Y_3Y_4$ govern yellow seed leaves versus green. The expression of "pattern," which ranged from a seedling with distinct areas devoid of chlorophyll to one which has a small amount of chlorophyll throughout the leaf, is due to two ($C_1C_2$) and possibly three ($C_3$) different genetic factors. It is possible that two of these factors are linked. The amount of cross fertilization in cotton in the field at the station in 1924 was estimated to be 2.46%.


Covers correlation studies on lint per boll, ginning outturn, number of 5-lock and 4-lock bolls, number of monopodia, number of sympodia, and height in Upland cotton.

1054. STROMAN, G. N. 1934 a. Cotton breeding investigation 1928 to


The observations were made on a supposedly natural cross between *G. hirsutum* and *G. barbadense*. Two genes (P and B) determine yellow pollen colour. These are assumed to be controlled by an inhibitor, I, capable of suppressing either P or B when alone, but not P and B together.


A recessive, female sterile rogue common in Acala 8, was shown to be due to a single gene for which no symbol was suggested.


Four strains of Acala have been distributed. Strain tests are summarized for 1942–45.


Numerous simple, partial and multiple correlation coefficients were calculated for characters in related progenies. Ginning out-turn and lint index were positively correlated each year. Other significant correlations varied as to degree and relationship from year to year.


With regard to wilt (*Verticillium*), immune varieties have a firm pith of small cells and medullary rays of many layers always filled with reserve starch, whereas susceptible varieties have a loose-textured pith and inconspicuous medullary rays of one or rarely two to three layers with little starch. Selection based on these anatomical distinctions is recommended for breeding work.

Varieties susceptible to gummosis (*Bact. malvacearum*) diffused more organic matter into water than did resistant varieties when fresh uninjured leaves of both were immersed in distilled water at 30° C. The diffusion from young leaves of susceptible varieties was higher than from old, and increased with increase of temperature while both factors were without effect in resistant varieties. Rapidity of ageing of the leaf tissues and consequent reduction in diffusion of organic matter may possibly be a factor in determining resistance.

Fertile hybrids between *G. hirsutum* and *G. herbaceum* and between *G. vitifolium* and *G. herbaceum* are recorded.


Diploid chromosome numbers of 20–26 are given for Ishan (*G. vitifolium*), 18–22 for Baronéli, 20–26 for Koriba (*G. punctatum*) and about 20 for *G. arboreum-sanguinolentum*.

The hybrids Ishan x Karunganni (*G. herbaceum-indicum*) had 20–26 and Ishan x Saria (*G. punctatum*) 22–26.

These results confirm the opinion of Symanek and Gavaudan (1932), of the existence of polyploidy within *Gossypium* species.

The *G. vitifolium* x *G. punctatum* hybrid is said to be more resistant to climatic changes, diseases and pests, with lint sometimes better than the parents.

The hybrids again resemble the female more than the male parent.


Interspecific crosses were made between the varieties Hartsville and Allen of *G. hirsutum*, and the varieties Karunganni and Garo Hills of *G. herbaceum*. A few abnormal fruits were formed when Hartsville was used, and perfectly normal F₁ plants were produced. The crosses with Allen were not successful. The characters of *G. herbaceum*, which was used as female, predominated but the characters of the other species were observable in the boll form and lint quality.

Chromosome counts were made on the parents and hybrid revealing 10–13 haploid chromosomes in *G. herbaceum*, 20–26 diploid in the Hartsville variety of *G. hirsutum* and 12 haploid in the F₁ hybrid. A self-fertilized line of Allen also showed 20–26 diploid chromosomes, as in Hartsville, whereas the unselected Allen had this number in the haploid stage and as many as 50 in the somatic tissue.


It is claimed that F₁ hybrids of *G. hirsutum* x *G. herbaceum* and *G. vitifolium* x *G. herbaceum* which resembled *G. herbaceum*, according to an earlier account, now show traces of the male parents.


Advocates wiring or girdling of the stem in crosses between Asiatic and Upland, to increase nutritive material available for the growing seed.


Deals with the effect of ringing or wiring of the flowering branches of the female parent, upon the production of hybrid seed. In crosses between *G. herbaceum* and *G. hirsutum*, ringing or wiring gave better results than the control. The best
results were given by ringing. By this method 56.4% hybrid seed was obtained from the cross *G. herbaceum* (♀) x *G. hirsutum* (♂) in contrast with 35.5% from the control cross, and 15.0% hybrid seed was obtained from the reciprocal cross in contrast with 2.1% from the control. If *G. herbaceum* was used as female and *G. hirsutum* as male, only empty seeds were produced. In the reciprocal crosses, however, some viable seeds were obtained.


A list of 2,116 species of plants is arranged alphabetically by Latin names under each family. The ratings for cotton root rot, shown in the list, are based on the percentage of plants which developed visible disease symptoms when exposed to infection under favourable conditions.


A mutation occurred in Upland in 1933, giving rise to waveness of the cotyledons, young leaves and hypocotyl.


The percentage of outcrossing between green-leaved and red-leaved varieties was 0.69% and 1.01% in two trials in 1937, and 0.90% and 2.23% in 1938. The proportion of vicinism varied in the three periods 10–11 a.m., 11–12 a.m. and 12–1 a.m., being highest in the first.


The effects of pollination by a limited number of pollen grains were observed, in order to study the qualitative character of the male gametes. Up to 20 pollen grains were transferred to a stigma; the number of seeds formed was found to vary between 8 and 15 per boll. The varieties were C–15 (Upland) and 35–1 (Egyptian). The *F*₁ plants so obtained consisted of plants inferior to the controls in respect of all characters and others excelling the control plants. No segregation was observed in the *F*₂. The author ascribes the nature of the *F*₁ population to the qualitative heterogeneity of the male gametes.
of a single flower, and the lack of segregation in the $F_2$ to the effect of intra-floral hybridization, and is of the opinion that the so-called method of limited pollination may be applied in practical breeding to improve a variety or to obtain a new strain from an existing variety in a short time.


Two experiments are described showing how grafting can improve cotton. In the first experiment, $F_1$ Egyptian x American hybrids, while still young, were grafted on Egyptian stocks. The $F_2$ seed generation did not exhibit excessive segregation, and even in the $F_3$ generation there were several fertile plants of the Egyptian type which were superior to normal Egyptian strains. In the second experiment, Peruvian cotton, which in Tashkent is late and poor yielding, was grafted on to the $F_1$ American x Egyptian hybrid. Seed of the $F_1$ generation produced high-yielding early plants.


By pollinating one type of cotton with pollen from two other varieties, hybrids were obtained combining characters from all three parents. The female parent Bolgarka (Bulgarian) 78, an American cotton ($G. hirsutum$), had the recessive characters of green colour, low height and absence of petal spot. The first male parent was the Krasnolistyi (Red Leaf) 1677 variety ($G. hirsutum$) whose principal dominant character was the dark red colour of the leaves, stem and margins of the corolla. The second male parent was the Egyptian cotton ($G. barbadense$) variety 35–1. Its dominant features were long internodes, strong petal spot and bright yellow stamens.

The $F_1$ hybrids had the height, long internodes and yellow stamens from one male parent and the character of intermediate red colour of all parts of the plants from the other. Unlike the ordinary $F_1$ hybrids between the American and Egyptian cottons, whose flowers contain traces of anthocyanin, the $F_1$ hybrids obtained as a result of triparental fertilization had no petal spot. Furthermore, the character of the seed bolls of the $F_1$ resulting from triparental fertilization differed from that of the $F_1$ from the cross between Bolgarka 78 and Krasnolistyi. More evidence of the participation of both male varieties in the fertilization process is furnished by the $F_2$. Similar results are reported in triparental fertilization experiments with the American cotton variety 18819, which was pollinated with the pollen of a variety having red leaves and another in which the cotton was brown.


Previous investigations of
multiparental crosses have been continued, the most recent results suggesting that the growing embryo assimilates substances supplied by the pollen tubes during the process of fertilization.

The material comprised *G. hirsutum* varieties. The female, 18819, had the recessive characters of green palmatifid leaves and white lint. It was pollinated with 10 pollen grains of a red-leaved white-linted variety, 1677, and, four hours later, with larger amounts of pollen of the variety S-4006. This variety had a palmatisect leaf and brown lint.

The *F₁* from the cross segregated four hybrid types, two of which showed the characters of both male varieties in respect of leaf shape and colour and cotton colour. As a result of selfing the types possessing the characters of both male varieties, 627 plants were obtained in the *F₂*. Of these 549 were normal hybrids between the initial female variety and one or the other male parent, while 78 hybrids showed characters of both male varieties participating in the original cross. It was remarkable that the *F₂* from the hybrids of the type 18810 x 16772 in the *F₁* included 27 plants which had characters of both the male parents.

Three distinct types of hybrids with the characters of both male varieties are described. Their individual selections in the *F₂* gave uniform families in the *F₃*.

Similar changes in morphological and economic characters were obtained in experiments with the green-leaved variety 108F which was pollinated with two grains of self pollen and with large amounts of pollen of the red-leaved variety four hours later.


In crosses between Upland cottons, naked-seeded cottons with low amount of lint (Ab) crossed with fuzzy types having a high amount of lint (aB) gave a naked high *F₁* and in the *F₂* segregated into 2 naked high (AB) : 1 naked low (Ab) : 1 fuzzy high (aB) : 0 fuzzy low (ab).

The lint colour gene from Texas Rust (C) was independent of A and B.

Red coloration (G) from Red Leaf Upland was found to be linked with cluster (d). The *F₂* figures totalled: 136 red non-cluster (GD) : 48 red cluster (Gd) : 73 green noncluster (gD) : 0 green cluster (gd).

Linkage was also noted between the B and G loci.


The entirely naked seed of the Upland variety No Lint is fully dominant over fuzzy seed and segregates into a simple 3:1 ratio in the *F₂*.

The partial fuzz typical of Egyptian cotton seed, when crossed with fully fuzzy American Upland gave no clear ratios in the *F₂*.

Yuma Egyptian cotton has an almost naked seed except for small tufts at the ends which extend along the raphe. Crossed with Upland, this gave an *F₂* comprising 3 plants entirely naked: 5 almost naked, but with a little fuzz at one end: 10 with Yuma type of seed: 10 entirely fuzzy (green felted): 10 plants entirely fuzzy (woolly).

The Upland variety No Lint has a lint index ranging from 0 to 1 (compared with 3.0–5.5 for
the other American varieties) and a ginning outturn of 0–10% (compared with 26–36% for the others). In crosses between No Lint and Lonestar, Texas Rust, Red Leaf and Acala, 3 : 1 ratios of high amount of lint to low amount were obtained in the F₂.

“This ratios indicate that a single factor is involved in this pair of characters, and expectations were fulfilled in the F₃ generation.”

In crosses between Sea Island and Upland, Egyptian and Upland, and also within the Upland group, long staple was dominant over short in the F₁ generations.


From over 4000 pollinations between Old and New World cottons, 19 seeds were obtained from which 13 plants were raised. Three of these were selfs.

THAKAR, B. J. 1947. See Patel, G. B., Thakar, B. J. and Deodikar, G. B.

THAKAR, B. J. 1950. See Patel, B. G. and Thakar, B. J.


This paper includes a list showing the relative susceptibility of a number of cotton varieties to F. vasinfectum. There was considerable variation in resistance within the Upland group; Sea Island proved highly resistant.


TIJERO, L. 1932. See Wille, J. E., Carrera, J. L. and Tijero, L.

TILLEY, R. H. 1947. See Kime, P. H. and Tilley, R. H.


The average incidence of cotton wilt (Fusarium vasinfectum) at various localities in Alabama, in which experiments were conducted for three years and upwards, ranged from 45 to 83% in the highly susceptible variety Half-and-Half and from 9 to 56% in the weakly tolerant group, including Cook 1138, Rowden 2088,
Deltapine 12 and A, Delpress 3, Mississippi WR and Miller 610. At six out of the nine test sites no appreciable difference between the reactions of the resistant varieties (including Cook 307, Cook Wiregrass, Dixie Triumph 12, Silver WR, Cleveville 6 and Cleveville 7) and highly tolerant varieties (Coker's 4 in 1, Dixie 14-5, Dixie Triumph 85, Toole, Cook 144-68 and Cook 1006) could be discerned, but at the remaining three sites the former group was clearly superior to the latter. The increased severity of infection among the tolerant-resistant groups in two out of three localities is attributed to potash deficiency, while in the third, root knot nematodes were suspected of contributing to the virulence of the disease. The Sea Island variety, for the one year in which it was included in the tests, was immune from wilt in one place and showed only a trace of vascular discoloration near the end of the season in another.


Tetraploid strains of seven Japanese varieties have been produced after treatment with colchicine. They showed the usual gigas characteristics and in addition were highly fertile.


A general survey of work in the leading cotton breeding stations of the world.


It is concluded that vicinism was high enough at Giza in 1921 to be a "seriously detrimental factor in the propagation of pure strains." The value of one-variety communities is emphasized.


Contains a brief historical account of cotton breeding in the Sudan.


The variety was produced in 1931 by individual plant selection from the variety Janovich. It is 7-8 days earlier than Maarad and yields 44% more cotton before the onset of the frosts than Pima and Maarad. Its average yield of seed cotton in the six years 1934-39 was 16.4% higher than that of Maarad.

The bolls are above average size, equal to or somewhat larger than Maarad, many having 4 locks and occasionally 5.

The lint length averages 37-39 mm.

The first generation from intra-varietal crosses in 4 varieties of G. barbadense made in 1937 showed increases in energy of germination, yield and improved quality; a greater proportion of the crop being picked before the frosts. Maarad gave the greatest yield increase, the variety 12761 the least, Pima and 2 Iz being intermediate. In the following generation, differences in yield were still evident. No difference was observed in size of boll, lint length or ginning outturn.

The experiment was repeated in 1938 with Maarad, 2 Iz and 3 varieties of G. hirsutum, 36 Me, 8617 and 1306. Local Turkmen material served in each case as maternal parent and was pollinated with material reproduced elsewhere. This gave much greater yield increases than crosses between the local material. The variety Maarad was especially improved as regards earliness.

Tuller, A. V. 1928. See Humphrey, L. M. and Tuller, A. V.

Tuller, A. V. 1943. See Humphrey, L. M. and Tuller, A. V.


Deals with the discoveries at Mohenjo-Daro in Sind c. 2700-3000 BC. The fibre properties suggest that the cotton found was similar to G. arboreum.

1097. Turner, T. W. 1941. Seven-year experiment in cotton breed-

An account of the breeding of an Upland type carrying 96% of 5-lock bolls.


Gives a detailed description of G. raymondii.


A detailed account of the Poona technique for breeding for resistance to Fusarium wilt. The author considers that there are clear indications that wilt resistance in Indian cottons is not due to a single immunity gene, but may be controlled by cumulative genes.


Part I. Cotton strains and segregates of crosses that had been inbred for several years and grown in wilt sick soil in the field, were found to be segregating for wilt resistance in pot culture tests. These strains and segregates became homozygous for
100% wilt resistance when re-selected in pot culture under optimum conditions of infection for 3 to 4 years.

Part II. In the cross KF x 1027 ALF (both G. herbaceum) wilt resistance was due to a single dominant gene, and clear 3:1 F<sub>2</sub> and 1:1 backcross segregations were obtained.

In the G. arboreum crosses studied, three complementary factors were involved in wilt resistance.


Preliminary tests showed late ripening varieties to be more drought resistant.


Crosses between different species of cotton with either the same or different numbers of chromosomes have failed, even with the aid of colchicine, to produce true-breeding, fertile and vigorous hybrids. Such hybrids as have been produced are regarded as worthless, offering little promise of possible improvement; they are usually sterile, or soon become so, and are late in development. It has been suggested by some Russian investigators that it is not so much cytological as physiological causes which make the hybrids so ill-adapted to their surroundings. It is believed that certain cultivated cottons having 52 chromosomes have originated in the crossing of two 26-chromosome species, one from the New World and the other from the Old, with subsequent doubling of the chromosome number. Attempts to reproduce the existing cultivated cottons artificially have failed.


Selections combining resistance to Verticillium wilt with high lint length and ginning percentage have been obtained.


Normal Delta Webber was crossed with a form having short leaves with 3–5 narrow lobes; this plant was found in Delta Webber and may be either a mutant or a segregate from a natural cross with okra; in leaf type it is almost identical with G. schottii.

The F<sub>1</sub> was intermediate, in
both reciprocal crosses. It was selfed and backcrossed and the results conformed with a single factor interpretation.


Covers work on the improvement of Tangüis by selection. Characteristics considered in selection, such as weight of seed cotton per plant, earliness, ginning outturn, weight of 100 seeds, weight of seed cotton and fibre per boll, resistance to wilt, etc., are discussed, and indications are given of progress being made.


Jassids (E. devastans) are a serious pest of Upland cotton in the Punjab, but desi cottons are practically immune.

It is shown that sweeping with a hand net gives a quick and reliable estimate of comparative infestation. Of the commercially important Upland varieties, LSS was most resistant and 289F/K 25 most susceptible. 4F and 289F/43 were intermediate.

The chief difference between resistant and susceptible varieties was in the number of eggs laid in the leaf veins of these strains. The eggs when once laid had, however, no difficulty in hatching and the nymphs of all stages also could feed and reach normal maturity on all cottons equally well.


Female sterility was found to be due to a single recessive gene stg.


The object was to obtain constant hybrids in wide crosses, which unite the valuable lint characters, yield, earliness, etc., of the respective groups.

Three species took part in the 1929 crosses, viz. G. hirsutum, G. barbadense and G. herbaceum, the objects being (a) to combine in one variety the valuable lint character of the Egyptian (G. barbadense) and the earliness, strength of lint and high yield of the Upland (G. hirsutum) and (b) to produce from the cross G. herbaceum x G. hirsutum reliable drought resistant productive types with hairy bolls. In all, 75 lines were used, and 75,000–80,000 pollinations were made.

Crosses between New and Old World forms succeed extremely seldom, certain combinations giving a higher percentage of success than other; this occurs
also in crosses of the same chromosome number. Thus out of 1000 crosses of 100 (Upland type) with 0671 (G. barbadense) 9330 hybrid seeds were obtained, whilst with 0100 (G. hirsutum) the same number of crosses gave 3328 hybrid seeds. Similar differences were observed in the number of seeds in individual bolls.

Natural crossing between varieties belonging to different chromosome groups was shown to occur to the extent of about 0.003%. All the F1's obtained were sterile both when self-pollinated and backcrossed. Various methods for obtaining later generations are being tried, including the action of certain narcotics.


Regeneration from a wound callus is extremely rare in cotton. Cuttings will, however, root with ease and from these roots, some of which may be mutants, stem regeneration is possible by cutting down the aerial part of the plant.

Experiments are also being made with the action of ultrashort light waves on the seeds.


The equipment and methods of five stations are briefly detailed. Up to now the methods of breeding have been mass and pedigree selection. One station has reached the third, the others the second generation. A detailed description of the ideal type in view is given.


Deals with the strains 145C55 and 270D64.


Wallace, R. W. 1931. See COLLINGS, G. H. and WALLACE, R. W.


An investigation was carried out to study the genetic and environmental factors causing the formation of infertile seeds of cotton. Such seeds are found in all varieties of cotton. They are less than 1 mm. in diameter, hairless or with very short hair.

Fifteen varieties of both native and foreign cotton, producing varying yields, were studied for two years. The results are summarized as follows:

1. On the average the Chinese cottons contain 10-18% infertile seed and the American varieties 17-98%. Some varieties are constantly high and some are constantly low in the percentage of these seeds year after year.

2. Most of the infertile seeds
are found in the basal portion of the boll.
3. The percentage of infertile seeds is independent of nutrition and fertilizers.
4. The percentage of infertile seeds varies with season. It is higher in the early and the late flowers.
5. The percentage of infertile seeds is positively correlated with temperature and negatively with atmospheric humidity. Temperature is comparatively more important.

Red plant colour shows monohybrid inheritance with 1 : 2 : 1 ratios in the F₂.
It is noted that, at Scott, natural crossing was less than 1%, while the average at Fayetteville was 40.9%.

The inheritance of ginning outturn was studied in four sets of crosses (a) Pima, 30-9% x Winesap, 31.9%; (b) Pima, 29.6% x Upright, 36%; (c) Winesap, 30.7% x Sea Island, 20.8% and (d) ScanL Lint, 5.6% x Normal, 34.3%.
High ginning outturn was incompletely dominant in the F₁ of (d). The F₂ and the backcross to the low ginning outturn parent showed monogenic control of ginning outturn. The F₁ in (c) was intermediate. In both (a) and (b) the F₁ gave a lower ginning outturn than either parent.


In a cross between Pima and Upland the F₁ was 14.7 ins. taller than the parents and this was shown to be due to heterosis. The parents differed in node number and the higher node number was dominant in the F₁.

Earlier work had shown that in crosses between (a) Pima x Winesap, (b) Pima x Upright and (c) Winesap x Sea Island, low lint percentage was intensified in (a) and (b) but that high lint percentage was incompletely dominant in (c). These results are now further analysed and more data are provided on seed weight and lint index.

Hybrid vigour, affecting seed weight, was found to account for the low lint percentage in the (a) and (b) crosses. The parents of the (c) cross were not genetically pure for this character. When the weight of lint from 100 seeds was taken as a standard, dominance was incomplete in the F₁ of (a) and (b) and complete in (c).
No, or hardly any, hybrid vigour in lint index was shown in (a), (b) or (c). The investigations
were continued in backcrosses and the F₂ generation.


Varieties of Upland cotton (*G. hirsutum*) with three shades of brown lint and with green lint were crossed with varieties with white lint. The colour was always incompletely dominant in the F₁, and in the F₂ the segregations were multifactorial.

There was linkage between the fine texture of the lint and the green colour, and coarse lint was dominant over fine lint.


The following are classed as wilt resistant: Dixie Triumph (Watson), Dixie Triumph (Marett), Dixie 14, Lightning Express, Super Seven (Coker) and Miller. The following are classed as wilt tolerant: Arkansas 17, Arkansas Rowden 40, Arkansas Rowden 2088, Arkansas Rowden 2119, D. and P.L. 4, and 6, Express 121, Cleveland 54 and Wilson Type Big Bull. Resistance was independent of lint, boll and seed characters.


The author uses the gene symbols R, O and G for the three characters red plant colour, okra leaves and green lint. All three were inherited independently.


Red plant colour (R), okra leaves (O) and Nankeen lint (N) were inherited independently, each being due to a single gene.


Gives data on the newest Arkansas wilt resistant strains.


1130. Ware, J. O. 1940. Relation of fuzz pattern to lint in an Upland cotton cross. *J. Hered.*, 31, pp. 489-496.

Progenies of the cross Hastings Upright x No Lint were classified on seed fuzz. Hastings has abundant fuzz covering the entire seed surface. No Lint has naked seeds and sparse lint. Fuzz was graded on a 1-20 scale and these grades are defined and illustrated. Grades 1-10 represent the recovered fuzzy class, 13-16 are the heterozygous or naked adherent class and 18 and 19 are the naked class. In the F₂, and in F₃ progeny from heterozygotes in the F₂, 1 : 2 : 1 ratios were obtained of these three groups and the fuzzy and naked types bred true. The naked adherent class, characterized by the attached lint base stubs or segments, segregated indefinitely. There was a high positive correlation between high lint index and degree of fuzziness, but it is
pointed out that varieties combining high lint index with sparse fuzz may be bred.


The naked seed character associated with sparse lint in some Upland cottons is dominant to fuzzy seeds of other Upland varieties. The heterozygous classes are distinguishable by the presence of broken-off basal lint segments which, in the more pronounced stages, give the seeds a downy appearance. This seed type is designated as naked-adherent. The F2 classes are 1 fuzzy : 2 naked-adherent : 1 naked. The backcross to the fuzzy parent segregates into 1 fuzzy : 1 naked-adherent; and when made to the naked parent, into 1 naked-adherent : 1 naked.

Apparently one main factor controls naked seed and is either very closely linked to, or identical with the gene that largely governs the development of sparse lint. One or more modifying genes act independently on lint development without altering to any extent the seed covering other than lint. The modifiers affecting fuzz do not alter lint index or lint percentage.

In the no lint x okra leaf study, the independent inheritance of leaf shape and seed coat covering or naked seeds is demonstrated. There was a tendency for plants with larger leaf area to have higher lint index and seed index.


Red plant colour and degree of seed fuzz were inherited independently. Naked seeds and sparse lint, both from the No Lint variety, are either closely linked or pleiotropic effects of the same gene. Plant colour was independent of this gene. There was a tendency for high seed index and green plants to be associated.

1133. Ware, J. O., Jenkins, W. H. and Harrell, D. C. 1943. Inheritance of green fuzz, fiber length, and fiber length uniformity in Upland cotton. J. Amer. Soc. Agron., 35, pp. 382-392. (Abst. from Plant Breed. Abstr., 13, pp. 345-346). F1 and F2 generations and first generation backcrosses were obtained from Florida Green Seed x Rowden. The genetics of fuzz colour was investigated. The F1 showed a narrow colour range intermediate between the deep green of Florida Green Seed and the pure white of Rowden. In the F2 an almost complete series of colour variation was found, excepting the pure white, which did not reappear; the backcrosses showed less extensive colour ranges.

Fibre length was also investigated. The longer values were incompletely dominant in the F1 and a unimodal distribution of lengths appeared in the F2. The backcross with Florida Green Seed reduced the fibre length below the F1 mean but the Rowden backcross did not produce a corresponding increase, perhaps owing to a rather shorter fibre length in the Rowden plant used.

A slight association between green colour and shorter fibre length was discovered.
COTTON BREEDING AND GENETICS


In the cross Florida Green Seed x Rowden, the Florida parent had a lint strength index about 1 unit higher than the other parent. This quality showed intermediacy in inheritance. F2 plants tended to maintain the F1 strength but were less uniform than either parent.


Individual plants of Seabrook, Westberry, Bleak Hall, Andrews and Gaddis (all Sea Island varieties) were analysed to determine the relation of naked seed and seed fuzz tufts to lint percentage, lint index, staple length and seed index.

In Westberry, Bleak Hall and Andrews, the location and size of the tufts did not materially affect the level of lint percentage, lint index, staple length, or seed index.

The fuzzless or naked-seeded individuals of Seabrook produced lint percentages and lint indexes lower than those of the normal seed fuzz forms in this variety. Staple length and seed index were not appreciably affected by the type of fuzz in Seabrook.

The Gaddis variety has a much larger proportion of naked seeds and has shorter staple, lower lint percentage, lint index and seed index than Seabrook, but there appeared to be no significant differences in the levels of these characteristics in the different fuzz grades.

Naked seed in Sea Island appeared to be a recessive character.

WARE, J. O. 1945. See POPE, O. A. and WARE, J. O.


All naked seed x fuzzy seed crosses in Upland cotton heretofore, have shown naked to be dominant over all degrees of fuzziness. In a naked-seeded brown linted Upland variety (Acadian Brown) from Louisiana, naked is recessive to fuzzy.

“In F2s from Acadian Brown separately crossed with eight fuzzy seed varieties the seeds in each case were fuzzy. The fuzzy condition, however, was not completely dominant showing a range of fuzz pattern from that of full and complete fuzziness to that of a pronounced tuft on hilum end and some thin patches of fuzz hair on the raphe and chalazal end.”

“The previous work in the study of dominant naked and recessive fuzzy has indicated naked as being a simple dominant character and not carrying a suppressed fuzzy gene. On the other hand the 13:3 ratio obtained from crossing dominant naked and recessive naked... suggests that naked dominance... is due to an inhibitor epistatic to fuzz development rather than to a pure condition of a dominant gene itself. The naked character in Acadian Brown in contrast appears to be conditioned by a single recessive gene.”

The genes concerned are expressed as “I for inhibitor or epistatic action, r for recessive naked, i for absence of inhibitor, and R for fuzzy which is expressed when I is replaced by I.”
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   Brief notes are given on the results of cotton selection based on the mean maximum length of fibre, percentage of available fibre, average weight of seed, and percentage of lint to seed. Further cotton investigations included studies with crinkled dwarf rogues, inheritance of the number of teeth in the bracts of cotton, resistance to leaf-blister mite (Eriophyes gossypii) in budded cottons and in cotton hybrids, Brazilian cotton, and fertilizer tests with Sea Island cotton.

   Methods of selection are discussed in relation to improvement of yield, quality, earliness, and disease and storm resistance.


   In the F2 of some hitherto unre corded interspecific hybrids between the American cultivated and wild species, the chromosome complement at reduction division was 13 pairs and 13 single chromosomes; in hybrids between cultivated American species and G. sturtii, 9-4 pairs and 21-39 single chromosomes were found, and in hybrids between wild American species and G. sturtii,
26 single chromosomes. In addition, hybrids between G. sturtii and Thunbergia thespsioides \( (n = 13) \) have been found to exhibit 26 single chromosomes at first metaphase.

These new findings are taken as indicating the allopolyploid nature of American cultivated cottons.


The haploid chromosome number 13 for all Asiatic cottons, for wild American species and for *G. sturtii* was confirmed, as was also 26 as the haploid number for all cultivated American cottons. Evidence is presented showing that the chromosomes within a cotton species are heterogeneous in shape and very nearly equal in size.

The question of the possible tetraploid nature of the species with 26 pairs of chromosomes is mooted, and reasons for the apparent absence of aneuploid individuals in cotton are considered.


In \( F_1 \) hybrids of crosses within the cultivated American cottons *G. hirsutum, G. punctatum, G. barbadense, G. contextum* and *G. schottii* meiosis was similar to that in the parent species, 26 bivalents being the usual arrangement at metaphase I, occasional quadrivalents being observed; there appeared however to be a smaller number of chiasmata per cell.

The meiosis of \( F_1 \) hybrids within the cultivated Asiatic cottons (*G. arboreum* vars. *sanguineum* and *neglectum, G. africanum* and *G. herbaceum*) usually showed 13 bivalents though occasionally 2 univalents were observed; there was a considerable reduction in chiasma frequency. The \( F_1 \) hybrid between two wild American species *G. harknessii* \( (n = 13) \) and *G. armourianum* \( (n = 13) \) showed regularly 13 bivalents.

The usual arrangement at metaphase I in *G. hirsutum* \( (n = 26) \times G. armourianum \ (n = 13) \) and *G. contextum* \( (n = 26) \times G. armourianum* was \( 13_H + 13_I \) though \( 11_W + 9_H + 13_I, 21_W + 9_H + 13_I, \text{ and } 12_H + 15_I \) were also observed. The bivalents form a well-organized plate which generally includes a few elongated univalents, the remainder of the univalents being more or less spherical and scattered over the achromatic figure. The univalents on the plate occasionally are fragmented at anaphase. At the second division there are usually two major and several diminutive achromatic figures while the pollen tetrads contain 2 to 12 grains of various sizes.

In the similar cross, *G. barbadense* \( \times G. harknessii\), more than 13 univalents were never observed and more of the bivalent chromosomes were united at both ends than in the other two crosses of this type. Meiosis in the hybrid between *G. barbadense* and the wild Australian species *G. sturtii* \( (n = 13) \) was very irregular and 39 univalents was the commonest arrangement, 1, 2, 3, and 4 bivalents being observed in different cells. Second metaphase plates with 39 chromosomes were observed and from 2 to 14 spores were formed in the tetrads.

Rather more bivalents than
in the last cross were formed in hybrids between wild American species \( (n = 13) \) and \( G. sturtii \), from 0 to 6 being observed. Fragmentation of univalents was again observed in these crosses and in the preceding cross.

The hybrid \( Thurberia thespesioides \times G. sturtii \) was characterized by complete absence of chromosome pairing and the pollen tetrads were highly abnormal.

As in the crosses Asiatic \( \times G. sturtii \) and Asiatic \( \times \) wild American, no viable seeds were obtained from attempts to cross Asiatic with cultivated American cottons, but a natural hybrid of this type was studied. The commonest conjugation was \( 13_1 + 13_1 \); pairing as low as \( 9_1 + 21_1 \) was observed and as many as 4 quadrivalents were sometimes formed.

In general the degree of compatibility between different species is not closely correlated with their morphological or taxonomic relationship.

In discussing the bearing of the cytological results on phylogeny it is suggested that the occurrence of quadrivalents in certain hybrids between species with \( n = 26 \) and species with \( n = 13 \) confirms the suggestion that the basic number 13 has arisen by modified tetraploidy. The limited pairing in wild American species \( \times G. sturtii \) crosses may also support this hypothesis. The characteristic arrangement of \( 13_1 + 13_1 \) in hybrids between cultivated and wild American species and between Asiatic and cultivated American species, considered in conjunction with the almost complete absence of pairing in the hybrid \( G. barbadense \times G. sturtii \), confirms the hypothesis that the cultivated American cottons are allopolyploid, though the author considers that before the hypothesis that they arose by chromosome doubling in a cross between Asiatic and wild American cottons can be accepted, the nonhomology of the chromosomes of the Asiatic and wild American cottons must be demonstrated.


In \( F_1 \) hybrids between cultivated Asiatic species and \( G. anomalum \) and between wild American species and \( Thurberia thespesioides \), 13 bivalents were observed; \( 13_1 + 13_1 \) were found in hybrids of cultivated American species with \( T. thespesioides \) and with \( G. anomalum \); \( 0_1 \) to \( 8_1 \) to 26_1 were found in hybrids of cultivated Asiatic species with \( G. stocksii \), while in hybrids between cultivated Asiatic species and \( T. thespesioides 26_1 \) occurred.

Comparison of the results obtained in crosses of wild American and cultivated Asiatic cottons with \( T. thespesioides \) indicates that the complements of wild American and cultivated Asiatic species are nonhomologous, supporting Skovsted's contention that the cultivated American species arose from a cross between types related to these forms. The occurrence of 13 bivalents in the hybrids of \( T. thespesioides \) with wild American species supports the view that \( T. thespesioides \) is congeneric with \( Gossypium \).


A pair of twins in Acala was
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diploid-diploid, with regular meiosis except for occasional quadrivalents. A second diploid-diploid pair of twins was obtained in the F_2 of G. nanking x G. thurberi; the two plants were conjoined and died at an early stage. A haploid-diploid pair was obtained in G. barbadense. The diploid member had regular meiosis except for occasional quadrivalents and univalents while the haploid had 26_1 in 22 cells, 14_1 + 24_1 in one cell and 24_1 + 22_1 in two cells.

Of the fourth pair of twins one member died and the other was diploid.


The cytogenetic literature bearing on interspecific relationships in Gossypium is tabulated and the meiotic chromosome conjugation in the F_1 of 23 new interspecific hybrids, as well as in the F_2 and F_3 of some of these hybrids, is reported. These results strongly support the following grouping of species: (1) the Australian species, G. sturtii, (2) Asiatic species, (3) wild American species and (4) cultivated American species.

The small amount of chromosome conjugation in G. sturtii hybrids indicates that there is very little chromosome homology between it and other species, with the possible exception of G. davidsonii.

Chromosome behaviour in crosses involving Asiatic species indicates (1) that the cultivated Asiatic species are very closely interrelated; (2) that G. anomalum is rather closely related to the cultivated Asiatic species; (3) that G. stocksii is not closely related to the cultivated species or to G. anomalum; (4) that, of the Asiatic species, the cultivated ones are most nearly related to the cultivated American species, G. stocksii is most distantly related and G. anomalum occupies an intermediate position; and (5) the Asiatic species are not closely related to the wild American species.

The wild American species appear to fall into two, or possibly three, sub-groups, the inter-relationships of which are discussed. Eriococylum aridum should probably be included in the genus Gossypium in the subgroup containing G. thurberi. It appears that the chromosomes of these species and those of the Asiatic species are homologous with different sets of 18 of the cultivated American species.

The relationship of G. davidsonii and G. klotzschianum to either G. stocksii or the cultivated American species is unknown.

The various cultivated American species are closely interrelated. The chromosomes within their haploid complement are partly homologous, whereas such homology is absent or very slight in all the 13-chromosome groups.

Various hypotheses as to the origin of the 13- and 26-chromosome Gossypium species are advanced and discussed.

1152. WEBBER, J. M. 1940. Polye­


Most of this paper deals with other genera but it is noted that in this genus, twins are mainly haploid-diploid in the 26-chromosome species and diploid-diploid in the 13-chromosome group.

1153. WINDLING, R. 1944. A tech­

ique for testing resistance of
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A technique is described for testing resistance of cotton seedlings to the angular-leaf-spot bacterium. Seed was inoculated by immersing in suspensions of bacteria for short and lengthy intervals. Seedlings were grown for 3 weeks at 27-35°C. In general, varietal reaction to the disease organism in these seedling tests conformed with that of field plants. The method offers possibilities as a rapid supplementary test in breeding varieties for resistance to the disease. For this purpose the technique may be adapted to the material under test by modifications, such as the use of sand culture in place of the paper-towel technique described here.

Weindling, R. 1948. See Simpson, D. M. and Weindling, R.


It is suggested that periclinal chimaeras might make possible the growing of ‘quality’ lint on a resistant wild-type ‘core.’


Wells, W. G. 1908. See Kearney, T. H. and Wells, W. G.

Wells, W. G. 1918. See Kearney, T. H. and Wells, W. G.


This includes an account of the distribution of *G. raimondii* and states that this species is chiefly confined to the valleys of Jequetepaque and Chicama in northern Peru. It harbours *Dysdercus ruficollis*.

Wille, J. 1945. See Boza Barducci, T., Rada, G. G. and Wille, J.


It is noted, *inter alia*, that fuzzy tip is produced by a pair, or pairs, of characters distinct from those for naked and fuzzy seed. It is not an intermediate stage between naked and fuzzy.


On the genetic side it is noted that homozygous naked x homozygous fuzzy gave a naked F1 and a 3:1 ratio in the F2. Crosses between homozygous fuzzy tip and homozygous naked and pure fuzzy showed that naked is dominant over all grades of fuzz and that less fuzz is dominant to more fuzz.


Gives directions for improving cotton by the plant-to-row method.

Certain strains of American Upland owing to their hairiness, were practically immune to injury by jassid (Choreta fusciellis). Hairless varieties were the first to be attacked. Where this pest is prevalent, cotton breeders should include hairiness as one of the characters to be selected. A correlation between hairiness and short staple has been observed, so that care should be exercised to select only hairy plants with good staple.

A detailed review deals under the following heads with the work that has been done in various countries on the cytology and genetics of Gossypium: botanical classification, chromosome numbers of the species, gamete formation from the cytological aspect, hybrids between Asiatic and American forms (including the technique of hybridization and a detailed review of pollen tube behaviour), and the origin of the species found in various countries.

Hybridization between Asiatic and American cottons has been....
performed successfully. Most of the pollen tubes pass through the basal part of the style 12 hours after pollination. Feng has stated that 24 hours are required for the pollen tube to reach the basal part of the style. His experiments were carried out in a room at 25°C, but the author’s were undertaken outdoors at 35°C. The germination rate of pollen on the stigma is somewhat lower in cross pollination than in self pollination. The osmotic value of the leaf tissue is 2 to 3 atm. higher in Asiatic than in American cotton strains. The pollen tube with a certain osmotic value, passing through stylar tissue with a lower value, may absorb too much water, so as to lead to its breaking (Asiatic within American). Pollen tubes with low osmotic value within stylar tissue with a higher value are not able to absorb sufficient water for normal development, so that malformations appear (American within Asiatic).


Polyplold cotton plants (2n = 104) have been obtained from a strain of Sea Island cotton (2n = 52) by treatment with colchicine. Although a few well-developed pollen grains were observed in the polyploids, this was exceptional, the pollen being usually sterile and the anther dehiscence feeble.

YANG, J. Y. 1941. See LING, L. and YANG, J. Y.

1170. YAMASHITA, K. 1940. (Cotton plants treated with colchicine).


The characteristics and inheritance of the following mutants occurring in Upland cotton have been investigated at Kingyang, Shensi; the new virescent mutants, $V_a$, $V_c$, $V_r$, and $V_i$ Kingyang crinkled leaf, and a mutant termed “irregular waved margin of leaves,” previously described by Brown and Cotton (1937) under the name “round leaf.” These mutants were found to be simple recessive factors. The four new virescent forms and $V_k$ are morphologically distinct; $V_a$, $V_c$ and $V_k$ were found to be complementary factors. The Kingyang crinkled leaf character showed linkage with green leaf and green seed colour. The other mutants were independently inherited in relation to leaf colour, seed colour and other characters.

The symbols for the inheritance of anthocyanin pigmentation in the Old World cottons were not found to be applicable in the study of New World cotton. The author suggests a revision of the symbols.

Selection is mainly on early ripening, boll size, disease resistance, adaptation to poor cultural conditions, quantity, length, strength and uniformity of lint, and oil content of seed.

YOSINAGA, R. 1926. See MOHARA, S. and YOSINAGA, R.


The first part of this paper deals with varietal trials and manurial experiments. Miller 610 has strong wilt (Fusarium) resistance combined with long staple, large bolls and good yielding capacity.

YOUNG, V. H. 1932. See WARE, J. O., YOUNG, V. H. and JANSSSEN, G.

YOUNG, V. H. 1934. See WARE, J. O. and YOUNG, V. H.


Gives results of tests of varietal resistance to F. vasinfectum.


The following petal spot allelomorphs were established: \( R \) (red centre), \( R_y \) (yellow centre) and \( r \) (white centre). \( R \) is dominant over \( R_y \) and \( r \), but the heterozygote \( R_y r \) has a red centre, segregating into 1 yellow : 2 red : 1 white on selfing. In studying the inheritance of leaf shape, Leake’s leaf factor was found to be better than the leaf index. A single factor pair \( C_f \) (deep
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serration), cf (shallow serration) was found to be operating, with incomplete dominance.

Leaf glands were controlled by a single dominant gene Ne, the glandless condition (ne) being recessive.

Red petal margin was conditioned by a single factor We, the recessive we producing no red margin.

The following factors for colour of stem were found P_y, P_o, p_o and p_o. P_y produces the purple stem of yellow-centred Chinese cotton, P_o the purple stem of ordinary Chinese cotton, p_o green stem (red colour under green epidermis) and p_o sun-red.

Yellow petal colour was incompletely dominant over white or cream, giving 3:1 segregation in the F_2 of crosses yellow x white or yellow x cream.

The genes for petal colour and colour of flower centre were independent in inheritance. The latter was also shown to be independent of the factor for leaf shape, and the former independent of the factor for glands.


This paper firstly gives a criticism of the method employed for testing the percentage of natural crossing in cotton suggested by H. H. Love.

The authors prefer planting two varieties of cotton with contrasting characters and assessing the percentage of natural crossing from the percentage of dominant plants among the progeny of the recessive type.

The general average of out-crossing over three systems of planting was 7.79% on the basis of seed number. The results vary with the methods employed, as well as the years. The results for various distances between the varieties are 5.64% for 7.5 ft. and 0.28% for 75.0 ft.


Yellow seedling, a lethal gene in Asiatic cotton, is a simple Mendelian recessive to normal. It has been discovered three times in three unrelated varieties.

Yellow seedling and anthocyanin pigmentation are linked. The cross-over value is about 9%.

Yellow seedling is inherited independently of curly leaf and corolla colour.


Curly leaf, cu, and virescent bud, v_b, are two newly discovered genes affecting seedlings. Both of them are completely recessive, and form single factor pairs with the normal.

It is shown that curly leaf and leaf shape are linked with a cross-over value not far from 16.6%.

Curly leaf and the following characters are independently inherited: anthocyanin pigmentation, corolla colour, lint colour and seed fuzz.

Virescent bud and the following characters are independently inherited: curly leaf, anthocyanin pigmentation, corolla colour, seed fuzz, leaf shape and yellow seedling.

From the linkage studies of
Hutchinson and the writer, it is concluded that the lint colour genes which they investigated are distinct.


Three virescent mutants, differing from one another and from the previously reported $v_1$ (see Yu 1939 $b$) occurred in 1935–37 and are described. Data are presented to show that $v_1$ and $v_2$ are inherited independently and are complementary factors, and that $v_2$ and $v_3$ are independent; $v_3$ is inherited independently of the genes for anthocyanin pigment, corolla colour and curly leaf.

Yu, C. P. 1942. See Silow, R. A. and Yu, C. P.


The so-called multiple allelic series for anthocyanin pigmentation of Asiatic cotton is extended from fourteen to twenty members.

The genetic substance affecting the characters in this series seems to be separable. Sometimes two members of the series may be combined to form another; sometimes one member may be split into two others. But such combining and splitting take place only between petal characters, or between plant body coloration and petal characters. Plant body coloration, itself, seems to be very stable. At least in one case, crossing-over was clearly established. The so-called multiple allelic series, therefore, may be subdivided into several series.

Hutchinson's explanation of the inheritance of anthocyanin pigmentation in Asiatic cotton is considered in detail in this paper. Some modification is necessary to make it fit the new facts. Probably a three-unit mechanism will prove more acceptable than his original two-gene-centre hypothesis. On this basis, there is a multiple allelic series corresponding to each locus, namely, plant body coloration, ghost spot and spotless series. These consist of nine, three, and three alleles, respectively; and the number of possible combinations among the series is sufficient to account for the existing types.

A new system of nomenclature of anthocyanin characters in Asiatic cottons is suggested.


Gives a detailed description of the rhythm of flower production in cotton. Ten hours after pollination about 50% of the pollen tubes have had time to pass down the whole length of the style (17 mm.). Natural crossing under Turkestan conditions is about 5%.


A full account of this was published in 1927 (in English) in the *Agric. J. India*, 22, pp. 155–167.
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(1) When crossing distant species, such as G. hirsutum or G. barbadense, with G. herbaceum or G. obtusifolium various mechanical obstacles disturbing fructification, should be considered. (2) One of the principal mechanical obstacles is delayed growth of the pollen tube in the foreign tissue of the style, and the premature rupture of the latter. (3) This rupture of the style may be prevented by the complete removal of the perianth (corolla and staminal column), laying open the whole pistil, thus making it possible for the slow-growing foreign pollen tubes to reach the ovules and fertilize them. (4) This removal of the mechanical obstacles, makes possible the formation of hybrid zygotes, though these are characterized by weakness in development.


A detailed account of this appeared in 1927 in the same journal. (See G. S. Zaitsev, 1927).


Describes in detail two artificial F₁ hybrids between G. herbaceum ♂ and G. hirsutum ♀ obtained by pollinating over 1000 flowers after removing the whole corolla including the staminal column. A long description is also given of four natural hybrids of similar parentage.

The author concludes that although under exceptional conditions hybrids between G. herbaceum and G. hirsutum may be obtained, they are useless in view of their complete sterility.


Amphidiploid plants, or amphidiploid sectors, were produced by colchicine treatment of the seeds or shoot apices in the following Gossypium crosses: G. hirsutum x G. sturtii, G. hirsutum x G. armourianum, G. herbaceum x G. anomalum, G. hirsutum x G. barbadense, G. hirsutum x G. arboreum and G. hirsutum x G. stocksii. The usual inverse relationship between the fertility of the F₁ and of the amphidiploid was observed.


The percentage of natural hybridization found by various workers is tabulated and discussed. It is shown to depend largely on spacing, weather and variety. Attempts to breed totally self-fertilized types (short style and other methods) have failed. A brief historical account
of cotton hybridization is given, including the work of Zaitzev in combining the quality of lint of American cottons with the early ripening necessary for cultivation in Turkestan.


A male sterile but female sterile amphidiploid shoot was obtained by treating a shoot of G. arboreum x G. thurberi with colchicine. Amphidiploids (2n = 104) have also been obtained by colchicicne treatment of germinating seeds of G. hirsutum x G. barbadense. These amphidiploids were partly fertile. A triploid [hexaploid] plant (2n = 78) was also obtained but it is suggested that this was due to the union of an unreduced gamete with a reduced one and not to the colchicicne treatment.


Different graftings showed differences in the time of inception of flowering, the intensity of flowering, the number of ovaries shed, the development of anthers and ovules, and the number of mature bolls and seeds, and that these differences depended upon the genetical affinities between stock and scion. The time of onset of flowering, the rate of blooming and the number of mature bolls showed hastening and increase with greater genetical disparity, while the fertility of anthers and ovules appeared to increase with closer affinity between stock and scion.
## APPENDIX I

### THE GENOMS OF *Gossypium*

<table>
<thead>
<tr>
<th>Species</th>
<th>Genom</th>
<th>Specimen</th>
<th>Genom</th>
</tr>
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<tr>
<td><strong>Asiatic and African</strong> $(n = 13)$</td>
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<tr>
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<td><em>G. thurberi</em></td>
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<td><em>G. klotzschianum</em></td>
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<td>E_1</td>
<td><em>G. davidsonii</em></td>
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<td>E_2</td>
<td><em>G. aridum</em></td>
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<td>E_3</td>
<td><em>G. raimondii</em></td>
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<td>C_1</td>
<td><em>G. barbadense</em></td>
<td>[AD]_1</td>
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<td>C_2</td>
<td><em>G. tomentosum</em></td>
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In the above table the classification used by Hutchinson, Silow and Stephens (1947) has been adopted. The genome symbols are based on Beasley (1942), Stephens (1947), Douwes (1961 and 1953), Brown and Menzel (1952) and Douwes & Cuany (1952).

### REFERENCES


<table>
<thead>
<tr>
<th>Symbol suggested</th>
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<td>Frm</td>
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(Continued)
## COTTON BREEDING AND GENETICS

### Appendix II—(continued)

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[Continued]
## Cotton Breeding and Genetics

### Appendix II—(Continued)

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<th>Gene effect</th>
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<td>R&lt;sup&gt;40&lt;/sup&gt;</td>
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<td>barb.</td>
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<td>R&lt;sup&gt;40&lt;/sup&gt;</td>
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<td>Y&lt;sub&gt;2&lt;/sub&gt;&lt;sup&gt;B&lt;/sup&gt;</td>
<td>yellow corolla</td>
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<td>darwinii</td>
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<td>Y&lt;sub&gt;2&lt;/sub&gt;&lt;sup&gt;Y&lt;/sup&gt;</td>
<td>yellow petal</td>
<td>490, 991, 157</td>
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<td>pale petal</td>
<td>710, 490, 991</td>
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<td>Y</td>
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<td>Chinese yellow petal</td>
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<td>yellow depressor</td>
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Gene linkage in *Gossypium*

ASIATIC COTTONS

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<tr>
<td>1 a.</td>
<td>( L : \text{cu} : Lc_1 )</td>
<td>1179</td>
</tr>
<tr>
<td></td>
<td>(-16-6)</td>
<td>993</td>
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<td></td>
<td>(-15)</td>
<td>993</td>
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<td></td>
<td>(-23-7)</td>
<td>499</td>
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<td></td>
<td>(-29-9)</td>
<td>G. arboreum x G. herbaceum 993</td>
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<tr>
<td></td>
<td>(-27-2)</td>
<td>Cuany (unpubl.) 993</td>
</tr>
<tr>
<td></td>
<td>(-24-5)</td>
<td></td>
</tr>
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<td>b.</td>
<td>( L : Lc_1 )</td>
<td>370, 373</td>
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<tr>
<td></td>
<td>(-17-1)</td>
<td></td>
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<td></td>
<td>(-19-5)</td>
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<td></td>
<td>G. arboreum x G. herbaceum</td>
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</tr>
<tr>
<td>c.</td>
<td>This chromosome carries a fuzz modifier</td>
<td>500</td>
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<td>2</td>
<td>( H_a : Lc_2 )</td>
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<td></td>
<td>(-7-1)</td>
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<td>3</td>
<td>( Y_a : Lc_3 )</td>
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<td>4</td>
<td>( P_b : Ne )</td>
<td>367; Cuany (unpubl.) Cuany (unpubl.)</td>
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<td>5 a.</td>
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<tr>
<td></td>
<td>interspecific</td>
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<td>b.</td>
<td>( P_a : \text{modifiers of } Lc_3 )</td>
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<tr>
<td>6</td>
<td>( R_a : Y_b )</td>
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<tr>
<td></td>
<td>(-1-2)</td>
<td>Silow (unpubl.) (Linear order not implied) 864, 391b, 1178 932a</td>
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<td>7 a.</td>
<td>( Ch_{12} : R_2 : 30 : Cl )</td>
<td>Knight (1954) (Linear order not implied) 10 496</td>
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<td>b.</td>
<td>( R_a : \text{wilt resistance} )</td>
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<td>c.</td>
<td>( H_a : Y_b )</td>
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<tr>
<td>8</td>
<td>( Fx : \text{lint length : seed weight} )</td>
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<td>9</td>
<td>( h_b : \text{protruding stigma} )</td>
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<td>10</td>
<td>( Y_a : \text{petal length} )</td>
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## COTTON BREEDING AND GENETICS

### APPENDIX III—contd.

#### NEW WORLD COTTONS

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<tr>
<td>1 a.</td>
<td>R₁ : cl₁ 13.9 16 8 18.5 14-1-19.6</td>
<td>432 733 733 819 903</td>
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<td>b.</td>
<td>R₂ : low lint index</td>
<td>1078, 1132</td>
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<td>2</td>
<td>R₁ : cl₂ 10.4</td>
<td>998</td>
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<td>3</td>
<td>H₁ : ch₁</td>
<td>Knight &amp; Sadd, 1964</td>
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<td>4 a.</td>
<td>H₂ : short lint</td>
<td>1002; Knight &amp; Sadd, 1963</td>
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<td>H₃ : lint colour G. tomentosum crosses</td>
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<td>5 a.</td>
<td>Cr : L₉ g</td>
<td>Stephens (unpubl.)</td>
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<td>6</td>
<td>B₁ : d₁ 32</td>
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<td>7</td>
<td>B₂ : B₃ 50</td>
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<td>8</td>
<td>L₉ : shortened lint</td>
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<td>9 a.</td>
<td>V₉ : Fgr</td>
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<tr>
<td>b.</td>
<td>V₉ : green leaf</td>
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In the foregoing gene list, the symbolization adopted by Hutchinson and Silow, 1939 (Abst. 620), has been retained. Italicized symbols refer to genes from Old World species or to genes in New World species known to be located in the A genome. The use of brackets in the last column indicates species to which the gene concerned has been transferred from its original species by hybridization.
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D b 95

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