THE GENETICS OF WITHERING OR DECIDUOUS BRACTEOLES IN COTTON

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CONTENTS

Introduction

The economy of the Sudan, at present, is mainly based on the Gezira, with its annual area of some 200,000 acres of irrigated Sakel (*Gossypium barbadense*) cotton. There can be little doubt, however, that if the Sudan is to progress there will come an expansion of agriculture in the less populated rain-lands in the 25–30 in. rainfall belt. This will mean an increasing use of mechanical cultivation and, if Upland (*G. hirsutum*) cotton is to be the cash crop in any of these areas, it will probably have to be picked mechanically. For this reason all morphological aids to mechanical picking possessed by the cotton plant are of interest in this country.

The production of a cotton with involucral bracteoles either lacking or much reduced in size, or with bracteoles which either shed or wither away before the boll opens, would be valuable, since much of the trash which becomes mixed with cotton picked mechanically consists of pieces of bracteole.

This paper records notes on the genetics of such bracts. The transference of 'withering bracts' to a commercial Upland type was given up as soon as it became clear that the character could not effectively be separated from its deleterious ancillary effects. For this reason the genetic investigation was somewhat incomplete.

Small or deciduous bracteoles in the wild *Gossypiums*

The ideal type of bract is that found in some of the wild diploid relatives of cotton from the New World, notably in *G. aridum*, *G. armourianum* and *G. thurberi*. These three species all have very small bracteoles; those of *armourianum* are shed before the flower opens, whilst in *thurberi* the bracteoles are often caducous at the time the boll opens. *G. aridum* also has very small bracteoles which are, however, persistent. Another species worthy of consideration is *G. harknessii*, the bracts of which, though larger than those of the other species mentioned, fall off when the flower opens. Finally, the African and Arabian species *G. anomalum* and *G. areysianum* both have very narrow bracts.

Crosses of *G. armourianum*, *G. thurberi*, *G. harknessii* and *G. anomalum* with Sakel (*G. barbadense*) give more or less sterile triploids with normal-sized persistent bracteoles.

The hexaploids *G.* '*armadense*' (from *armourianum* × *barbadense*) and *G.* '*thurbadense*' (from *thurberi* × *barbadense*) also have normal-sized persistent bracteoles, as does the synthetic tetraploid *G.* '*thurboreum*' (from *thurberi* × *arboreum*). Furthermore, in two acres of progenies of *G.* '*armadense*' and *G.* '*thurbadense*' crossed three times on to New World types, no plants with deciduous bracts and none with minute bracts were present. Neither did any such plants appear in $1\frac{1}{2}$ acres of selfed and natural material from these backcross progenies of '*thurbadense*' origin. Selfed progenies from the '*armadense*' backcrosses were not grown.

From this it seems unlikely that the small and/or deciduous bracts found in certain of the New World diploid *Gossypiums* can be transferred direct to the cultivated tetraploids. The tetraploid cottons of commerce carry an *A* genom deriving from the Asiatic group, and a *D* genom similar to that of the New World diploid *Gossypiums*. It is probable that the genes for small and caducous bracts are submerged by the *A* genom genes for large and persistent bracts. The only possibility of utilizing these potentially economic genes is if they can first be transferred to an Asiatic cotton. Thus if the small deciduous *armourianum* bract could be transferred to *G. arboreum*, the resulting 'small deciduous *arboreum*' could be crossed with *armourianum* and the product doubled to make the allotetraploid *G.* '*armoreum*'. This synthetic allotetraploid would then be homozygous in both the *A* and the *D* genoms for the genes responsible for small deciduous bracts; from it these genes might be transferred, by backcrossing, to their appropriate positions in both the *A* and *D* genoms of a commercial New World cotton.

Small or deciduous bracteoles in the cultivated cottons

Cook & Hubbard (1926, 1928) draw attention to the small bracts found in their *G. patens* and *G. tridens*, and to the fact that the bracts of *G. evertum*, though full sized, turn outwards away from the bud. Stephens (1947) records that 'At Stoneville a mutant type, with a greatly reduced bracteole which withers before the boll opens, is being investigated. However, as might be suspected on morphogenetic grounds, the bracteole abnormality is associated with a leaf abnormality, and it is not yet clear to what extent the leaf can be normalized without sacrificing the advantages of the abnormal bract.' Dr Stephens kindly sent seed of this mutant Upland to Shambat, where it was grown in 1945 under the name 'Withering Bract' and crossed with BAR. SP84, the commercial rain-grown type of Upland cultivated in the Sudan.

F_1 and F_2 of 'Withering Bracteole' × BAR. SP84

In 1946, 192 F_1 plants of Withering Bract × BAR. SP84 composition were raised; all were normal both as regards bracts and also leaves. Self-bred progenies were grown from two of these plants in 1946–7 winter and these gave 149 Normal: 66 Withering Bract plants and 179:68 respectively. These figures compare with expectation on a 3:1 basis of $161\frac{1}{4}:53\frac{3}{4}$ and $185\frac{1}{4}:61\frac{3}{4}$, and suggest that withering bracts are due to a single recessive gene. In all cases plants with withering bracts had crumpled leaves and often bolls which were not well filled, but there was much variation in all these characters.

First and second backcrosses to BAR. SP84

A few Withering Bract plants in the straight F_2 were 'bulk backcrossed' to BAR. SP84 and sixty-nine plants of this origin were raised in 1947. All were normal. These sixty-nine plants were 'bulk backcrossed' to BAR. SP84, producing a progeny consisting entirely of normals. In this progeny nineteen plants were selected for selfing.

F_2 of second backcross to BAR. SP84

Nineteen second backcross F_2 progenies were raised in 1948. Twelve of these contained plants with withering bracts and seven contained only normal plants. In Table 1 the plants in these twelve families are classified into Normal and Withering Bracts, and a note is given of the average degree of leaf crumpling and general plant upset amongst the plants with withering bracts in each family.

Table 1. *Classification of the second backcross F_2*

Family no.	Normal	Withering bracts	Ratio	Remarks
J 1321/48	101	14	7·2:1	Very mild
J 1326/48	83	14	5·9:1	Very mild
J 1319/48	181	36	5·0:1	Mild
J 1316/48	160	50	3·2:1	Rather mild
J 1318/48	156	52	3·0:1	Rather mild
J 1324/48	168	55	3·1:1	Rather mild
J 1328/48	166	49	3·4:1	Rather mild
J 1317/48	148	47	3·1:1	Typical
J 1327/48	83	29	2·9:1	Typical
J 1332/48	163	38	4·3:1	Typical
J 1331/48	119	45	2·6:1	Rather severe
J 1330/48	70	33	2·1:1	Severe
Grouped totals	184	28	6·6:1	Very mild
	181	36	5·0:1	Mild
	650	206	3·2:1	Rather mild
	394	114	3·5:1	Typical
	119	45	2·6:1	Rather severe
	70	33	2·1:1	Severe
Totals	1598	462	3·46:1	

Discussion

The distributions given in Table 1 bear out the monofactorial interpretation suggested by the F_2 families of Withering Bract × BAR. SP84. The main gene involved has been given the symbol **Bw** for normal bracts and **bw** for its allele controlling withering bracts. Clearly **bw** is subject to considerable modification by minor genes.

Table 1 has been arranged in descending order of degree of modification of **bw**, it being presumed that families with little modification showed severe symptoms (J 1330/48 and to a lesser extent J 1331/48), whilst those showing only mild effects from the presence of **bw** carried a larger number of modifiers (J 1321/48 and J 1326/48). The fall in the ratio of Normals: Withering Bracts from 7·2:1 in the case of J 1321/48, to 2·1:1 in J 1330/48, suggests that in the presence of a sufficient complex of modifiers **bwbw** plants can be raised to normality. The ratio of 2·1:1, on the other hand, suggests that the gene **bw** confers an advantage on pollen grains carrying it, as compared with those carrying **Bw**. This is borne out by the ratio of families splitting for Withering Bracts to those homogeneous for normal bracts in the F_2 of the second backcross. Out of nineteen families in the second backcross F_2, twelve carried **bw**, whereas a normal expectation would have been for only 50 % of the families to be of this composition. If it be assumed that successful fertilization by pollen grains is approximately in this proportion of 7 **Bw**: 12 **bw**, and that the female gametes are produced in the normal proportion of 1 **Bw**: 1 **bw**, then the self-bred progeny of a **Bwbw** plant should comprise the following phenotypic proportions:

7 **BwBw**:19 **Bwbw**:12 **bwbw**. This gives just under 2·2 Normals:1 Withering Bract—a close approximation to the proportion obtained in J 1330/48, the family with the most severe symptoms.

It is evident that the gene **bw** is of no economic value, since in its full expression it is markedly deleterious and, when modified by minor genes sufficiently for it to be only slightly deleterious, it does not cause the bracts to wither away effectively. These two extremes of expression of **bwbw** are shown by families J 1321/48 and J 1330/48 (Table 1). In J 1321/48, **bwbw** plants had normal-sized bracts which tended to wither to a variable extent but which persisted when dead, thereby *increasing* the trash likely to be caught up by a mechanical picker. The leaves of such plants were only slightly crumpled and fertility appeared to be approximately normal. In J 1330/48 the **bwbw** plants with the most severe symptoms had greatly reduced bracts (smaller than those of the original Withering Bract parent), crumpling of the foliage was severe and no flowers were produced, the buds shedding before they attained full size.

Clearly the gene **bw** is of no value to plant breeders. Whether any other gene or genes which reduce or remove bracts can be employed without lowering yield is at present only a matter for speculation, but it is significant that Kearney (1929) showed that excision of the bracts at anthesis reduced boll size, and the weight of seed and of lint per boll. He suggested that the involucral bracts contribute to the nutrition of the boll which they subtend.

SUMMARY

The character Withering Bracteole in *Gossypium hirsutum* is shown to be controlled by a single recessive gene **bw**. This gene has a pleiotropic action causing leaf crumpling and also sterility to a greater or less extent. Pollen grains carrying **bw** appear to have an advantage in fertilization.

At a low modifier level F_2 ratios of 2·1 Normal:1 Withering Bract were obtained, and **bwbw** plants were more or less sterile and had severely crumpled foliage. At a higher modifier level F_2 ratios rose to 7·2:1, presumably because many of the **bwbw** plants were indistinguishable from normal. In such families the deleterious effects of **bw** were largely masked, but as a result the bracteoles also failed to wither effectively. This gene is therefore considered to be useless as a means of removing the bracteoles to facilitate mechanical picking.

REFERENCES

COOK, O. F. & HUBBARD, J. W. (1926). Primitive cottons in Mexico. *J. Hered.* **17**, 463–72.

COOK, O. F. & HUBBARD, J. W. (1928). New cotton characters from Colombia and Ecuador. *J. Hered.* **19**, 177–90.

KEARNEY, T. H. (1929). Development of the cotton boll as affected by removal of the involucre. *J. Agric. Res.* **38**, 381.

STEPHENS, S. G. (1947). Some recent trends in cotton research in the United States. *Emp. Cott. Gr. Rev.* **24**, 28–35.