CHROMOSOMAL MUTATIONS IN SACCHARUM

by

G. BREMER (Pasoeroean).

With 3 textfigures and tab. II and III.

The Javanese varieties of *Saccharum spontaneum* (Glagah) have 56 chromosomes in their haploid phase. A Glagah-variety of North Celebes, named Glagah Tabongo, on the other hand has a haploid chromosome number of 40. In outer characters it differs somewhat from the Glagah of Java; for instance it has longer internodes and the uppermost floral leaf has a much longer blade.

Since 1921 Glagah Tabongo was propagated by cuttings in the field of the Experiment Station of Pasoeroean. In 1923 a self fertilization was made of it by Dr. J. Jeswiet. For that purpose an inflorescence was enclosed in a bag of cotton to prevent cross fertilization. From this selfing many seedlings could be obtained. Among a large number of normal plants Jeswiet found giant plants, which had much thicker stems, longer internodes and broader leaves. The stems of Glagah Tabongo are 1.2—1.6 cm. in diameter, the stems of some of those giants 2—2.3 cm. (See photograph plate I).

I collected material for cytological investigation from normal and giant plants. It was evident that the giant plants had quite abnormal stamens. These stamens were carpellodic and had a feathered stigma at the top (fig. 1). Sometimes the anthers were well developed. In fullgrown state they could open and the pollen could germinate on the stigmata of the anthers. Often the anthers were greatly reduced in size and remained closed.

In one spikelet one or two anthers may be of normal size and the other much reduced. In some individuals the anthers are always small and when the spikelet opens, the filaments of the stamens do not stretch and one may only see a bundle of stigmata coming out of the top of the spikelet. Especially when the anthers are very small they often show strange modifications and bear peculiar excrescences. In microtome sections of such anthers one may observe, that not four microsporangia are developed but

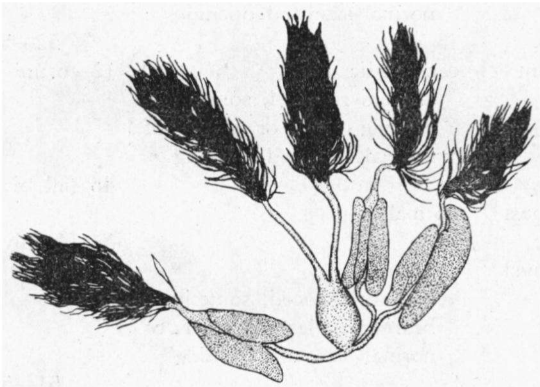

Fig. 1. Three carpellodic stamens, each bearing one feathered stigma and an ovary with to feathered stigmata.

only from one to three and that they often bear one or more ovules at their ventral side. If the carpellodic stamens have anthers of more normal length four microsporangia are developed and in that case they rarely bear ovules.

Microtome sections were made from giant plants which all had stigmated stamens and from plants of more normal size. I was greatly surprised to find that normal and

Number of plant	Size of plant	Stamens	Chromosome number in pollen mothercells	
			in diakinesis or metaphase	in anaphase
202 M 1	robust	normal	52—53 (1—3 univalents)	103
202 M 13	giant	carpellodic anthers reduced, sometimes bearing ovules or anthers of normal size and opening	51—52 (2—4 univalents)	—
202 M 16	giant	carpellodic anthers reduced, sometimes bearing ovules or anthers of normal size and opening	52—54 (2—6 univalents)	—
202 M 29	robust	normal	48 (all bivalent)	—
202 M 48	robust	carpellodic anthers reduced, sometimes bearing ovules or anthers of normal size and opening	54 (4 univalents)	104
202 M 53	normal	carpellodic anthers of normal size, always opening, very small pistills	51—53 (3—7 univalents)	99
202 M 56	normal	normal	48 (all bivalent)	96
202 M 70	giant	carpellodic anthers always reduced in size, bearing many ovules, filaments not stretching	54—56 (0—4 univalents)	108
202 M 76	normal	normal	48 (all bivalent)	96
202 M 88	giant	carpellodic anthers always reduced in size, bearing many ovules, filaments not stretching	no reduction division present in preparations	

abnormal plants had chromosome numbers which differed from the number 40 of the parent plant. In the table on p. 84 a short account is given of the size of the plants, the chromosome numbers and the character of the stamens.

The plants had different chromosome numbers. In some plants a regular reduction division was found, in which

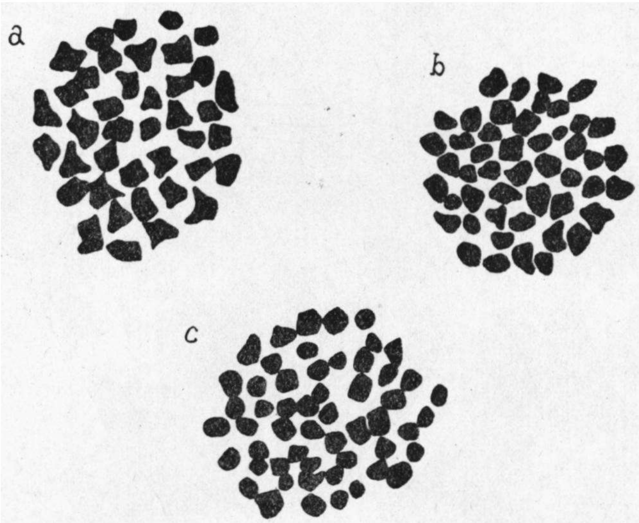

Fig. 2. *a*. Metaphase of heterotype division of 3 N 5 (n = 40); *b*. Metaphase of heterotype division of 202 M 76 (n = 48); *c*. Metaphase of heterotype division of 202 M 76 (n = 54). × 2300.

only bivalent chromosomes were seen. In pollen-mother-cells of other plants I observed a small but varying number of univalents, originating from non-conjunction. These univalents lagged behind during anaphase and were split longitudinally. Fig. 2*b* pictures a nuclear plate of the heterotype division of 202 M. 76 in which 48 chromosomes could be counted. Fig. 2*c* gives a nuclear plate of 202 M 70 with 54 chromosomes.

The figures 3 and 4, plate III, show photo micrographs of pollen mothercells of the same plants. In the nuclear plate of 202 M 76 one may easily count 48 chromosomes.
A transverse section of three stamina and an ovary of

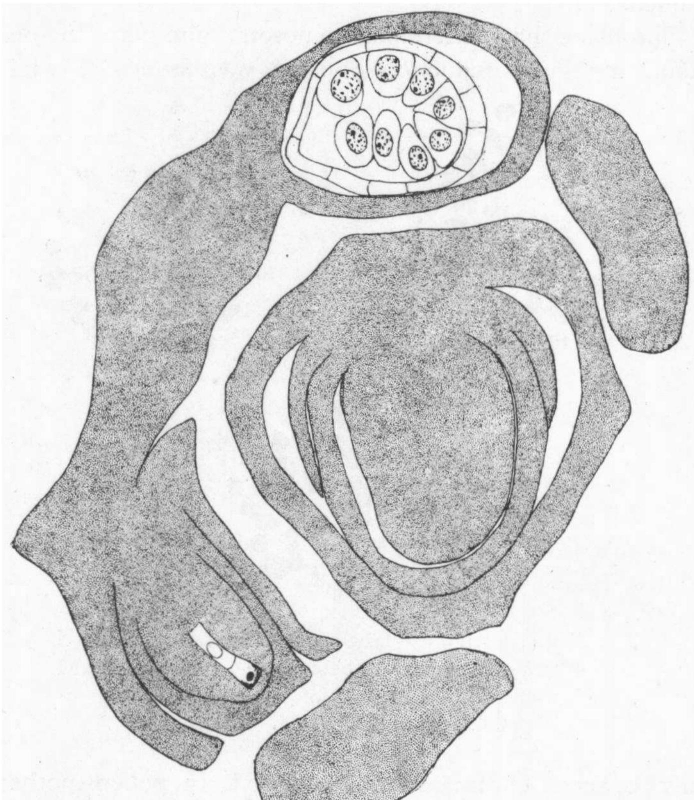

Fig. 3. Transverse section of three stamina and an ovary of 202 M 70. × 200.

202 M 70 is pictured in fig. 3. From two stamina one sees a section through the filament, from the third through the anther. The anther shows at one side a microsporangium with pollenmothercells in diakinesis, at the other side an

ovule with two integuments. Also in fig. 5 plate III a photo micrograph of the same transverse section has been reproduced.

In 1924 again two inflorescences of Glagah Tabango were selfed, from which a large progeny arose. The result was not the same as that of the preceding year. Only very few plants were gigantic; almost all plants showed a normal habit. Material was collected from 15 plants, two of them being giants. From these 15 plants only one giant plant showed carpellodic stamens. Preparations were made from material of the two giant and four normal plants. 2 N 1 was a giant with normal stamens and had 48 chromosomes in its heterotype metaphase. The other giant 3 N 3 had carpellodic stamens. Often each stamen showed not one, but two or three feathered stigmata.. The anthers were always much reduced in size and strongly modified in shape. They bore many ovules and they rarely contained a small microsporangium in which only very few pollen-mothercells were found. It was impossible to those pollen mothercells. The ovule within the ovary never count chromosomes in contained 2 normal megaspore-mothercells but instead of this a group of large archespore-cells. Frequently these cells contained more than one nucleus. No embryosacs were developed. The chromosomes of this individual could not be counted. The four normal plants, which were examined, 2 N 3, 2 N 4, 3 N 5 and 3 N 6 all showed 40 chromosomes in the haploid phase like the parent plant. In fig. 2*c* a nuclear plate of the heterotype division of 3 N 5 has been pictured. A photo micrograph of 3 N 5 has been reproduced in fig. 2 plate III.

Summarizing one may say about the self fertilization of Glagah Tabongo:

1. In 1923 many giant plants arose among a large number

of plants of normal habit. In 1924 very few giant plants were obtained.

2. Many plants of 1923 showed carpellodic anthers; among the plants of 1924 carpellody was exceptional.
3. Among the plants of 1923 every one of the 9 plants in which chromosomes have been counted, showed a chromosome number which deviated from that of the parent plant. The plants of 1924 mostly showed the chromosome number 40 of the parent plant. Plants with deviating chromosome numbers seemed to be rather rare.

It is plain that there must be some connection between these abnormal chromosome sets and the gigantic stature and also between these chromosome sets and the carpellody. It seems probably that the carpellody of stamens is due to some unbalancing effect of the extra chromosomes, which comes to expression during stamen formation.

The plants which were used for cytological investigation were propagated by cuttings every year from 1924 up till now. A clone deriving from one plant which showed carpellody in 1924 (plant from the selfing in 1923) also had carpellodic anthers in the following years, but it was remarkable, that from many plants the anthers were more reduced in size in 1924 than in 1926 and that in 1924 more ovules were formed in the anthers than in 1926. It is evident therefore, that outer circumstances also have some influence upon stamen formation.

The results obtained by this investigation slightly resemble those obtained by Helen Sorokin[1]) with *Ranunculus acris*. Gynodimorphic forms of R. acris had 18 chromosomes in the somatic mitoses, the normal forms 12.

[1]) H. Sorokin. Cytological and morphological investigations on Gynodimorphic and normal forms of Ranunculus acris L. Genetics 12, 1927, p. 59.

By crossing a gynodimorphic plant with the pollen of normal plants she got an extremely variable progeny. „Some plants were remarkably tall, other were of the type of the nanella mutations". The plants showed different chromosome numbers from 12 to 18, but there was no correlation between the numbers of chromosomes and the degree of reduction of the anthers. The original gynodimorphic plant with 18 chromosomes was not a real triploid form, because the chromosomes could not be arranged in six trivalent sets.

In Ranunculus acris „gynodimorphism is associated with unstable conditions of the plant characters and is an indication of the unbalanced types of changes which have taken place in the chromosome compliment of the nuclei". This is also the case with the carpellody in the progeny of the Saccharum spontaneum variety.

The origin of gynodimorphism in R. acris is explained as a result of hybridization followed by segragation. It would be interesting to know if gynodimorphism also can be the result of a sudden aberration of normal iploid R. acris forms like carpellody associated with chromosome-aberrations in Saccharum spontaneum.

Chromosomal mutations as described above are not yet found in other plants. Mutants are known which are triploid, tetraploid or pentaploid in comparison to the plants from which they originate. Formation of diploid generative cells or doubling of the chromosomes by splitting within the zygote is probably the cause of the appearance of such mutant plants. Other mutants would arise by non-disjunction. These mutants mostly show one extra chromosome. These Saccharum mutants however show many additional chromosomes. The diploid number of the parent plant is 80. The number of the daughter plants amount from 96 to 108. There are 16 to 28 additional chromosomes. The cause of these aberrations is unknown. One may suppose that non-disjunction of many chromosomes in the parent plant is the cause of it. But this is highly improbable. In 1923 material of one inflorescence of Glagah Tabongo was examined, in 1924 material of two inflorescences. A normal reduction division of pollen-mothercells was found. Univalent chromosomes, originating from non-conjunction were rarely observed in very small numbers The origin of the extra chromosomes therefore remains obscure. It seems the most likely explanation that some of the chromosomes spilt during fertilization in the zygote, an individual with extra chromosomes resulting from this splitting.

Carpellody has also been observed in other Gramineae. According to Penzig[1]) carpellody was found in rice by I. Hori. About this phenomenon Penzig writes: „I. Hori notirt auch Umwandlung der Stamina in Carpelle, z. Tle. mit interessanten Uebergangsformen (gefiederte Narben an der Spitze der geöffneten Antheren"). In this case drought was the cause of carpellody.

Leithly and Sando found pistillody in wheat. Kajanus[2]) gives the following information about this question: „Anthony (1918) beobachtete, dass einzelne Staubblätter teilweise als Stempel ausgebildet waren, die Umwandlung erschien aber dabei ziemlich umbedeutlich. Ueber weitgehendere diesbezügliche Veränderungen haben Leithly and Sando berichtet. In ihrem Materiale kam nicht nur partielle, sondern auch vollständige Verwandlung von Staubblättern in Fruchtblätter vor, obwohl keine Körner erzeugt wurden, auch nicht bei künstlicher Bestäubung; ausserdem war die Anomalie — in vielen Abstufungen — bei zahlreichen Blüten der betreffenden Ähren vorhanden. In der

---

[1]) O. Penzig. Pflanzenteratologie Bd. 3, p. 450.

[2]) B. Kajanus. Die Ergebnisse der genetischen Weizenforschung. Bibliographia genetica III, 1927, p. 217.

Internodes of Saccharum spontaneum (of Java), Glagah Tabongo, 202 M 70 and 202 M 88 Half of natural size.

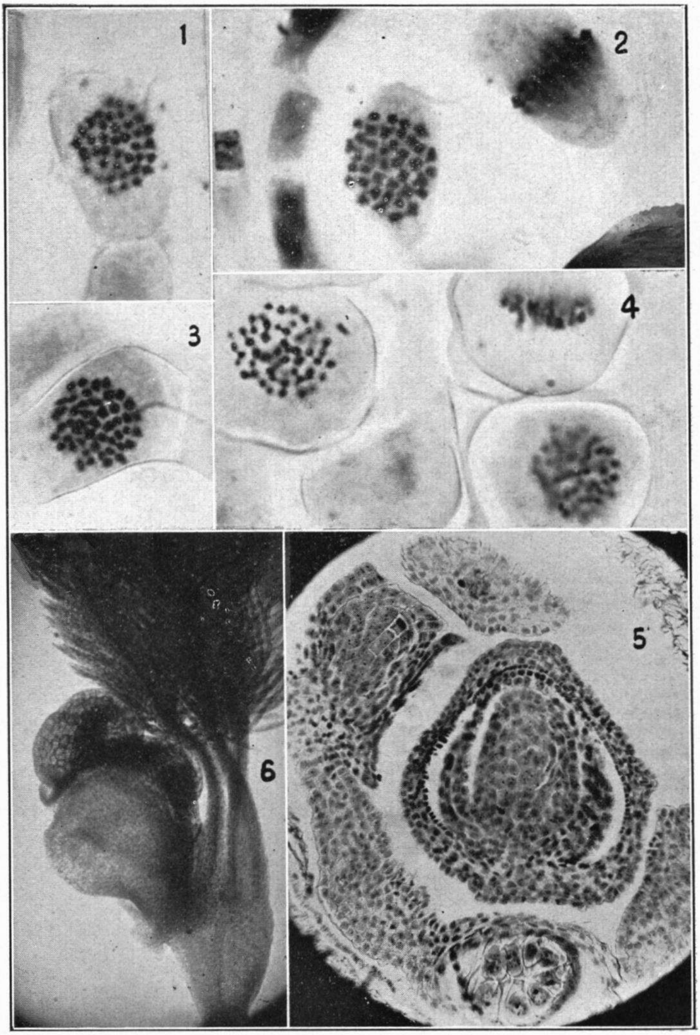

Fig. 1. Photo-micrograph of the metaphase of heterotype division of Glagah Tabongo (n = 40) × 1200. Fig. 2. Metaphase of heterotype division of 3 N 5 (n = 40) × 1200. Fig. 3. Metaphase of heterotype division of 202 M 76 (n = 48) × 1200. Fig. 4. Metaphase of heterotype division of 202 M 70 (n = 54) × 1200. Fig. 5. Transverve section of three stamina and an ovary of 202 M 70. × 150. Fig. 6. Carpellodic stamen with three feathered stigmata of 3 N 3.

Nachkommenschaft der abnormen Pflanzen trat die beschriebene Erscheinung nicht wieder auf".

Worsdell[1]) remarks on carpellody: „A frequent phenomenon, reveiling to us the fact that stamen and carpel are very closely-allied organs, and the facility with which the one may change into the other, doubtless due to the fact that both are derived from a common ancestor, the asexual sporophyll, which exists today in some of the more primitive types of plants, such as ferns, horse-tails, and some lycopods". The cause of the transformation of stamens into carpels in different cases may be not the same. We have seen that unfavorable external influences sometimes are the cause of it, but also unbalanced chromosome sets, which may originate from chromosomal mutation or probably also from hybridization. All Saccharum plants are hybrids. Therefore in Glagah Tabongo the chromosomal mutation itself may be the result of the hybrid state.

[1]) W. C. Worsdell. The principles of plant-teratology. Vol. II, 1916, p. 182.