ON THE HOMEOLOGOUS CHROMOSOME SUBSTITUTION HYPOTHESIS IN SORGHUM VULGARE PERS.¹

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INTRODUCTION

Seedlings of diploid sorghum, Sorghum vulgare Pers., treated with colchicine yield, in addition to tetraploids, diploid true-breeding and nontrue-breeding mutants (see Sanders and Franzke, 1964, for references to many of the papers published on the colchicine-induced diploid sorghum mutants). At least three proposals have been given to explain the origin of the diploid mutants following colchicine treatment (Franzke and Ross, 1952; Harpstead et al., 1954; Simantel et al., 1963; Sanders and Franzke, 1964). The first proposal was based on a phenomenon known as reductional grouping of the somatic chromosomes which would result in the chromosomes containing gene blocks from one ancestor of the polyploid species occurring in one cell (Franzke and Ross, 1952). A plant originating from this phenomenon would contain duplications and deficiencies for entire chromosomes even though the diploid number did not change. At meiosis in such a plant multivalents would be expected. However, detailed cytological studies by Harpstead et al. (1954) revealed no detectable irregularities in chromosome arrangements and pairing. The original hypothesis was therefore abandoned and a new one was proposed by them which postulates that the diploid mutants are the result of changes in chromatin which are in the nature of multiple point mutations, some of which may involve minute structural changes. With the use of cytological markers, Simantel et al. (1963) showed that a somatic reductional process involving the entire chromosome set was in some way associated with the mutational phenomenon.

Recently, Sanders and Franzke (1964) and Franzke and Sanders (1965) presented a third proposal as the most probable means for the origin of the colchicine-induced diploid mutants. This proposal which is similar in some respects to the first proposal states that “Colchicine-induced diploid mutants arise from the substitution of chromosomes of similar phylogenetic origin (homologous or analogous chromosomes), and that substitutions have not been detected cytologically because there is a tendency for bivalent rather than multivalent pairing to occur in sorghums with 2n=20, and because pairing may occur between analogous chromosomes.”

Information on chromosome association in autotetraploid sorghums played a significant role in formulating the hypothesis proposed by Sanders and Franzke. However, when one observes the cytological data published for autotetraploid and autotetraploid-like sorghums, one notes a considerable degree of variation in average chromosome associations reported by various workers, much of which appears not to be in agreement with the hypothesis. It was the purpose of this study therefore to make a careful cytologically

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logical analysis of chromosome pairing in auto-tetraploid sorghums and to review a specific but pertinent set of data involving chromosome translocations to further evaluate the homologous chromosome substitution hypothesis. These data are reported here, and they point to the conclusion that the available information, both genetic and cytological, provide little, if any, support for the hypothesis.

Materials and Methods

Disinfected (10% chlorox) seeds of the cultivar Combine Kafir 60 were germinated on a ½ to ⅔ inch layer of two per cent bacto-streptomycin water agar and treated with colchicine.

The procedure used in applying colchicine to the diploid sorghum seedlings to produce autotetraploids involved a modification of the method used by Nielsen and Drulson (1964). When the coleoptiles reached a length of ⅔ to ¾ inch, an additional layer of cool (semi-fluid) water agar was added to protect the base of the coleoptiles and roots from colchicine. Between 16 and 24 hours after the addition of the second layer of agar, the exposed coleoptile tips were decapitated. The seedlings were then divided into three lots and treated with 0.05, 0.1, and 0.2 per cent aqueous solution of colchicine which was poured over the agar surface until the cut coleoptiles were submerged. The dishes were then placed in a vacuum desiccator and aspirated. The vacuum used was that created by pulling a column of mercury to a height of 20 inches in a glass tube. The vacuum was then released slowly and a second vacuum was created. This method enabled the colchicine solution to be drawn inside the coleoptile to make contact with the shoot primordium. After the second evacuation the colchicine solution was poured off and the seedlings were rinsed with distilled water. The dishes were covered and the seedlings remained in the laboratory for 24 hours before being transplanted to pots in the greenhouse.

The seedlings were grown in the greenhouse for a period of four weeks and those that survived were transplanted to the field. Observations were made periodically during the growing season to detect plants that possessed certain gigas characters. When a plant was observed that was different from the normal or control, it was tagged for further observations. All tagged plants were studied cytologically. For cytological studies panicle branches were collected and fixed in a 3:1 ethyl alcohol-glacial acetic acid mixture. Twenty-four hours after fixation they were placed in a 70% alcohol solution for storage until cytological examination. The standard propionic carmin-squash technique was used for staining of pollen mother cells for cytological studies. Cytological analyses were made at metaphase-I which is the best stage for critical analyses of chromosome conjugation.

Chromosome counts were made from slides containing well-spread cells. This allowed the scoring of nearly all cells on a slide. Whenever there was any question whether a cell contained, for example, 4 or 5 quadrivalents, the lesser number was recorded for that cell. This was done to avoid as much as possible any bias toward a higher frequency of quadrivalents per cell.