



## Cytological mechanisms of unreduced pollen formation in *Solanum tuberosum* L. cv. Morfana

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Received 18 July 2001; Accepted 24 October 2001

### Abstract

In this study, the meiotic division in pollen mother cells (PMCs) of *Solanum tuberosum* L. cv. Morfana was investigated and the following irregularities were observed: univalent and multivalent formation, chromosome bridges, fragments, lagging chromosomes, condensed chromosomes, tripolar separation. In majority of pollen mother cells the first telophase was followed by cytokinesis and dyads are formed. These cells do not undergo second meiotic division. As a result, unreduced microspores are produced. The frequency of premature cytokinesis corresponded well with the frequency of dyads leading to unreduced pollen formation. It was concluded that the major cytological mechanism of unreduced pollen formation is premature cytokinesis in this cultivar of potato.

**Key words:** Potato, meiosis, unreduced pollen grains, premature cytokinesis, cytological mechanisms

### *Solanum tuberosum* L. cv. Morfana'da indirgenmemiş polen oluşumunun sitolojik mekanizmaları

#### Özet

Bu çalışmada *Solanum tuberosum* L. cv. Morfana çeşidinin polen ana hücrelerinde mayoz bölünme incelendi ve şu bozukluklar görüldü: univalent ve multivalentlerin oluşumu, kromozom köprüleri, fragmentler, gecikmiş kromozomlar, yoğunlaşmış kromozomlar, tripolar dağılım. Polen ana hücrelerinin çoğunda telofaz I i sitokinez izler ve diatlar oluşur. Diat hücreleri mayoz II yi geçirmezler ve indirgenmemiş kromozomlu mikrosporları oluştururlar. Erken sitokinez ve diat oluşum yüzdeleri arasında paralellik vardır. İndirgenmemiş polen oluşumunun temel sitolojik mekanizmasının erken sitokinez olduğu sonucuna varılmıştır.

**Anahtar sözcükler:** Patates, mayoz, indirgenmemiş polen taneleri, erken sitokinez, sitolojik mekanizmalar

#### Introduction

The occurrence of  $2n$  pollen is frequently observed in tuber-bearing *Solanum* species that consist of nearly 200 species ranging from diploid to hexaploid (den Nijs and Peloquin 1977, Watanabe and Peloquin 1991). Matsubayashi (1981) classified the  $2n$  pollen

formation in these species into four cytological modes including 10 mechanisms. Watanabe and Peloquin (1993) summarized the principal cytological mechanisms of  $2n$  pollen formation: 1. parallel orientation of spindles at the second meiotic division resulting in dyads, 2. premature cytokinesis at either telophase I or prophase II and no second division

resulting in dyads leading to  $2n$  pollen formation, 3. synaptic abnormalities that are due to variations in chromosome pairing and (or) in chiasma formation in the first division followed by a normal second division resulting in dyads.

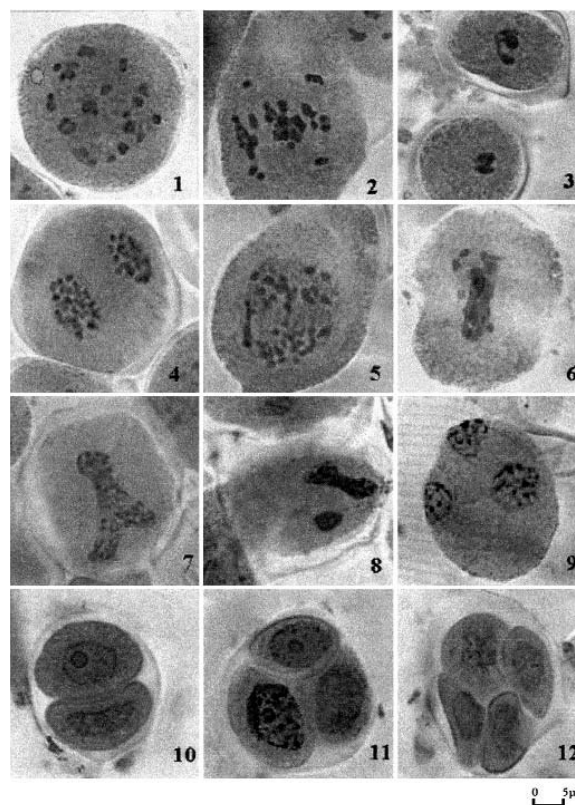
The present study deals with meiotic chromosome behavior of *Solanum tuberosum* L. cv. Morfana in order to understand the cytological status of pollen grains.

### Materials and methods

Studies were made on the cultivar clone of *Solanum tuberosum* L. cv. Morfana obtained from Bolu. Flower buds were collected from the plants growing in fields. The anthers were fixed in acetic-alcohol (1:3) for 24 h at room temperature and stored in 70 % ethanol at 4°C. The anthers were squashed in aceto orsein.

### Results

The meiotic cell division was studied from diakinesis to microspore tetrad stages. In diakinesis, the pollen mother cells (PMCs) with 12 bivalents were seen. Besides bivalents, univalents and trivalents, have also been observed (Figure 1). Figure 2 presents the chromosomal configuration seen at metaphase I. The multivalents were not visible due to overcrowding of the bivalents at the equatorial plate of the spindle. 1-4 number of univalents (27 %) and 1-2 bivalents (2.9 %) fail to orientate on the equatorial plate. 427 of 600 cells observed (70.1 %) had normal orientation of chromosomes at the equatorial plate, whereas 173 of them (29.9 %) were unorientated. In some cells the chromosomes were not distinguished as separate structures since they aggregated on the equatorial plate (Figure 3). The percentage of equal distribution of chromosomes at anaphase I was 85.6 (Figure 4). Lagging chromosomes, fragments and chromosome bridges were seen in first anaphase (Figure 5). Bivalents and multivalents separated normally to the poles but the univalents lag or are eliminated. The occurrence of bridges was 1.6 %. In some cells, chromosome bridge was so thick that the two chromosome groups was not allowed to be separated from each other (Figure 6). As a result, dumbbell shaped nucleus occurred. Dyad, 11. Triad; 12. Tetrad.



**Figure 1-12:** Meiotic division in pollen mother cells of *Solanum tuberosum* L. cv. Morfana. 1. Diakinesis showing 8 bivalents 1 tetravalent and 4 univalents; 2. Metaphase I, side view with non-orientated univalents and a bivalent; 3. Metaphase I showing condensed chromosomes; 4. Anaphase I showing equal distribution of chromosomes; 5. Anaphase I showing a chromosome bridge and laggards; 6. Anaphase I with a thick bridge; 7,8 Fusion of chromosome groups at tripolar distribution; 9. Tripolar distribution; 10. Dyad, 11. Triad; 12. Tetrad.

The first meiotic division was followed by cytokinesis in most of the PMCs resulting in the formation of dyads. Second meiotic division did not take place in these cells. Watanabe and Peloquin (1993) called this event premature cytokinesis that was frequently seen in potato species. It seemed that the occurrence of premature cytokinesis in the cultivar was highly associated with the occurrence of dyads. Dyads produced unreduced pollen grains.

In a small number PMCs the second meiotic division occurred on normally resulting in the formation of microspore tetrads. But some irregularities such as chromosomes bridges, tripolar

**Table 1:** Frequency of monads, dyads, triads and tetrads.

	No of cells	Percentage
Monads	30/1177	2.7
Dyads	924/1177	85.7
Triads	102/1177	9.7
Tetrads	21/1177	1.9

spindles and fusion of chromosome groups were also observed (Figure 7-9).

Premature cytokinesis frequently seen resulted in the formation of dyads (Figure 10), but triads were also produced by tripolar distribution of chromosomes in which one group is larger than the other two groups (Figure 11). Obviously, the restitution nucleus with 24 chromosomes was nearly twice as large as the haploid nuclei with 12 chromosomes each. Normal meiosis that was rare, resulted in microspore tetrads (Figure 12). Monads were formed by the fusion of two chromosome groups at telophase I. The frequencies of these structures were given in Table 1. As it is clearly seen in the table, the dyads occurred in highest frequency, normal tetrads in lowest.

## Discussion

The formations of unreduced microspores are frequently observed in tuber-bearing *Solanum* species. Ramanna (1974) studied the mechanism of unreduced microspores in 7 aneuploids of *S. tuberosum* and one clone of *S. phureja* and observed that unreduced microspores were produced not only by nuclear restitution at meiosis but also by aberrant cytokinesis in the meiocytes. The two spindles fused at metaphase II stage in some PMCs of the two species and resulted in the formation of 2 groups of 24 chromosomes at each, instead of 4 groups of 12 chromosomes formed from a normal division. The fused spindles caused the formation of unreduced microspores in *S. tuberosum* and *S. phureja* (Ramanna 1974). Tripolar spindles were also seen in these two species.

Sangowawa (1987) observed the following meiotic irregularities in *S. mochicense* Ochoa: univalent and multivalent formation, chromosome

bridge, fragments, lagging chromosomes, unequal distribution of chromosomes and aggregation of chromosomes. These aberrations resulted in the formation of deformed pollen and presumably indicated the hybrid origin of *S. mochicense* Ochoa. Watanabe and Peloquin (1993) investigated the cytological mechanism of 2n pollen formation in 2x, 4x and 6x taxa of tuber-bearing *Solanum* species that were originally collected from Mexico, Central and South America. It was concluded that parallel spindles, tripolar spindles and premature cytokinesis were the mechanisms of 2n pollen formation. Parallel spindles were also observed in cultivated potato groups and their related wild species by Camadro and Peloquin (1980), den Nijs and Peloquin (1977).

In this study the meiotic analyses was carried out in *S. tuberosum* L. cv. Morfana. Some of the homologous chromosomes failed in pairing and multivalent and univalent were observed in addition to bivalents. The occurrence of such multiple associations has been demonstrated in *Solanum* by Choudhuri (1943, 1971, 1972, 1975). The effects of hybridization and genetic factors in reducing chromosome pairing are well known (Sangowawa 1987). Chromosome bridges, fragments, laggards were also observed in the first meiosis which was followed by cytokinesis resulting in the formation of dyads. Premature cytokinesis caused unreduced pollen grains. Each pollen grain had one chromosome with two sister chromatids, instead of one. In the normal course of diploid meiosis, four chromatid of a bivalent is distributed in to the four microspores of spore tetrad.

Cytological investigation on the cultivar Morfana showed that there is good evidence for regarding it as of hybrid origin.

## Acknowledgements

The authors thank to M.A. Tüfekçi for his technical helps.

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