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PLANT BIOASSAYS TO SCREEN GENOTOXIC EFFECTS OF ENVIRONMENTAL POLLUTANTS AND CLIMATE CHANGE Dr. Öğ. Üy. Sema Tülay HEKİMBAŞI ABSTRACT Global climate changes may cause environmental stress on organisms and human being. Monitoring possible damage on DNA under environmental stresses such as UV radiation, high temperatures and acid pH caused by ongoing global climate change is a global concern nowadays. Potential phyto-cyto and genotoxicity of other environmental pollutants such as heavy metals, PAHs, Disinfection by-products (DBPs), pollutants of soil, air and wastewater, silver and titanium dioxide (TiO2) nanoparticles have screened using animal, bacterial and plant model organisms up to date. In vitro and in vivo studies are both conducted for these observations. Higher plants have been frequently used in ecotoxicological and genotoxic assessment procedures. They are ideal indicators of cytotoxic and genotoxic effects of environmental chemicals and preferred for easy handling and have some advantages over other short-term tests that need longer procedures. Their cost-effectiveness, reliability and sensitivity make them ideal for screening and identifying DNA reactive environmental compounds. Mitotic index and some nuclear abnormality observations are used to evaluate the potential cytotoxicity. Micronucleus tests and chromosome aberrations are used to analyze the potential mutagenicity of pollutants. Germination rate and seedling growth length are applied to detect the potential phytotoxicity. Besides these, some molecular methods were developed to monitor mutagenicity at both the chromosomal and DNA level. The FISH method provides a detailed detection and analysis of possible chromosomal rearrangements. TUNEL test and Comet assay is used to estimate possible DNA fragmentations. Model plants mostly prefered to be used in bioassay systems are: Allium cepa, Tradescantia, Arabidopsis thaliana, Vicia faba, Hordeum vulgaris, Glycine max, Zea mays and Brassica campestris. Key words: Environmental pollutants, Climate change, Genotoxicity, Cytotoxicity, Plant bioassays. ÖZET Küresel iklim değişiklikleri, organizmalar ve insanlar üzerinde çevresel strese neden olabilme potansiyeline sahiptir. Devam eden küresel iklim değişikliğinin neden olduğu UV radyasyonu, yüksek sıcaklıklar ve asit pH'ı gibi çevresel stresler altında DNA'daki olası hasarı izlemek önem taşımaktadır. Ağır metaller, PAH'lar, Dezenfeksiyon yan ürünleri (DBP'ler), toprak, hava ve atık su kirleticileri, gümüş ve titanyum dioksit (TiO2) nanoparçacıkları gibi diğer çevresel kirleticilerin potansiyel fito-sito ve genotoksisitesi, hayvan, bakteri ve bitki modeli kullanılarak araştırılmaktadır. Bu gözlemler için, hem in vitro hem de in vivo çalışmalar yürütülmektedir. Yüksek bitkiler, ekotoksikolojik ve genotoksik değerlendirme prosedürlerinde sıklıkla kullanılmıştır. Bu bitkiler, çevresel kimyasalların sitotoksik ve genotoksik etkilerinin ideal indikatörleri olarak kabul edilmektedir. Kolay kullanım için tercih edilirler ve daha uzun prosedürler gerektiren, diğer kısa süreli testlere göre bazı avantajları vardır. Maliyet etkinlikleri, güvenilirlikleri ve hassasiyetleri sayesinde, DNA'ya reaktif olan çevresel bileşiklerin taranması ve tanımlanması açısından idealdirler. Potansiyel sitotoksisiteyi değerlendirmek için mitotik indeks ve bazı hücre çekirdeği anormallik gözlemleri araştırmaları tercih edilir. Kirleticilerin potansiyel mutajenitesini analiz etmek için mikronükleus testleri ve kromozom anormallikleri testleri kullanılır. Potansiyel fitotoksisiteyi tespit etmek için ise, çimlenme oranı ve kök büyüme uzunluğu gözlemleri kullanılır. Bunların yanı sıra, hem kromozomal, hem de DNA

düzeyinde mutajeniteyi izlemek için bazı moleküler yöntemler de geliştirilmiştir. FISH yöntemi, olası kromozomal yeniden düzenlemelerin ayrıntılı bir tespitini ve analizini sağlar. TUNEL testi ve Comet testi, olası DNA fragmantasyonlarını tahmin etmek için kullanılır. Biyoassay sistemlerinde en çok tercih edilen model bitkiler; Allium cepa, Tradescantia, Arabidopsis thaliana, Vicia faba, Hordeum vulgaris, Glycine max, Zea mays and Brassica campestris'tir. Anahtar Kelimeler: Çevresel kirleticiler, İklim değişikliği, Genotoksisite, Cytotoksisite, Plant bioassay'leri. INTRODUCTION The effects of Global Climate Change on organisms are important matters of concern (Intergovernmental Panel on Climate Change, 2007). In this context, it is essential to understand and predict the several aspects of these possible harms. Climate Change may negatively affect biodiversity, reproduction (Hedhly et al., 2009) and development (Liu, 2017; Craufurd and Wheeler, 2009). An elevated level of temperature (Macor and Ebringer, 1988), atmospheric CO2 (Ezraty, et al. 2011), and some pollutants (Kohn, 1983; Hercog et al., 2020) considered being related to genotoxic hazards on organisms. Toxicity (Pinheiro et al.,2020), cyto- and genotoxicity (Pinheiro et al.,2019) of aluminium (Al) are reported to be elevated by temperature and acid pH on the freshwater teleost Astyanax altiparanae (Teleostei: Characidae). Environmental stresses; such as heat, ionizing radiations, UV light, heavy metals, and environmental pollutants caused by Climate Change may damage DNA in plants (Macovei, 2016). Potential cyto- and genotoxicity of some environmental pollutants such as heavy metals (Lyu, et al., 2020), PAHs (Cachot et al., 2006), Disinfection by-products (DBPs) (DeMarini, 2020; Cortés and Marcos, 2018) pollutants of soil (Kovalchukab, 1998), wastewater (Fiskesjö, 1993), silver nanoparticles (Vannini et al, 2014; Kumari et al, 2009) and titanium dioxide (TiO2) nanoparticles (Ghosh et al, 2010) have screened using animal, bacterial and plant model organisms, up to date. PLANT BIOASSAYS AND ENVIRONMENTAL GENOTOXICITY TESTS Higher plants have frequently are used in ecotoxicological and genotoxic assessment procedures (Rank and Nielsen, 1998; Leme and Marin-Morales, 2009; Ma, 1982). They are ideal indicators of cytotoxic and genotoxic effects of environmental chemicals and are preferred for easy handling. They have some advantages over other short- term tests that need longer procedures. Their cost-effectiveness, reliability, and sensitivity make them ideal for screening and identifying DNA reactive environmental compounds (Grant, 1994). Model plants mostly prefered to be used in bioassay systems are: Allium cepa, Tradescantia, Arabidopsis thaliana, Vicia faba, Hordeum vulgaris, Glycine max, Zea mays and Brassica campestris (Ma et al. 2005) METHODS USED IN GENOTOXICITY TESTS Mitotic index (Carvalho et al., 2018) and some nuclear abnormality observations (Martinez-Valenzuela, et al., 2017) are applied to evaluate the potential cytotoxicity. Micronucleus (Hu et al., 2017) and chromosome aberration tests (Ranjan et al., 2019) can be ideal for observing the potential mutagenicity of pollutants. Germination rate (Carvalho et al., 2018) and seedling growth length (Fiskesjö, 1993) are applied to evaluate the potential phytotoxicity. Besides these, some molecular methods are used to monitor the mutagenicity at both the chromosomal and DNA level (Maluszynska and Juchimiuk, 2005). The FISH method provides a detailed detection and analysis of possible chromosomal rearrangements (Chung et al., 2002, Jolanta and Jolanta, 2005). TUNEL test and Comet assay are suitable to estimate possible DNA fragmentations (Jolanta and Jolanta, 2005; Hu et al., 2017). CONCLUSION Possible Effects of Climate Change on the rate of development and injury on the cells and DNA need to be monitored on suitable model organisms. Plant model organisms can ideally be used in these observations, considering their advantages.

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