Induced Desynapsis in Grain Sorghum

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Many examples of genotypic control of meiotic process have been reported in literature; most of them from natural populations and in the progeny of mutagen treated plants (Rees 1961, Riley and Law 1965). The possibility of bivalent formation and the genetic demonstration of recombination of genes in homozygous recessive plants makes the gene better definable as desynaptic rather than asynaptic (Miller 1963). In desynaptic meiosis the chromosomes pair almost normally but fall apart due to the failure of chiasma formation. The univalents formed show aberrant behaviour at anaphase I and subsequent stages of meiosis causing different degrees of sterility. In *Sorghum*, there were reports dealing with such abnormality under the name 'asynapsis' (Krishnaswamy and Meenakshi 1957, Ross *et al.* 1960, Stephens and Schertz 1965). These plants were isolated either in natural or hybrid populations and the recessive controlling genes in different lines have been assigned gene symbols as^1 , as^2 , as^3 and as^4 .

In a programme of cytogenetic study to evaluate the relative mutational response of some parental lines and their hybrid derivatives of *Sorghum bicolor* (L.) Moench, we came across two desynaptic plants in hybrid populations representing second generation after mutagen treatments. Cytological observations made in these plants are reported in the present paper.

Materials and methods

One of the desynaptic plants ($2n=20$) was located in hybrid population of parentage IS 7155 $\times$ BD 569 and treated with 0.1% ethylmethanesulfonate (EMS). The second plant was isolated in the population of the hybrid BD 569 $\times$ IS 2965, the seed of which was irradiated with 30 K-rad dose of gamma rays. BD 569 is a dwarf line and the other two parents were tall varieties and further differed among themselves in a number of morphologically well defined attributes. Material for meiotic study was fixed in 1:4 acetic alcohol and smear preparations were made in 1% acetocarmine.

Results

The two desynaptic plants differed from their normal sibs in the same population notably in the reduced panicle size and were characterized by high pollen sterility and poor seed set. Meiotic observations revealed that pairing of the chromosomes at pachytene stage was apparently normal in several of the cells examined. In a

few others, unpaired distal regions could be discerned in 1 to 3 bivalent chromosomes (Fig. 1). In their basic morphology the differentiated pachytene chromosomes in the present material resembled other grain sorghums described earlier (see Reddi 1976).

At diakinesis and metaphase I, univalent frequency varied from 2 to 10 with the mean value of 2.94 in the EMS-induced desynaptic plant (No. 23-11). In addition there is a marked increase in the frequency of rod bivalents which is accompanied

Figs. 1-4. 1, pachytene. Three bivalents with distal unpaired regions (arrows) in plant 23-11. $\times 1000$. 2, metaphase I. 10 univalents + 2 ring bivalents and 3 rod bivalents in plant 23-11. $\times 1000$. 3, telophase I with persistent bridges in plant 23-11. $\times 1000$. 4, a hexad with micro-nuclei in plant 23-11. $\times 1000$.

by a corresponding decrease in ring type (Fig. 2). On the other hand, the gamma ray induced desynaptic plant (No. 4-7) showed a higher range of 8-16 univalents with an average of 11.46 per cell (Table 1). While there was reduction in ring bivalents from 8.80 in control to 0.76 in the desynaptic 4-7, the rod type frequency in the latter is about three times higher than the former. It appears that the formation of chiasmata fails in both the arms of several bivalents in this plant whereas in the other such a failure is more often limited to one of the two arms of the bivalents as judged from the increased rod bivalent formation in the latter. Average chiasma

frequencies were significantly lower in both the plants when compared to the control values, although it was lowest in 4-7 (Table 1).

At anaphase I normal distribution of 10-10 chromosomes was found rarely in plant 23-11 but they were absent in the second. Unequal segregations accompanied by variable number of laggard formation were found in 24.97% of the cells in the former while in the latter the frequency of such cells was 47.04%.

Bivalent and univalent bridges apparently caused by chromosome stickiness were formed in both the plants of the present study. Their frequencies were 62.44% and 44.10% of the cells studied respectively in the two plants (Fig. 3). Telophase I was also highly irregular with variable number of laggards and persistent bridges. During second division of meiosis lagging chromosomes remained in the cytoplasm and were not included in the nuclei, resulting in numerically unbalanced chromosome distributions. At anaphase II and telophase II also, bridges and laggards were formed. Micronuclei were common in quartets. At sporad stage, in addition

Table 1. Chromosome associations at diakinesis and metaphase I in the desynaptic plants of *Sorghum* ($2n=20$)

Plant no.	No. of cells scored	Bivalents				Univalents		
		Ring type		Rod type		Total	Average no. of univalents per cell	average no. of chiasmata per cell
		Total	average no. of bivalents per cell	Total	average no. of bivalents per cell			
IS 7155 × BD 569 control	20	160	8.00	40	2.00	—	—	18.10 ± 1.41
Desynaptic plant no. 23-11	207	583	2.81	1182	5.71	610	2.94	11.37 ± 2.25
BD 569 × IS 2695 control	40	352	8.80	48	1.20	—	—	18.97 ± 0.93
Desynaptic plant no. 4-7	30	23	0.76	105	3.50	344	11.46	5.03 ± 1.88

to tetrads, triads, pentads and hexads consisting of cells having different sizes were observed (Fig. 4).

Discussion

Since one to several bivalents were always present in addition to variable univalent formation, the desynapsis observed in the two plants of the present study appears to be partial. A somewhat similar variability characterized the lines of *Sorghum* described previously. However, in the line examined by Stephens and Schertz (1965) cells were found with complete univalent formation in addition to those with one or more bivalents. The additional peculiarity observed in the present material not described previously, relates to the formation of bridges more commonly at anaphase I and to a limited extent at anaphase II as well. It appears that stickiness is the main factor for their origin and probably caused by the desynaptic mutant genes.

In the two lines of *Sorghum* described by Krishnaswamy and Meenakshi (1957) symbols as^1 and as^2 have been assigned to the genes involved. Ross *et al.* (1960) described a third line and had assigned the symbol as^3 to the controlling gene. Stephens and Schertz (1965) described the fourth line and further checked that the controlling gene was non-allelic to as^3 and therefore, designated the mutant gene as as^4 . In all these studies listed the aberrant meiosis was described as 'asynapsis'. However, in the present material, in view of almost normal pairing of the chromosomes at pachytene in a good majority of the cells examined, the condition appears to represent desynapsis. Failure of synapsis observed in a few cells at pachytene is invariably limited to distal regions of 1 to 3 bivalents in the complement.

The origin of the desynaptic plants in the mutagen treated hybrid populations and their absence in the parental and hybrid controls, indicates that heterozygosity and heterogeneity is more favourable for the induction of desynaptic mutant genes in the present material. The segregation of 3 to 1 fertile to sterile plants in some of the normal plant progenies of the two desynaptics indicates that, in each case a recessive mutation was responsible. It is probable that two different recessive gene mutations are involved and therefore designated tentatively as_5 and as_6 . The present study confirms and extends the previous reports on similar lines and points to the possibility of polygenic control of meiosis in *Sorghum* species as has been reported in most of the higher plants including *Pisum* (Gottschalk and Baquar 1971).

Summary

Desynapsis with reduced pollen and seed fertility was observed in two mutagen treated plants in intervarietal hybrid progenies of *Sorghum bicolor* (L.) Moench. These plants showed apparently normal pairing at pachytene except for occasional unpaired distal regions in 1 to 3 bivalents. Variable number of univalents and increased number of rod bivalents were found at diakinesis and metaphase I. Anaphase I and II bridges recorded appear to be due to chromosome stickiness. The degree of desynapsis, however, differed in the two plants as measured by the univalent and laggard formation. It is suggested that two different mutant genes designated tentatively as as_5 and as_6 are involved.

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