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# Improvement of Malaysian Ornamental Plants through Induced Mutation

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## ABSTRACT

Malaysian Nuclear Agency (Nuclear Malaysia) has started research on the improvement of ornamental plants through induced mutation (mutagenesis) since the early 1990s. The research emphasis was initially on creating new ornamental varieties through the use of the nuclear technology and later through a combination with biotechnology. Concurrently, several other species of landscaping plants, flowering and foliage were also subjected to radiation for further improvement. To date, Nuclear Malaysia has produced more than 20 new varieties of ornamental and landscaping plants. These new varieties have been transferred to various end-users, private nurseries and government agencies, such as the National Landscape Department and local councils, through collaborations and partnerships. Besides diversifying local ornamental germplasms, these efforts are also in line with the government's vision to make Malaysia a "Beautiful and Advanced Garden Nation" by the year 2020.

*Keywords:* Ornamental plants, induced mutation, mutation breeding

## INTRODUCTION

Induced mutation is an alternative and a complementary technique in plant breeding for the introduction of genetic changes and the establishment of new genetic resources. The technology, which is also known as mutation breeding, was started in the early 1930s using mainly X-rays as a source of mutagen. Since 1950s, it has been widely used, specifically in crops with low genetic variability and those that are not amenable to improvement through conventional breeding methods. The number of physical and chemical mutagens used in mutation breeding is

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numerous and continuously increases, such as gamma rays, beta rays, neutrons, electron beams, ion beams (physical), sodium azide, ethylmethanesulfonate, and colchicines (chemical) (Ahloowalia, 2001; Medina *et al*., 2004; Jain, 2007). Through induced mutation, a large number of plant varieties have been developed with improved traits such as high yield, early maturity, as well as high protein content, biotic and abiotic resistance. According to IAEA Mutant Varieties Database (http://www-mvd.iaea.org), 2,570 mutant varieties have been officially released worldwide. Of these, 625 varieties are ornamental and decorative plants, and the improved characters include compact growth, attractive variegated leaves and novel flower colour and shapes.

Malaysian Nuclear Agency (Nuclear Malaysia), which was formerly known as Malaysian Institute for Nuclear Technology Research (MINT), has been involved in plant breeding and improvement projects since 1990s. The projects, led by the agency's Agrotechnology and Biosciences Division, mainly focussed on the application of nuclear (radiation) technologies to develop new plant varieties with commercial potentials. To date, Nuclear Malaysia has produced more than 20 new varieties of ornamental and industrial crops. Among the varieties which have been officially launched are ornamental plants such as *Hibiscus rosa-sinensies* "Siti Hasmah PinkBeauty", "Siti Hasmah RedShine" and "Nori", *Cordyline terminalis* "Teguh", "Jaguh" and "Mantap", *Cordyline fruticosa* "Shuhaii", *Duranta repens* "marginata" and "variegata", orchids (*Dendrobium* "Sonia KeenaRadiant", "Sonia KeenaOval", "Sonia KeenaAhmadSobri" and "Sonia KeenaHiengDing") and *Petunia hybrida* "NK Tropicana". The new varieties of industrial crops include *Musa cavendishi* "Novaria" and groundnuts (*Arachis hypogaea* "KARISMA Sweet" and *Arachis hypogaea* "KARISMA Serene").

A number of these varieties have been successfully transferred to end-users, which include private growers, government agencies and local councils such as the National Landscape Department, Selangor State Agriculture Department, Taiping Municipal Council, and Hexagon Green Sdn. Bhd., through collaborations and partnerships. In the recent years, molecular techniques have also been incorporated into our mutation breeding programmes to facilitate mutation selection process and develop molecular markers for mutant genes and plants. This paper summarizes mutation breeding works at Nuclear Malaysia to improve selected Malaysian ornamental plants.

## MATERIALS AND METHODS

Determination of the optimum dose of irradiation treatment was carried out on both *in vivo* materials (cuttings, rhizomes, bulbs) and *in vitro* (tissue-cultured) materials [protocorm-like bodies (PLBs), nodes, leaf and petal cultures]. In the *in vivo* mutagenesis approach, cuttings, rhizomes or bulbs were irradiated at the predetermined optimum doses and then propagated vegetatively until four vegetative generations (M1V4) are reached to ensure the stability of the mutated traits. Meanwhile, the phenotypic variations were periodically observed on irradiated plants. The mutated plants were isolated and further propagated, either through conventional propagation procedures or by tissue culture (*in vitro* procedures).

In the *in vitro* mutagenesis approach, similar procedures were followed except that the irradiation treatment was done on the tissue-cultured materials. Prior to this, the most suitable medium for the micropropagation had been formulated for various species and explants. The irradiated explants were multiplied until the fourth subculture cycle (M1V4) before they were transplanted in the nursery. Observations on the morphological changes in irradiated plants were done at both *in vitro* and *in vivo* stages. Selected mutant(s) were then conventionally propagated or tissue-cultured to obtain clonal mutant lines.

## RESULTS AND DISCUSSION

Mutation breeding programme for the ornamental plants at Nuclear Malaysia was initially aimed at improving plant and flower characteristics, which were very difficult to achieve through conventional breeding. Characters of interest for improvement were new flower/leaf colours and morphology using acute gamma radiation. The first batch of ornamental mutant varieties was officially launched in 2000 by Tun Dr. Siti Hasmah Mohd Ali, during Nuclear Malaysia Flora Day. Since then, newly developed mutants, either of ornamental or food crops, were launched almost every year during the same or similar events. Details on the characteristics of the new ornamental mutants are shown in Table 1. In addition to ornamental plants, Nuclear Malaysia has also released mutant varieties of food and industrial crops through gamma irradiation, such as bananas, in collaboration with International Atomic Energy Agency or IAEA (1994), groundnut (2002) and signal grass, in collaboration with Veterinary Institute, Kluang, Johor, Malaysia (2003).

Since 2003, through bilateral agreement with Japanese Atomic Energy Agency (JAEA), Japan, another physical mutagen (ion beam) has been used to create higher mutation effects especially on useful characters such as novel flower colour and pattern, pest and disease tolerance, and long flower shelf-life to meet the continuous demand of commercial growers and consumers for value-added varieties. In contrast with other physical mutagens, ion beam irradiation has been efficiently used to change target phenotypes without affecting other useful agronomic traits in the irradiated plants (Okamura *et al*., 2003; Shikazono *et al*., 2005). Among the ornamental mutants that were successfully developed through ion beam irradiations include chrysanthemum (Nagatomi *et al*., 2003), rose (Yamaguchi *et al.,* 2003), as well as petunia and torenia (Miyazaki *et al*., 2006).

Tissue culture samples from two most important cut-flower plants in Malaysia (orchid and chrysanthemum) were sent to JAEA for ion beam irradiation. Apart from the new colours of flower, other target traits

TABLE 1
Ornamental mutant varieties officially released / developed by Malaysian Nuclear Agency using acute gamma irradiation

| Species/ variety | Explants | Mutagenesis type | Released mutants | New characters |
|---|---|---|---|---|
| *Hibiscus rosa-sinensis* | Cuttings | *In vivo* | Siti Hasmah PinkBeauty<br>Siti Hasmah RedShine<br>Nori | Pink flower colour, profuse flowering<br>Dark red flower colour, profuse flowering<br>Red, multiple-layer petal |
| *Chrysanthemum morifolium* | Petal cultures | *In vitro* | Nazarea Gracewhite<br>Nazarea Softpink | White flower colour and multiple petal layer<br>Light pink flower colour and multiple petal layer |
| *Cordyline terminalis* | Cuttings | *In vivo* | Teguh<br>Jaguh<br>Mantap | Dark green leaves, red stripes around the edges<br>Deep red leaves, white stripes around the edges<br>Light green leaves with narrow cream and red stripes |
| *Cordylines fruticosa* | Cuttings | *In vivo* | Shuhaii | Broad green leaves, dark red stripes in young leaves |
| *Duranta repens* | Cuttings | *In vivo* | Marginata<br>Variegata | Narrow, yellow leaves with dark green lining around the edge<br>Large, yellow leaves with various shades of green patches |
| *Dendrobium* Sonia | Protocorm-like bodies | *In vitro* | KeenaRadiant<br>KeenaOval<br>KeenaAhmadSobri<br>KeenaHiengDing | Narrow and elongated petals, pale purple flower<br>Oval shape, purple-pink petals<br>Diamond shape petal, narrow and long lip, uniform purple colour<br>Broad and pointed petal, pigmented veins and smudge of purple on sepals |
| *Tradescantia spathacea* | Young shoots | *In vivo* | Sobrii | Green and cream variegated upper leaf surface, reddish-purple lower surface |
| *Petunia hybrida* | Leaf discs | *In vitro* | NK Tropicana | Small, red-pink flower |
| *Hippeastrum puniceum* | Bulb scales | *In vitro* | Orange BioGamma | Bright orange flower, long leaves |

were found to have extended its shelf life and insect resistance. Several potential mutants for both orchids and chrysanthemum, irradiated with this mutagen have been developed and are now being propagated to verify the stability of the new traits (Affrida *et al*., 2008; Zaiton *et al*., 2009).

Recently Nuclear Malaysia completed the development of chronic irradiation facility called Gamma Green House, and has started using this facility in the present mutation breeding programme. Chronic irradiation is an exposure to ionizing radiation over a long period (weeks or months), depending on the nature and sensitivity of the irradiated plants (Azhar *et al*., 2009). Previous studies on chronic gamma irradiation have found that chronic irradiation is very useful in minimizing radiation damage, and can induce a few improved characters on irradiated plants at the same time (Okamura, 2008). To date, several potential mutant lines of *Hibiscus rosa-sinensis* with different flower colours have been identified and they will be propagated further up to the fourth generation (M1V4) to confirm the stability of the traits.

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