Arab Gulf J. scient. Res. **3** (2), pp. 709-715 (1985)

Univalent Shift – A Problem in Monosomic Analysis for Gene-Chromosome Association

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ABSTRACT. The study of 40-chromosome progeny of the breeding material for establishing a monosomic series in *Avena sativa* cv. Manod (2n = 6x = 42) by backcrossing it with *A. sativa* cv. Borreck GM1-1, revealed the presence of 19 bivalents and 2 univalents in all the pollen mother cells (PMC's) of Av. 562/3/41/53 as compared to normal 20 bivalents per PMC. It is highly likely that the original monosome (Satellite-2, Hafiz 1978) has undergone monosomic shift. Furthermore, it disturbs other homoeologous chromosomes because of greater affinity compared to the homologous partner. The paper also discusses the implication of monosomic analysis for gene-chromosome association in practical plant breeding.

Through monosomic analysis, several genes have successfully been located on specific chromosomes of crops such as wheat (*Triticum* sp.) and *Avena sativa* L. (Metzger and Silbaugh 1970, Morris 1973, Bares and Kosner 1975, Hafiz and Larik 1981, 1982, 1983). A gene associated with a particular chromosome can easily be transferred using the monosomic system (Sears 1953). It is recommended, however, that the derived progenies be periodically analyzed cytologically to ensure the absence of monosomic shift (Hafiz 1978).

During the course of a backcrossing program that was initiated primarily to (a) establish a monosomic series in the genetic background of *A. sativa* cv. Sun II, and (b) to use the newly produced monosomics to establish gene-chromosome associations, an opportunity was provided to study in some detail the problem of monosomic shift.

This paper describes the results of such a study.

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Material and Methods

The 42- and 41-chromosome plants and their derivatives used belong to the common oat, *Avena sativa* (2n = 6x = 42). Their sources and the schedule of the backcrossing program used has been reported earlier (Hafiz and Thomas 1978). Monosomic (2n = 41) individuals were allowed to self-pollinate and all progenies with 40-chromosomes were grown to maturity to confirm their nullisomic status.

The staining procedure for mitotic and meiotic studies adapted was that described by Snow (1963).

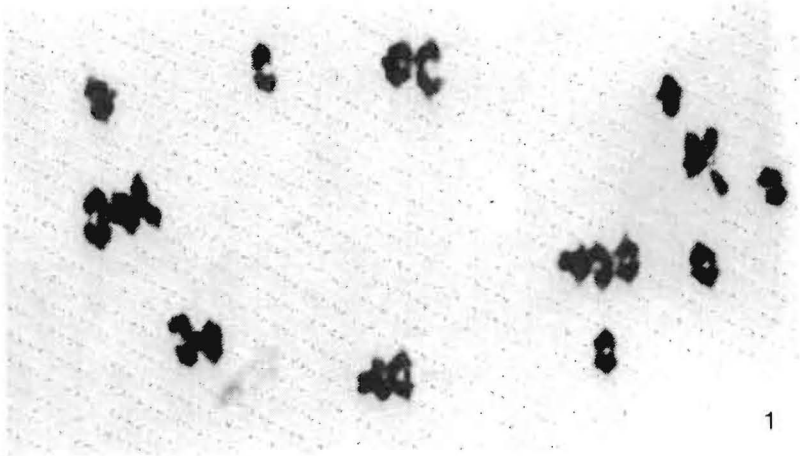
Results and Discussion

The loss of either a single chromosome (monosomy) or of a homologous pair of chromosomes (nullisomy) usually disturbs the genetic behaviour of an organism. The mature 40-chromosome plants initially obtained from the progenies of selfed monosomics were generally dwarf, feeble, and sterile with a reduced panicle size as compared to monosomic and disomic plants. The phenotypic similarities were uniform within and between families of Manod and Borreck GM1-1 series (Hafiz and Thomas 1978), however, in BCF_1 hybrids, all siblings resembled one another and exhibited 20 bivalents (Plate 1). The only exception was provided by Av 562/3/41/53 which possessed 19 bivalents and 2 univalents (Plate 2).

A particular monosome, would be in a different genetic background compared to another monosome belonging to same genome and consequently the behaviour will also be different in making the other chromosomes desynapse (Hafiz 1978). In the present study, the SAT-2 chromosome, that is responsible for monosomy in Borreck GM1-1, made two of the twenty pairs to desynapse (Plate 3) and behave as lagging chromosomes. The reason could be that in hexaploids each gene locus is triplicated and the monosome tends to pair with a homoeologous chromosome. The incidence of dimonosomics (2n − 1 − 1 = 40) in present study points to the fact that such meiotic disturbances could lead to the occurrence of monosomic shift (Plate 2). Such phenomena have also been recorded by Person (1956) in wheat, Hacker and Riley (1965) in oats, and Larter and Shigenaga (1971) in triticale.

That the incidence of univalent shift is more likely to occur in the earlier, heterozygous genotypes, is further supported by the present investigation in which the phenotypic expression within families was more uniform in later backcross generations as compared to earlier ones. However, it can be rather difficult to detect the occurrence of monosomic shift unless definite genetic and/or cytogenetic markers are identified specific for the particular chromosomes involved.

As suggested earlier (Hafiz and Larik 1982) the breeding program should always be associated with cytological examination of the breeding material to avoid



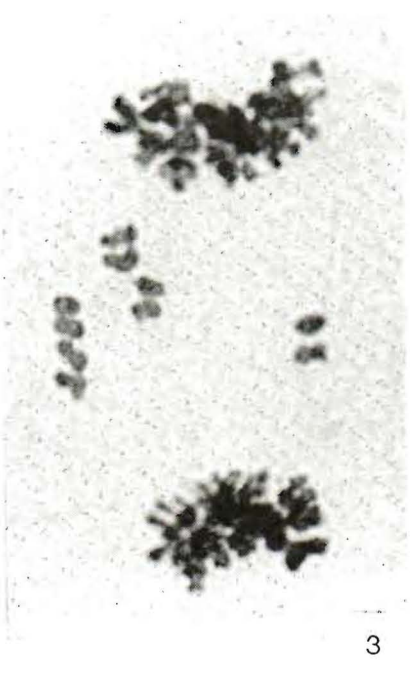


Plate 1. BCF_1 hybrid showing 20_{II} at metaphase.

Plate 2. Dimonosomic ($2n - 1 - 1 = 40$) Av 562/3/41/53 of BCF_1 showing $19_{II} + 2_I$ at metaphase.

Plate 3. Showing 5 dividing univalents at anaphase.

varied complications, the most important of which is the univalent-shift. The incomplete series of monosomics of *A. sativa* is an another limitation in this respect. It has been suggested that several factors affect the frequency of aneuploidy in the progenies derived from aneuploid parents (Khush 1973, Larik 1981). These include the loss of univalents during gametogenesis, certation effect of the pollen tubes from euploid and aneuploid pollen grains, and the differential viability of different zygotic combinations. The direction in which the cross is made can also differentially affect monosomic frequencies (Siddiqui 1972). As a result of one or more of these factors, n-1 gametes are produced in a disproportionately high frequency. As a result, chromosome numbers ranging from 38 to 44 were observed in the material under study, therefore the possibility of univalent-shift cannot be excluded (Person 1956).

The occurrence of univalent shift unless detected by routine cytological analysis, can obviously introduce errors into the monosomic analysis method for gene mapping. Furthermore, as in the present study, the occurrence of a double monosomic in the BCF_1 progeny, clearly points to the need for a cytological examination of each (or at least, alternate) backcross generations to ensure that the desired monosomic is being transferred. For the successful application of the monosomic technique in the transfer of a specific monosome, it is essential that cytological analyses be conducted concomitantly with the breeding program.

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(Received 04/02/1984;
in revised form 12/05/1984)

انتقال الكروموسوم الوحيد - مشاكل تحديد سلوك الكروموسوم الوحيد من أجل ترابط عمل الجين على الكروموسوم

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دلت دراسة النسل الحامل لـ ٤٠ كروموزوما والناتج من التزاوج الرجعي لـ *A. Sativa* من الصنف المنزرع Manod (2n = 6x = 42) مع الصنف المنزرع Borreck GM-1-1 وذلك للحصول علي اقتران كروموسومي في عدد الأزواج ينقصها واحدا (2n – 1) .

التزاوجات الكروموسومية أوضحت أن هناك تسعة عشر ازواج متوافقة وعدد اثنين كروموسوم تظهر بشكل افرادي التوزيع في كل خلية من الخلايا المنشئة لحبوب اللقاح لنبات التزاوج الرجعي Av 562/3/41/53 وذلك بالمقارنة الى الاقتران الثنائي العادي لعشرين زوج لبقية النباتات .

من المحتمل بأن الاقتران الكروموسومي الناقص قد أتى بواسطة التبادل مع آخر، وعلى نفس المنوال قد أدى الى تغير نظام التضاعف للأزواج الكروموسومية القرنيه والسبب في ذلك قد يعزى الى عظم الألفة بينهما بالمقارنة الى أزواج الكروموسومات الأبوية القرينة .

هذا العمـل يتضمن تحليلا للأقتران الكروموسومي الناقص وعلاقتة بتوافق فعل الجين على الكروموسوم لأغراض تربية النباتات العملية .