Describe of Arabidopsis thaliana plant as a model plant in biotechnology

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Abstract, Arabidopsis thaliana plant has appeared as a promising model because it is self-fertilizing, which makes it preserve its characteristics and can produce thousands of seeds, which makes it ideal for conducting mutagenesis experiments. it has received a projecting interest in genetic transformation and in all biotechnology studies for all biological functions in plants. The identification of its selected traits is more clear because it has a relatively small genome. Also the organization of the genome in it is simple and is especially suitable in genetic and biology experiments, as these plants represent small-sized and fast-rotating factories.

The objective of this current study to focus the most important aspects and applications related to the use of this plant in various fields of biotechnology and to clarify its most important advantages.

Keywords: Arabidopsis thaliana, plant model, Biotechnology.

Introduction

Arabidopsis thaliana,(mouse-ear cress or thale cress), herbaceous flowering species growing at tall 20–25 cm, belonging to Crucifer (Brassicaceae) family, in the dicotyledonous group of angiosperm vascular plants, it become in the last 20 years the plant species most used in plant biology[1,2,3]. A few rosette leaves at the plant base. Green to slightly purplish basal un stalked smaller leaves with an serrated margin; smaller and un-stalked leaves are covered by trichomes. The flowers are arranged in a corymb; having typical Brassicaceae structure with 3 mm in diameter. The fruit is a siliqua with 20-30 seeds [4,5,6,7,]. Simple roots are plumb downhill, advanced with smaller lateral roots that contacts with rhizosphere bacteria example (Bacillus megaterium) (Fig.1)[8].

Figure.1: Arabidopsis thaliana Plants[8].

A. thaliana has lifecycle completed in six weeks. It is an annual typical winter species has a short life cycle, which is advantageous for research. The plant has small size which is suitable for growing on small areas. Further, the specific habits of its supports genetic tests. Also the plant can yield numerous of seeds, the principles above indications to A. thaliana driven it a genetic model organism [12,13].

Development

A. thaliana can be divided into four major steps of development:[4,5]

- Transplants: cotyledons are initial and elongation after germination and seem the chief leaves.
- Rosette: their total variable contingent on genotype and growth situations, from 5 to 6 - several hundreds.
- Flowering: entrance of a main stem from the middle of their and initiate of the main flowers. Minor floral branches can grow from the improper. The production of seeds can be very supple.
- Seed and senescence: dehiscence of ripening fruits. The seeds germinate directly, the length of which depends on the genotype. A. thaliana is characteristically measured to be firmly autogamous but researchers seem to display that in natural situations out-propagation can occur between convinced populations (6,7). Particularly, initial flowering time, is an essential parameter affecting both the cycle and selective value of the plant. In the laboratory, the practice is to distinguish late or early ecotypes depending on the length of their vegetative (rosette) phase before floral initiation [8,9].

Applications of Arabidopsis thaliana:

1. Arabidopsis a genetic model organism.

Several plants have been intensively studied and become models organisms after the publication its genome sequence, the most significant recently being Arabidopsis thaliana, for research in plant biology and plant biotechnology about two years ago(12,15). Several researches of plant physiology and molecular biology depend on the creation of transgenic plants, especially of model plants as Arabidopsis thaliana .The successful in the field of transformation are applied to Arabidopsis plants, and are less able at generating transgenic plants in other species. A. thaliana is now generally used for studying plant sciences, genetics, evolution, population genetics and plant growth [12,14,17, 28,29,30].

From the distinguish character of A. thaliana on the other types of plants that has smallest genomes, so it has benefit to detect its genetic mapping and sequencing with about 157 mega base pairs and five chromosomes ,the genome encodes ~27,600 protein-coding genes and about 6,500 non-coding genes. Among the 27,600 protein-coding genes 25,402 (91.8%) are now marked with "meaningful" product names [18,19,20]. It was the first plant genome to be sequenced, completed in 2000 by the Arabidopsis Genome Initiative. The most up-to-date type of the A. thaliana genome is maintained by the Arabidopsis Information Resource [21,22,23,24].

The features such as fertility, small genome size, ease of crossing, short generation time and the ability to do mutational screens to saturation in the laboratory have all led to a huge increase in the ability of Arabidopsis research and expansion in its applications(Fig.2) [21, 25, 26,27].

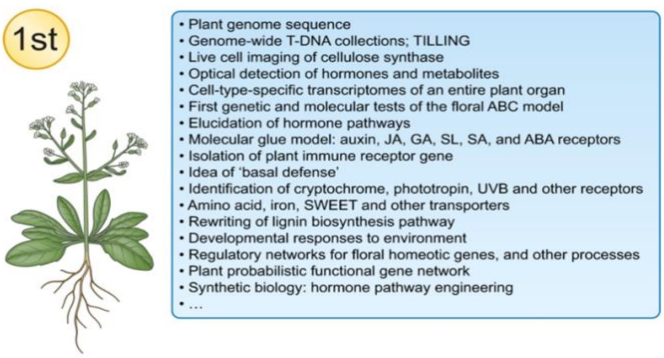

Figure.2:Arabidopsis applications, JA, jasmonic acid, ABA, abscisic acid; SL, strigolactones; SA, salicyclic acid (We can't put arrows because this figure explained the application only)

2. Applications of A. thailana in genetic transformation

Genetic transformation of it is monotonous, One of this plant advantage that the most important, concerns its facility for genetic transformation, which can be talented by simply placing the plant in contact with the bacteria Agrobacterium tumefaciens. The first acts of transformation "in planta" were carried out in 1987 by Feldman, who soaked the seeds in a suspension of Agrobacterium conferring resistance to kanamycin in the transformed plant cells. Afterwards, the technique was considerably simplified by employing vacuum infiltration of adult plants in a suspension of Agrobacterium In the descendants of selected infiltrated plants. There can be one or multiple copies of the T-DNA conferring a trait such as resistance to the herbicide Basta (31). All steps are performed in a glasshouse under standard horticultural conditions without the need for in vitro manipulations. Every laboratory now uses this technique to produce transgenic plants in this species, thus constituting an irreplaceable tool in most integrated biotechnology programs. Furthermore, this technique has been employed on a large scale to produce insertion mutant populations for functional studies [32].

Plant biology laboratories are not very long ago. Finally, A. thaliana is far from being a species of agronomic importance and the responses of the plant to agricultural treatments are not necessarily representative of a cultivated species, submitted to human selection for many thousands of years. [33].

Agrobacterium tumefaciens have ability to give its plasmids T-DNA genes to the plant cell and integration in its genome. The T-DNA insertion site has been identified for more than 300,000 independent transgenic strains [34].

3. The plant immune system in Arabidopsis plant

The main tool in the development of Arabidopsis research has been in the molecular facts of the plant's immune system. Now, Arabidopsis has been considered the primary organism to elicit modern values about the way plants and microbes. Many initial funding for Arabidopsis as a model for plant-pathogen interactions was met with the cynicism that a nonessential plant with a short span of time would not have real pathogens [35,36,37].

4. Response to abiotic stress

The main feature also of this plant is protective responses to damaging UV stress, with displays for mutants exhibiting UV-B hypersensitivity. Finally, it is vital that mechanisms of stress tolerance first identified in Arabidopsis have been introduced into crop species with resulting agronomic progresses. For example, overexpression of either native or Arabidopsis transcription factors in a number of crops has been shown to improve cold tolerance, and improved salinity tolerance is discussed in crops upon expression of Arabidopsis or native transporters that promote Na^+ isolation [37].

5. Arabidopsis as pumps, channels, transporters.

Arabidopsis serves as a still-innovative detection tool: recently, a whole group of new sugar transporters, were identify in Arabidopsis. These have been shown to play roles in nectar secretion, pollen feeding and seed filling in phloem loading [38,39,40].

Arabidopsis has fast ability to identification of the transporters characters and canals in plant. Essentially, the wide information base resultant from Arabidopsis has arranged the basis for biotechnology uses [41, 42].

6. Tissue Culture in Arabidopsis

We can get "callus" from Arabidopsis thaliana (Fig. 3). The first attempt in tissue cultures was got in 1965 from seedlings and from hypocotyl and in 1966 from seeds. Suspension cultures can also be gained very simply. The cultured on the medium supplemented with coconut milk or kinetin induces the formation of callus. The medium supplemented with 2,4-D at a suitable conc. stimulate the growth of the callus. If 2,4-D is at a lower conc., roots initiate from root primordial . Addition of vegetable juice instead of just vitamins seems vital as it indications to a faster growth of tissue. Callus initiate in the presence of vitamins are irregular in shape and contain a large number of tracheids (43). Also other research proved the ability to initiate callus from seedlings explant of Arabidopsis plant by using of many combinations of plant growth regulators (44).

Figure.3: Arabidopsis thaliana callus (45)

Practicle application of Arabidopsis in the lab

The current study is based on conducting a simple laboratory and field experiments to confirm the efficiency of this plant and the possibility of its cultivation by providing the appropriate conditions, which gives the opportunity for workers in this field to expand the scope of research and to benefit from this ideal plant in various applications of biotechnologies and to employ it practically for provides benefit to all researchers in various genetic and biotechnology fields. We can culture the seeds in two locations, the first was planted in Petri dishes to test their vitality by providing the appropriate conditions and sterilized distilled water (DW), and their efficiency was proven 100% after 3 days of culturing (Fig. 4A, B), while they were cultivated in the field and also proved their efficiency in field conditions and grew into young plants with high efficiency and vitality (Fig. 5).

(A) **(B)**

Figure 4: Arabidopsis thailana seeds cultured in petri dishes in lab (46).

Figure 5: Arabidopsis thailana cultured in field (46).

Conclusion and Recommendation

Since the importance of Arabidopsis thaliana plant as a model in molecular biology studies, it has received a prominent interest in the field of genetic transformation and in all biotechnology fields for all biological functions in plants.It is recommended to select plants in all genetic fields related to the occurrence of mutations and the fields of genetic engineering and the employment of the plant because of its properties in various genetic transformation studies.

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