GENERATING NEW VARIETIES OF SHRUBS FOR LANDSCAPES IN MALAYSIA

PENGHASILAN VARIETI BARU TANAMAN RENEK UNTUK LANDSKAP DI MALAYSIA

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Abstract

This project which was funded by National Landscape Department was aimed at generating new varieties of shrubs suitable for landscapes in Malaysia. Three species of shrubs commonly used in Malaysian landscapes (hibiscus, canna and turnera) were selected for generating new varieties through mutagenesis techniques using gamma rays and ion beams. The main objective was to produce new varieties with desired characters, such as longer bloom period, unique and prominent petal colours and larger flower size. Through this project, several potential mutants have been identified such as turnera with longer bloom period, canna with new flower colours and hibiscus with different flower form. These mutants are currently undergoing field screening at Serdang to analyze their genetic stability, and will be registered as new varieties with Department of Agriculture before being transferred to end-users.

Abstrak

Kajian ini yang dibiayai oleh Jabatan Landskap Negara adalah untuk menghasilkan varieti baru tanaman renek yang sesuai untuk perlandskapan di Malaysia. Tiga spesis tanaman renek yang biasa ditanam untuk landskap iaitu bunga raya, canna dan turnera telah dipilih untuk penghasilan varieti baru melalui teknik mutagenesis menggunakan sinaran gamma dan alur ion. Objektif utama kajian adalah untuk menghasilkan baka baru yang mambawa ciri-ciri yang diperlukan untuk landskap di Malaysia seperti tempoh kembang bunga lebih lama, warna bunga terang dan petal besar. Melalui kajian ini, beberapa mutan berpotensi telah dibangunkan iaitu turnera dengan bunga yang tahan lebih lama, canna dengan warna bunga baru serta bunga raya dengan morfologi bunga yang berbeza daripada induk. Kesemua mutan berpotensi kini di peringkat generasi ketiga kajian lapangan di Serdang untuk dinilai kestabilan genetiknya, dan akan didaftarkan sebagai varieti baru dengan Jabatan Pertanian sebelum dipindahkan kepada pengguna landskap.

Keywords

Shrubs, landscape, mutagenesis, hibiscus, turnera, canna

INTRODUCTION

Landscape is a valuable asset and heritage that contributes directly to the environment, socio-economic development and civilization of a country. Beautiful and unique landscapes not only create a conducive environment for recreation and social interaction for multi-cultural society, but may also act as a means to attract domestic and foreign investments. The National Landscape Policy (NLP) which was officially launched on 30th September 2011 is a proof of Malaysia's determination to be a Beautiful Garden Nation by 2020. This policy serves as an operational guideline for the development and maintenance of landscape as part of the national heritage, and provides a holistic path towards a better quality living environment.

The implementation of NLP requires the involvement, cooperation and commitment of all level of societies, from government agencies to the general public. With this in mind, National Landscape Department and Nuclear Malaysia had collaborated on a project to develop new varieties of ornamental plants that are suitable for Malaysian landscapes through induced mutation. The project which was started on July 2009 was aimed at developing landscaping plants with improved horticultural traits particularly for longer flower bloom period, attractive flower colours and larger petal size.

At present, landscapes in Malaysia are heavily dependent on imported annuals such as *Tagetes erecta L.* dan *Celosia argentea* for their flower uniformity and visual impact. Malaysia as a tropical country has various attractive flowering shrubs which can be exploited for landscape purposes. However most of these shrubs do not flower profusely or have a short bloom period, thus reducing their visual impact and decorative values. In this project, three species of landscaping shrubs commonly planted in Malaysia were used; *Hibiscus rosa-sinensis* red, *Turnera subulata* and *Canna generalis*. Hibiscus and canna have flowers that normally last for a day whilst turnera only blooms for approximately 3 hours (from 9 am to 12 pm).

Two types of gamma irradiation were applied in this study; acute and chronic irradiations. Using acute gamma irradiation, Nuclear Malaysia has successfully developed new varieties of ornamental plants and foliages such as hibiscus, cordylines, orchids, duranta, lilies and petunia (Ahmad et al. 2009). For the first time, chronic gamma irradiation were utilized for improving landscaping plants in Malaysia. Previous studies on chronic gamma irradiation have found that chronic irradiation is very useful in minimizing radiation damage, and at the same time can induce a few improved characters on irradiated plants (Okamura 2008). The chronic gamma irradiation effects are almost similar to ion beam irradiation. Thus, it is possible to change/improve one character of the plant without altering other useful characteristics (Dr Atsushi Tanaka, personal communication). This paper discusses the work in generating new varieties of flowering shrubs for landscapes in Malaysia using acute and chronic gamma irradiation.

MATERIALS AND METHODS

Acute Gamma Irradiation Treatment and Radiosensitivity Test

The healthy stems of hibiscus and turnera were cut into approximately 15 cm segments that contain 2 or 3 nodes. Canna rhizomes were cut about 5 cm from the base and cleansed from soils. The cuttings and rhizomes were irradiated at 10, 20, 30, 45 and 60 Gy using a gamma cell (Gammacell 220 Excel, MDS Nordion, UKM). A set of cuttings and rhizomes was used as the controls. Irradiated stem cuttings and rhizomes were then planted into sand-beds for rooting. After one month, the rooted stems were transferred into polybags and allowed to grow under 70% shade provided by plastic netting. The number of growing shoots from the stem cuttings and rhizomes was recorded after one month of irradiation treatments.

Determination of LD_{50} for acute gamma irradiation

A graph of the percentage of growing shoot against irradiation dose was plotted to determine LD_{50}. Based on the radiosensitivity test results, an optimum dose range was chosen for subsequent irradiations of the stem cuttings and rhizomes to induce mutation in all plant samples.

Chronic Gamma Irradiation Treatment And Radiosensitivity Test

For chronic gamma irradiation treatment, potted plants of hibiscus, turnera and canna (3 varieties) were placed at specific rings in Gamma Greenhouse. The selected rings were; 4 (0.17 Gy/hr), 6 (0.07 Gy/hr), 8 (0.04 Gy/hr), 10 (0.03 Gy/hr) dan 12 (0.02 Gy/hr) for hibiscus and turnera and rings 3 (0.30 Gy/hr), 5 (0.11 Gy/hr), 7 (0.05 Gy/hr), 9 (0.03 Gy/hr) dan 11 (0.02 Gy/hr) for canna. After a week, the original shoots were trimmed in order to induce the formation of new shoots (M1V1). M1V1 shoots would subsequently produce new shoots (M1V2, M1V3 and so on), as illustrated in Figure 1. These plants were exposed to radiation until flowering or approximately 3 months. Irradiation was done for 8 hours a day and 5 days a week. Weekly data were taken on the growth performance for the first 6 consecutive weeks and all morphological mutations were recorded.

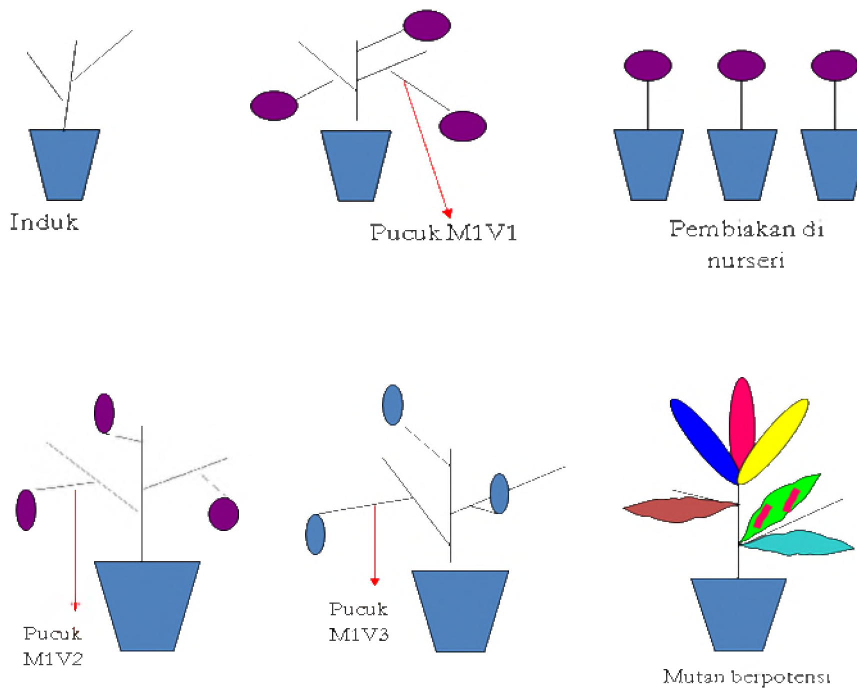

Figure 1 Illustration on the formation of new shoots for chronic gamma irradiated plants

Analysis of Mutation and Selection of Mutants

Observations on mutation effects were focused on flower colors, sizes and longevity. Irradiated plants with attractive variations of colours, flower patterns and flower longevity were selected as mutant candidates. These mutant candidates were further propagated for a minimum of 4 vegetative generations in the nursery and open field, concurrently. Open field screening was carried out in collaboration with the National Landscape Department and Department of Agriculture, Serdang. Mutants with stable traits will be chosen and registered as new varieties before transferring to end users.

RESULTS AND DISCUSSION

Determination of optimal dose range for gamma irradiation

The optimum doses for gamma irradiation were based on the LD50 values as well as morphological mutation frequencies. Doses with higher mutation frequencies without significant adverse effects on plant growth were selected as the optimum doses. For chronic gamma irradiation, the optimum doses were chosen based on the accumulated doses that induced the highest morphological mutation in treated plants. These optimum doses were recommended for further irradiation work involving these plants. Table 1 shows the optimum dose range for each plant species and sample type.

Table 1 The optimum dose range for different samples of hibiscus, turnera and canna using gamma irradiation

Spesies	Plant samples	Irradiation type	Optimum dose range
Hibiscus rosa-sinensis	Cuttings	Gamma (acute)	10-20 Gy
Hibiscus rosa-sinensis	Cuttings	Gamma (chronic) at 0.67 Gy/hr	7-10 Gy (accumulated dose)
Turnera subulata (putih)	Cuttings	Gamma (acute)	10-20 Gy
Turnera subulata (kuning)	Potted plants	Gamma (chronic) at 0.07 Gy/hr	33.6 Gy (accumulated dose)
Canna generalis	Rhizomes	Gamma (acute)	15-25 Gy (Medina et al 2005)
Canna generalis	Potted plants	Gamma (chronic) at 0.11 Gy/hr	52.8 Gy (accumulated dose)

Mutation frequency

Mutation frequency is the ratio of mutants to the total number of plants in the irradiated population. Mutation frequency data is very important for analyzing the efficiency of each dose treatment in inducing mutation on plant samples. In this project, all kinds of variations (including deformity) on the overall plant growth, leaf and flower morphologies at M1V1 stage were recorded and analyzed. Table 2, 3 and 4 summarize growth performances and morphological mutations observed on M1V1 generations of hibiscus and turnera. Generally, hibiscus irradiated with both acute and chronic gamma at dose 10 Gy exhibited the highest mutation frequency as compared to other doses. For turnera, irradiation doses in a range between 10 to 20 Gy were found to be the most optimum in generating various morphological mutations without adverse effect on plant growth.

Table 2 Growth performances and morphological mutations observed on M1V1 hibiscus after acute gamma irradiation

Dose (Gy)	Total samples	Mean new shoots	Mean shoot height (cm)	Leaf mutation	Slow Growth	Flower mutation (%)
0	10	4.2 ± 1.13	1.65 ± 0.47	0 (0%)	0 (0%)	0 (0%)
10	50	3.46 ± 1.05	0.65 ± 0.44	14 (28%)	2 (4%)	4 (8%)

20	50	2.82 ± 1.35	0.44 ± 0.38	9 (18%)	15 (30%)	1 (2%)

Table 3 Growth performances and morphological mutations observed on M1V1 hibiscus after chronic gamma irradiation

Accumulated dose (Gy)	Total samples	Mean new shoots	Mean shoot height (cm)	Total flower mutation	Mutation frequency (%)
0	30	10.3	1.20	0	0
4.1	30	5	0.84	3	10
6.6	30	7.5	1.01	3	10
10.7	30	8	0.92	4	13.3
11.8	30	7	0.91	3	10
12.1	30	7.5	0.36	0	0

Table 4 Growth performances and morphological mutations observed on M1V1 turnera after acute gamma irradiation

Dos (Gy)	Total samples	Number of mutation (%)				
		Curled leaves	Variegated leaves	Early flowering	Stunted growth	Others
0	20	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
10	54	14 (25.9%)	0 (0%)	4 (7.4%)	0 (0%)	1 (long stalk)
20	51	0 (0%)	13 (25.5%)	0 (0%)	5 (9.8%)	0 (0%)
30	20	0 (0%)	2 (10%)	0 (0%)	9 (45%)	0 (0%)
45	9	0 (0%)	0 (0%)	0 (0%)	7 (77.8%)	0 (0%)

Selection of mutants

Hibiscus rosa-sinensis

From both nursery and open field screenings, various morphological mutations, in terms of flower colour and shape, were observed on irradiated hibiscus. During M1V1 screening, a number of mutant candidates with interesting variations were observed. Among them were plants with six-petal flowers, pink flowers with red veins, larger petal size and different flower shapes such as compact and curly, compact large petal and flower with 2 stamens. Some of the variations are shown in Figure 2. However most of these variations were not permanent and reverted to the original traits after M1V2. At present, only one mutant, with compact and curly petal (Figure 3) has been found stable after M1V4 and is currently under field trial at Serdang. However, no mutant with extended bloom period was observed, but other horticultural traits such as frequent and profuse flowering are currently being monitored.

Figure 2 Some variations of hibiscus flowers after irradiation; 6-petal (A) and 2-stamen (B) flowers after acute gamma irradiation and pink flower with red veins (C) after chronic gamma irradiation

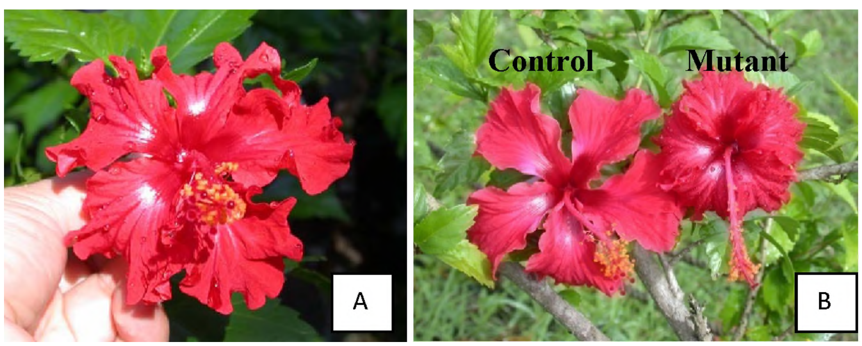

Figure 3 A stable mutant with compact curly petal (A) and a comparison of this mutant with the control (B)

Turnera subulata

For *Turnera subulata*, most mutations were in the form of flower longevity. At present, 4 mutants with extended bloom life have been identified. These mutants retain the original flower colour and shape of the parent cultivar, but the blooming period was extended for approximately 1-2 hours as compared to the control. Three of these mutants were generated from irradiation dose at 10 Gy and another one at 20 Gy. The performance of these mutants will be further monitored to ensure that they are truly genetically stable mutants. Previous studies have shown that turnera has a physiologically complex flowering process, which was influenced by various internal and external factors, such as temperature, light, humidity, hormone regulation, water uptake, sugar uptake and polysaccharide degradation (Ball 1933; Van Doorn & Van Meeteren 2003). Figure 4 shows the mutant plants at the landscape trial plot in Serdang which were still in full bloom at 1 pm as compared to the controls.

Figure 4 Mutant turnera plants (left) with blooming flowers at 1 pm as compared to the controls (right)

Canna generalis

Through acute gamma irradiation, a canna mutant was successfully obtained. This mutant which has red-pink petals was derived from a bright pink variety (Figure 5). Another canna mutant was generated from chronic irradiation of a red variety with coloured leaves at 0.11 Gy / hr for a total of 52.8 Gy (accumulated dose). This new mutant plant retains the original leaf colour but has orange flowers instead of red and is obviously shorter than the parent variety. Both mutants are currently under landscape trials in Serdang.

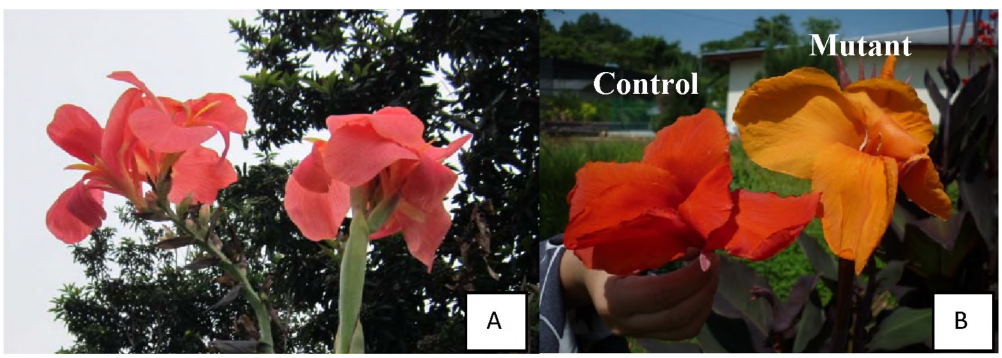

Figure 5 Canna mutant with pink flower (A) and an orange mutant generated from a red variety (B).

CONCLUSION

This project has successfully generated mutant varieties of landscaping shrubs with enhanced ornamental traits. At present, 7 promising mutants have been identified which consisted of 1 hibiscus with compact curly petals, 4 turneras with extended bloom life and 2 cannas with new flower colours. These mutants are currently in the process of registration for new varieties with Department of Agriculture.

ACKNOWLEDGEMENT

The authors would like to thank all members of the Ornamental Group, Mr Ahmad Zaki Hussain and Mr Norhafiz Talib for chronic gamma irradiation, Mr Ahmad Takim Saring (UKM) for acute gamma irradiation, Dr Rusli Ibrahim, Dr Azhar Mohamad and Prof Dr Siranut Lamseejan (Kasetsart University, Thailand) for technical advices on chronic gamma irradiation and Department of Agriculture Serdang for providing spaces and facilities for landscape trials. This project was funded by the National Landscape Department under research consultancy services (NM-R&D-10-04).

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