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Twin Sectors caused by Alternative Transpositions in Maize

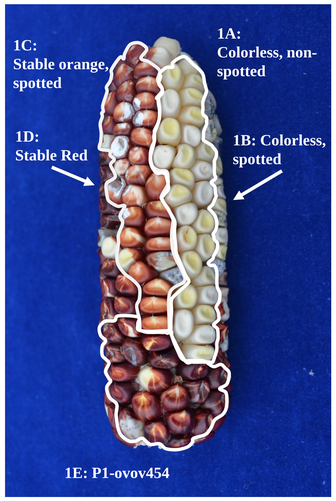
Abstract

- A standard transposition event occurs when a single transposable element undergoes transposition, relocates elsewhere in the genome or is lost; whereas Alternative transposition occurs when the termini of two different transposable elements are involved in the reaction, Activator (*Ac*) and *fAc* transposable elements (fractured Ac, *fAc*, has a 5' end deletion), which can generate large chromosome rearrangements: inversions, translocations, deletions, and duplications (Zhang et al., 2009).
- During develop of the maize ear an alternative transposition event can alter the chromosomal arms within a cell. After mitosis and segregation into two daughter cells, the result is two adjacent sectors with contrasting twin sectors.
- 6 different sectors on two maize ears were identified, and a series of PCR tests were conducted to classify the type of structural changes present in each sector. The junctions of the *Ac* transposon and flanking DNA were determined using PCR and sequencing. Then a proposed mechanism was developed.
- These findings showed that twin sectors develop in parallel, in addition to demonstrating how gene structure and gene expression can be altered by the *Ac* transposable element during ear development.

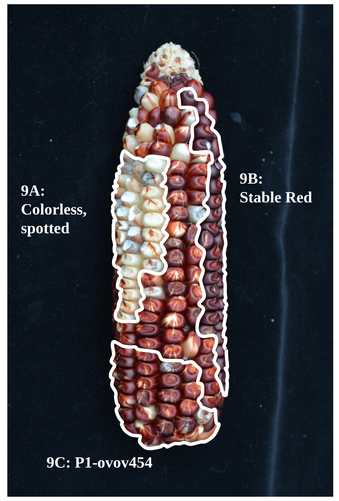
Background

The effects of Activator (*Ac*) transposon in the development of twin sectors on maize ears were studied on maize ears containing the allele P1-ovov454. This allele conditions orange-variegated pericarp and cob due to the presence of the Ac transposon in the p1 gene which controls kernel pericarp color. The P1-ovov454 allele contains *Ac* and *fAc* elements with termini in reverse orientation.

The maize ears 83JF1:T1 and 83JF1:T9 were generated by the cross: P1-ovov454 and Stock J (p1-ww[4Co63] r1-m3::Ds).



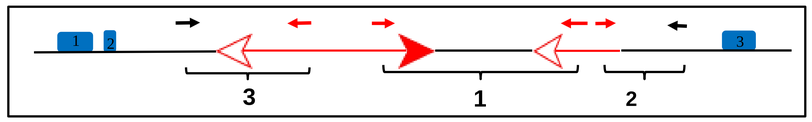
83JF1: T1



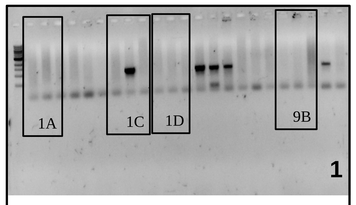
83JF1: T9

Legend: The phenotypes of the identified sectors from 83JF1:T1 were 1A (colorless, non-spotted), 1B (colorless, spotted), 1C (Stable orange, spotted), 1D (Stable Red), and 1E (P1-ovov 454, spotted). Sectors from 83JF1:T9 included 9A (Colorless, spotted), 9B (Stable Red), and 9C (P1-ovov 454, spotted)

Results

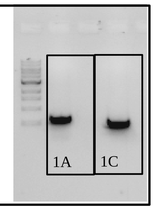


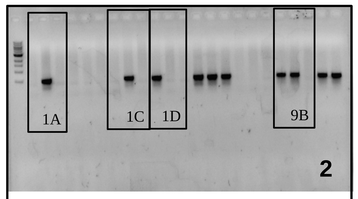
Legend: The blue numbered boxes indicate the exons of *p*1. Double red arrows represent Ac/fAc elements (filled and open arrowheads denote 5' and 3' termini, respectively). Smaller red and black arrows indicate primers used in PCRs, while 1,2, and 3 represent different PCR tests.



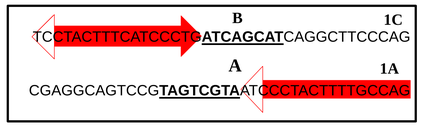
PCR 1: Tests for the presence of the DNA segment between *Ac* and *fAc*, using two *Ac* primers.

Confirmed the presents of a second copy of *Ac* in 1C, while proving 1A as a reciprocal. This PCR used two upstream *p1* primers

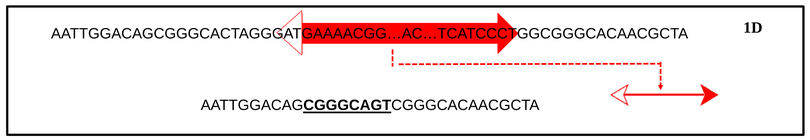


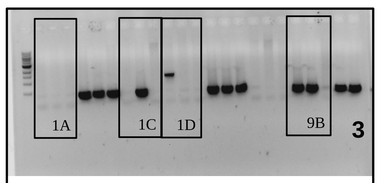


PCR 2: Tests for the junction of *fAc* and *p1* downstream, using *Ac* and *p1* primers.



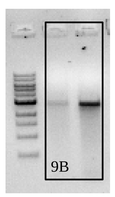
Legend: The underlined portion of the DNA sequence marks the 8 base pair target site duplication by *Ac*. **A/B** indicate the upstream and downstream sequence of *p1*, respectively





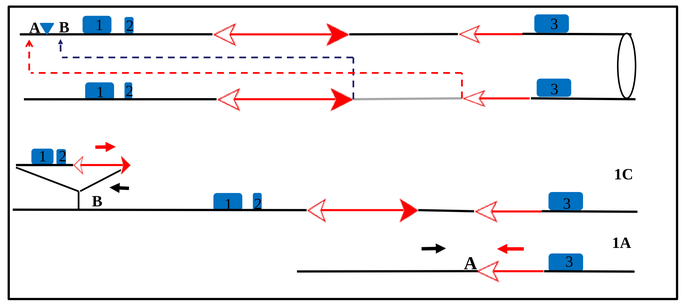
PCR 3: Tests for the junction of *Ac* and *p1* upstream, using *Ac* and *p1* primers. Note: 1D had a larger band than expected, consistent with the model.

Legend: The underlined portion of the DNA sequence marks the 8 base pair target site duplication left behind by the excision of *Ac.* This position is denote with an '**X**' in the model.

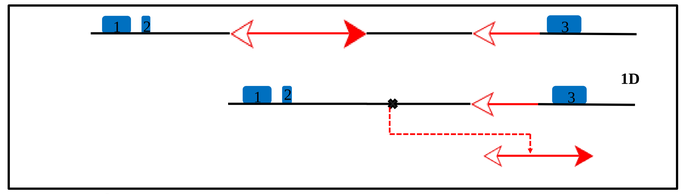


Confirmed the length of internal structure of 9B, using the *p1* primers from PCR 2 and 3.

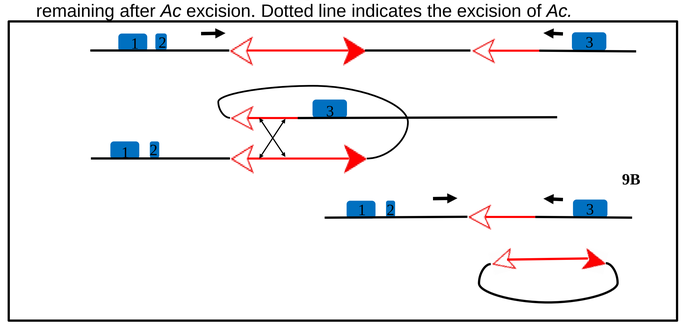
Models



Legend: Dotted lines indicate the re-insertion of *Ac.* 1C contains a 16.5 kb duplication, and 1A contains the reciprocal 16.5 kb deletion.



Legend: The '**X**' indicates the eight base pair target duplication site remaining after *Ac* excision. Dotted line indicates the excision of *Ac.*



Legend: The double arrow line indicate the crossing over between *fAc* and *Ac* on the same chromosomal arm.

Conclusion

1. The *Ac* transposon can affect gene expression and development of twin sectors by chromosomal rearrangements.
2. Some twin sectors are generated from simple transposition events, such as excision or re-insertion, while others formed from complex recombination events, such as intra-chromatid crossover
3. Twin sectors develop in parallel and adjacent sectors are likely to be reciprocals.
4. Further research is need to conclude whether or not, additional sectors can be derived from a different sector during development.

Citations

Zhang, J., Yu, C., Pulletikurti, V., Lamb, J., Danilova, T., Weber, D., Birchler, J. and Peterson, T. 2009. Alternative Ac/Ds transposition induces major chromosomal rearrangements in maize. Genes & Dev. 2009. 23: 755-765.

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