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INDICATION OF ENVIRONMENTAL MUTAGENESIS WITH THE USE OF HIGHER PLANTS SPECIFIC LOCUS SYSTEMS

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Abstract: *Plant assays play a great role in the biomonitoring of ecogenotoxicity and environmental pollution. Amongst them, specific locus systems provide a simple, relatively easily scored system for the detection of mutations in testing of chemicals and in situ. The screening is based on a phenotypic change caused by a mutation in a single locus. Numerous test systems have been developed, although some of them use a phenotypic characteristic based on more loci, and therefore are not a true specific locus system. A true specific locus system is for example the waxy locus of maize and the locus for the colour of Tradescantia stamen hair, while most of the chlorophyll mutants in most plants and embryonic mutants of Arabidopsis use a phenotypic characteristic based on more loci.*

Keywords: specific locus, ecogenotoxicity, plant bioassays, environmental mutagenesis

INTRODUCTION

Higher plants provide valuable genetic assay systems for screening and monitoring environmental pollutants and chemicals for cytogenetic aberrations and gene mutations (Mičieta, Murín 1996). Grant (1994, 1998) and Constantin (1978) have summarized the advantages and limitations of plant bioassays.

A specific locus is equivalent to a gene in the classical Mendelian sense. As such, it is defined as a chromosomal region that controls the development of a phenotypic characteristic, and that is separable by crossing over from adjacent loci governing other specific phenotypic characteristics (Constantin 1978). When the mutations at the gene level occur in a specific locus controlling a certain phenotypic characteristic, it is possible to score the mutants that differ in this characteristic. The principle of allele dominance and recessivity is often used in these systems, with a model organism with known genotype. If the dominant allele in a heterozygote mutates, the resulting phenotype is the one of the recessive homozygote. By scoring of this phenotype the number of mutations in the dominant allele can be estimated, although the mutants in the recessive allele remain undetected. It is also possible to score reverse mutations

in a recessive homozygote. In that case, the mutant phenotype is the one of a heterozygote or dominant homozygote, and mutations in both alleles are scored.

RESULTS

Tab. 1: Specific locus systems used in the tests for mutations

Test organism	Test principle	References
Oryza sativa	Induction of chlorophyll mutations in the M_1 and mutations in the waxy locus of pollen	Kumari, Vaidyanath 1989
Zea mays	Detection of mutations in the waxy locus of pollen (both forward and reverse mutations)	Plewa 1982
	The Yg_2 system with yellowish phenotype of the mutant heterozygote caused by deletion or mutation of the dominant allele	Smith et al. 1964 Conger 1976
Hordeum vulgare	The chlorophyll deficiency system observed in the M_2 generation (caused by mutations of numerous various loci)	Constantin 1982
Arabidopsis thaliana	The thiamine auxotrophy and embryonic mutants	Rédei 1976 Gichner et al. 1993
Tradescantia	Stamen hair mutation assay on the 4430, 02 clones heterozygous for the flower colour with dominant blue and recessive pink allele	Underbrink et al. 1973 Sparrow, Schairer 1971 Ma et al. 1994
Glycine max	Formation of mosaicism which leads to leaf spots varying in their colour and morphology; detection of somatic crossing over, chromosome deletions, nondisjunction and point mutations	Vig 1982
Nicotiana tabacum		
Avena sativa	The *al* locus of diploid oats, heterozygous for the albino gene	Nishiyama et al. 1966
Prunus avium, *Oenothera organensis* and others	The gametophytic type of the self-incompatibility systems based on a multiallelic S locus	Mulcahy, Johnson 1978

DISCUSSION AND CONCLUSION

The present concept of testing for mutagenicity involves a tiered-system approach including both prokaryotic and eukaryotic organisms. These organisms are used as surrogates for humans, and any substance which yields positive results is suspect (Constantin 1978). The use of plants as a model

organism enables not only the testing of single chemical with a potential mutagenic effect in the laboratory, but also *in situ* testing of all parts of the environment in their reciprocal interactions. The specific locus systems do not show all occurring mutation in the model organism, but enable a relatively simple and accurate scoring of the mutants according to the phenotypical manifestation of the studied locus. The principle of allele dominance and recessivity is used in a model plant cultivar with a known genotype. In that case, a divergence from the expected phenotype is caused by mutation in the specific locus. Both forwards and reverse mutations can be scored, with the difference that the reverse mutations enable the scoring of mutations in both alleles, while in the case of the forward mutations only the dominant allele can be examined. Neither of the possibilities discerns double mutants on both alleles.

In the terminology, several assays are listed as specific locus systems, but the scored phenotypical characteristic is in truth influenced by several loci. It is mostly the case of the chlorophyll mutants in several model plants, like *Oryza sativa* (Kumari, Vaidyanath 1989), *Hordeum vulgare* (Constantin 1982), *Arabidopsis thaliana* (Gichner et al. 1993), *Glycine max* and *Nicotiana tabaccum* (Vig 1982). Also the S-locus of the self-incompatibility system are actually two loci, responsible for the interaction of pistil and pollen (Tao, Iezzoni 2010). In a true single locus systems, like the *waxy* locus of Z*ea mays* (Plewa 1982), the phenotypical change connected with the mutation can be caused by various types of mutations in different positions of the locus and on all levels of the DNA structure. However, there are certain types of mutations characteristic for the given locus that occur more often than the other types, for example the insertion and deletion mutations of the *waxy* locus (Wessler, Varagona 1985). Therefore, several different assays should be executed in order to discern all possible mutagenic effects of the tested chemical or complex of chemicals.

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