Induced tetraploids of ginger (*Zingiber officinale* Rosc.)

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ABSTRACT

Autotetraploids were produced in a clone of ginger by treating sprouting buds on the rhizome with 0.25% colchicine solution. The tetraploid was more vigorous in growth, had larger rhizomes and high yield. Oil content of rhizomes, however, was lower in the tetraploid than in the original diploid cultivar.

Key words: ginger, *Zingiber officinale*, autotetraploidy

Introduction

Ginger (*Zingiber officinale* Rosc.) is one of the important spice crops widely grown in many tropical and subtropical countries. An essential oil and an oleoresin extracted from the fleshy aromatic rhizomes are used for flavouring purposes and in medicine. Several cultivars of ginger differing in fibre content and yield of rhizomes have been recognized (Purseglove 1975). The plant is propagated vegetatively by rhizomes. Though it flowers regularly, the plant is not known to set seeds. East (1940) reported self-incompatibility in *Z. officinale*. Pollen fertility is low in all varieties due to meiotic abnormalities (Ramachandran 1969). The lack of seed set has been a barrier to recombination breeding, and hardly any work has so far been done on the genetic improvement of the crop.

The ginger plant is ideally suited for polyploidy breeding as it has a low chromosome number and nuclear volume. Cytological studies hitherto have revealed only diploids (2n = 22). Furthermore, as the crop is vegetatively propagated, any improvement in yield or quality that may be produced can readily be maintained.

As there had been no previous report of natural or induced polyploidy in ginger, the present study was undertaken in 1979. The object of the present study was to develop tetraploid varieties, to investigate their cytogenetic behaviour and to evaluate them as improved varieties.

A preliminary report on the induced tetraploid was published (Ramachandran 1982). The present paper gives an account of studies on the morphology, cytology, fertility, yield and oil content of rhizomes in diploid and induced tetraploids of ginger.

Materials and methods

The cultivar 'Maran' was used to produce tetraploids. Tetraploidy was induced by treating sprouting buds on rhizomes with 0.25% aqueous solution of colchicine. A hole about 2 mm diameter and 4 mm deep made close to a sprouting bud with a cork borer was kept filled for 4 hours, from 10-14 hours. The rhizomes were washed in running water for 1 hour and stored in moist soil overnight. This treatment was repeated for two consecutive days after which the rhizomes were planted in pots. Eleven of the 90 plants showed visible morphological changes, and these were planted in separate pots. Chromosome number in root-tips were checked and four of these turned out to be tetraploids.

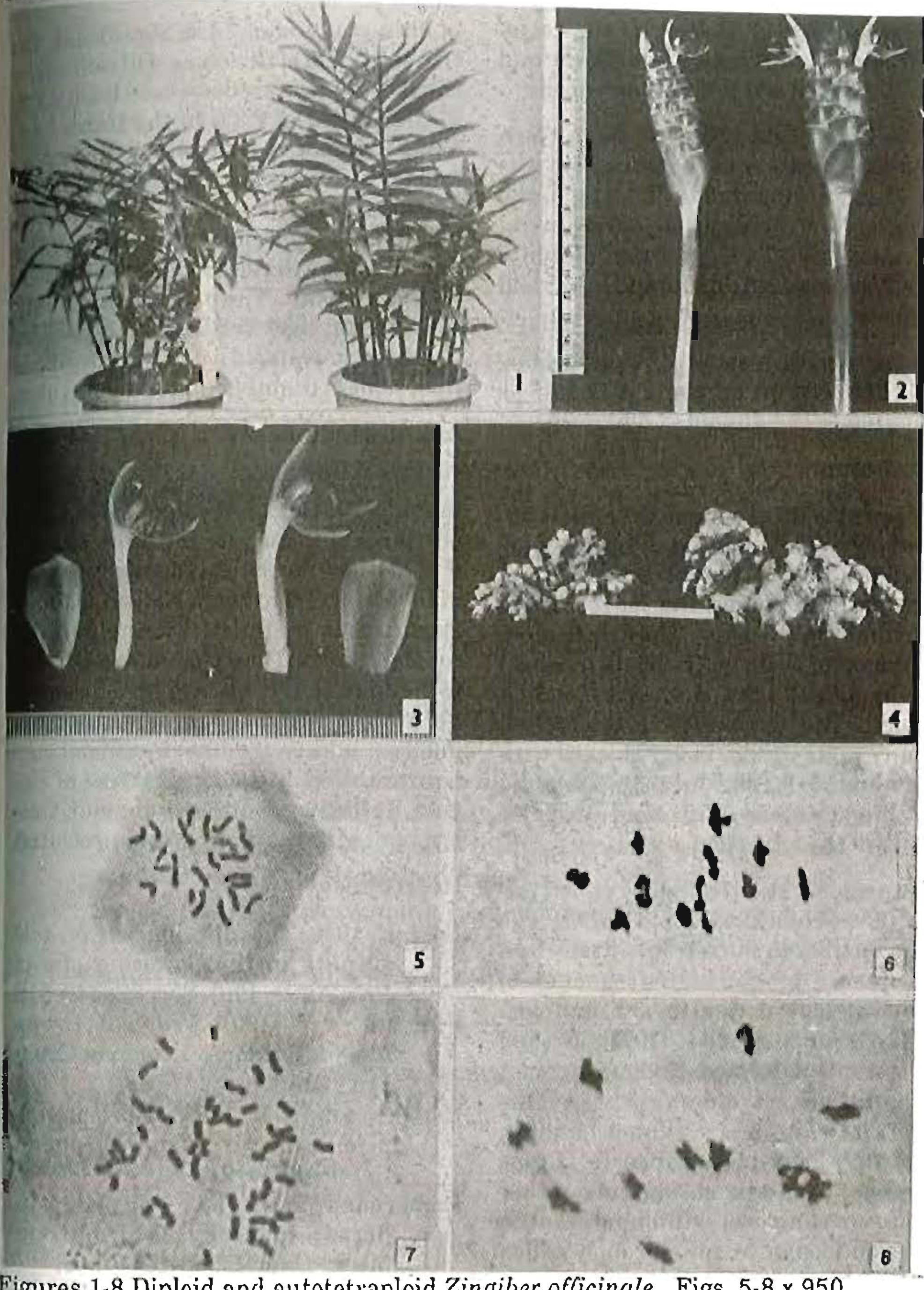
The somatic chromosomes of the diploid and the tetraploid plants were studied from root-tips pre-treated with 0.002 M hydroxyquinoline for 4 hours at 4° C, washed in water, and fixed in 1:3 acetic alcohol. For meiotic studies, anthers were dissected out from flower buds and fixed. Slides were prepared by the acetocarmine technique. For comparison of yield, the diploids and tetraploids were grown in raised beds in randomized block design, with plants spaced at 23 cm and the yield data was statistically analysed. Oil in the rhizomes was estimated by the EDC-cold percolation method.

Results

The tetraploids had thicker and taller leafy shoots than the diploids (Figure 1). The leaves were longer, broader, thicker and darker green compared to those of the diploids. The spadices, flowers and floral parts in the tetraploid were larger (Figures 2,3). The rhizomes were thicker, had longer internodes and were less branched than in the diploids (Figure 4). The tetraploids flowered at the same time as the diploids, in August.

Root tip cells in the diploid showed 22 chromosomes (Figure 5). Meiosis showed 11 bivalents at first metaphase (Figure 6). Occasionally a pair of univalents and fragments have been found. At anaphase 1, 1-3 chromatid bridges and fragments occurred in 40 out of 72 PMCs. The pollen was only 13% stainable.

The tetraploid showed 44 chromosomes in root-tip cells (Figure 7). At meiosis the chromosomes formed varying associations. In 50 pollen mother cells at diakenesis examined, the number of quadrivalents varied from 7 to the maximum of 11 (Figure 8), the mean being 9.7 per cell. The number of bivalents ranged from 0-6, with a mean of 1.8. Trivalents and univalents occurred in a low frequency. The most common configuration at metaphase 1 was 10 IV+2 II, having been observed in 18 out of the 50 PMCs. Approximately 80% of the total of 124 PMCs at anaphase I exhibited 22-22 disjunction, the others showing 21-23 (8%) and 20-24(5%). One or two lagging chromosomes occurred in 7% of the cells. As in the diploid, the tetraploid also showed chromatid bridges and fragments at anaphase I. The pollen grains of the tetraploid were noticeably larger than those of the diploid, and were 85% stainable and well-filled. Hand pollinations of flowers were tried in the diploid and



Figures 1-8 Diploid and autotetraploid *Zingiber officinale*. Figs. 5-8 x 950.
1. Diploid (left) and tetraploid (right) plants. 2. Spadices of diploid (left) and tetraploid (right). 3. Floral parts of diploid (left) and tetraploid (right). 4. Rhizomes of diploid (left) and tetraploid (right). 5. Somatic chromosomes of diploid (2n = 22). 6. Metaphase I in diploid showing 11 II. 7. Somatic chromosomes of tetraploid (2n = 44). 8. Diakinesis in tetraploid showing 11 IV.

tetraploid plants. Selfing of the tetraploid and crosses between diploids and tetraploids did not produce any seeds.

In the 1989 yield trial the mean fresh weight of rhizomes in the tetraploid was 198.71 g, as compared to 184.31 g in the diploid. The analysis of variance revealed statistically significant difference at 5% level between diploid and tetraploid means.

The tetraploid rhizomes showed a marginal decrease in oil content (2.3%) as compared to the diploid (2.8%).

Discussion

The tetraploids of ginger, like most induced polyploids, showed the gigas characteristics. There was increase in size of plant parts including the leaves, floral parts and the rhizome. They were more vigorous and their leafy shoots attained greater height than the corresponding diploid. The tetraploid rhizomes had more regular shape, being thicker with longer internodes and due to this reduced branching tendency. This is an attractive feature of the tetraploid ginger.

The tetraploid showed higher pollen fertility (85%) than the diploid (13%). The pollen fertility in the tetraploid may be a consequence of the high frequency of quadrivalent formation (87.3%) and even (22-22) disjunction at AI. The diploid and the tetraploid formed bridge-fragment configurations at anaphases. As the fragments vary in size (Ramachandran 1969) they may be ascribed to U-type exchanges between chromatids rather than to crossing over within paracentric inversion loops. In spite of high pollen fertility the tetraploid did not set seeds. The incompatibility system in ginger needs further study.

The tetraploid of the ginger variety used in this study showed a significant increase in yield of rhizomes. Oil content in rhizomes, however, decreased from 2.8% in the diploid to 2.3% in the tetraploid. Several authors have stressed the importance of a broad genetic base in polyploidy breeding pragrammes, as it has been found that only a small proportion of the diploid types will yield superior polyploids (Stebbins 1956). The present study indicates that it may be possible to produce improved tetraploid varieties of ginger from some of the other diploid clones also.

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