Asian Agri-History, *Vol 22(3), 2018*
ISSN (Print) : 0971-7730
DOI: 10.18311/aah/2018/20000

Drumavichitrīkaranam - The Ancient Approach to Plant Mutagenesis

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Abstract

Sustainable agriculture has come to the fore in recent times. Today agricultural scientists are in a race against time to maintain global resource sustainability and foremost on their agenda is food production. As populations increase exponentially and arable land is usurped for urbanization, the available arable land for agriculture is diminishing rapidly. Plant biotechnology can help in developing improved crop varieties, but it is not entirely without its perils. The long-term negative effects of Genetically Modified (GM) crops are still unclear. In the Indian context, a much safer technology may already be within our reach, locked in such ancient treatises as the *Vrikshāyurveda*. In tune with the current trends in organic agriculture, there also exists an organic methodology of plant mutagenesis- termed *Drumavichitrīkaranam*- in the ancient Indian treatises. The present study analyses the various aspects of *drumavichitrīkaranam*, such as the nature of the mutagenesis carried out, the type of mutagenic agents used, the the comparative study of the treatises, and presents possible applications of *drumavichitrīkaranam*.

Keywords: Biotechnology, *Drumavichitrikaranam*, Genetically Modified Crops, Mutagenesis, Sustainable Farming

(Received: 07 October 2017, Accepted: 26 March 2018)

1. Introduction

Moden plant biotechnology owes its origin to the extensive research done by scientists such as Matthias Schleiden, Theodor Schwann, and Fredrick Griffith. In recent decades, plant mutagenesis has emerged one of the primary techniques in this field of crop improvement. Many corporate entities have established their individual research units, and are quick to claim that Genetically Modified (GM) crops are the saviours of this hunger-stricken world in which arable land is diminishing rapidly. However, questions continue to be raised over the unknown long-term effects of widespread adaption of GM crops on humans, animals and the environment. Given that countries worldwide are increasingly focusing on sustainable farming, it would be desirable to more closely examine India's ancient agricultural practices where sustainability was the core principle.

It is very surprising that the concept of plant mutagenesis was fully understood even in ancient India. A number of ancient treatises have dealt with this topic under the Sanskrit term "*drumavichitrīkaranam*". Here *druma* means a tree and *vichitrīkaranam* means 'to make (it) appear extraordinary'. Hence the term means 'to make a tree appear extraordinary'[11]. In other words, the

term implies that there would be an alteration in the natural trait of the tree. Thus, the term '*drumavichitrīkaranam*' can be said to be akin to plant mutagenesis. It can be differentiated from the term *sankarajātyotpatti*, which means hybridisation (Figures 1 and 2).

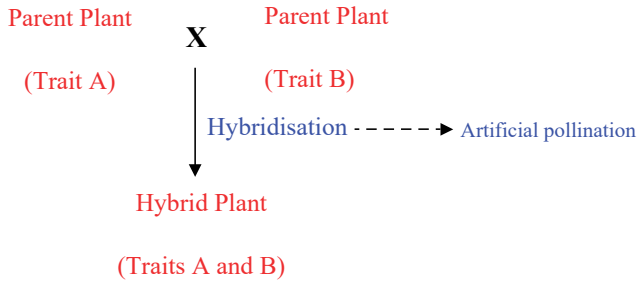

Figure 1. *Sankarajātyotpatti* (Hybridisation)

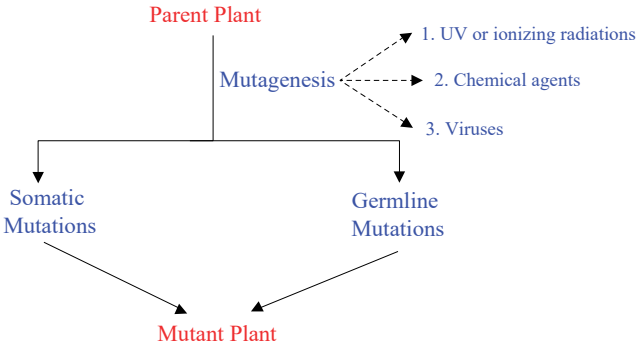

Figure 2. *Drumavichitrīkaranam*

2. History

The pioneer of *drumavichitrīkaranam* is said to be the Vedic sage Kaśyapa. It is described in the *Harivamśapurāna* that, pleased by the services rendered by Aditi, sage Kaśyapa transformed a *Mandāra* tree (*Erythrina variegata*) into a *Kovidāra* tree (*Bauhinia variegata*)[6]. Many encyclopaedic treatises describe some procedures of *drumavichitrīkaranam* under the general chapter of agriculture. However, certain treatises do contain a separate chapter on *drumavichitrīkaranam*. Six such treatises were chosen for study as follows:

1. Sūrapāla's *Vrikshāyurveda* (1000 CE)
2. Chavundarāya's *Lokopakāra* (1025 CE)
3. Someśvaradeva's *Mānasollāsa* (1131 CE)
4. Śārngadhara's *Upavanavinoda* (1300 CE)
5. Chakrapāni Miśra's *Viśvavallabhavrkśāyurveda* (1580 CE)
6. Basavarāja's *Śivatattvaratnākara* (1694-1714 CE)

3. Content Analysis

This study carried out content analysis with its focus on the kind of extraordinary traits with two objectives: a. to compare the treatises to determine their objectives over a period of time; and b. to examine the relevance of each of these objectives in the present-day context.

India's ancient agriculturists aimed to introduce several extraordinary traits into plants and trees such as: (i) to produce fruits and flowers throughout the year, as well as out of season, (ii) to produce and alter the fragrance of flowers, (iii) to alter the taste of fruits, (iv) to alter the colours of fruits and flowers, (v) to produce flowers and fruits on other species of plants and trees, (vi) to induce flowers on non-flowering trees and creepers, (vii) to transform trees into creepers and vice-versa, (viii) to dwarf the trees, (ix) to produce multiple kinds of fruits/flowers on a single plant/tree/creeper, (x) to selectively ripen fruits as well as to delay or accelerate fruit dropping, (xi) to destroy the trees, (xii) to enhance sprouting of seeds and hasten production of fruits, (xiii) to increase the size of fruits and flowers as well as to alter the shape of fruits, (xiv) to produce seedless fruits, (xv) to cure barren-ness (or improve fertility), (xvi) to increase production, quality and to cause trees to bear fruits/flowers in bunches, (xvii) to get jack-fruits at the ground level, (xviii) to hasten the flowering of jasmine, and (xix) to avert/delay the fading of *Barleria cristata* flowers.

Thus the above two objectives are relevant even in the present times and could provide suitable solutions to

the current needs. Information available in ancient literature on materials and methods to transform various traits are provided below.

1. **To produce fruits and flowers throughout the year as well as out of season:**
   Among the raw materials required to induce this trait, two are worthy of special mention: (a) *Kunapajala* - a liquid organic manure with fermented ingredients enables easy uptake of nutrients[8], and (b) Moonlight — as the moisture content of the soil is known to increase with greater gravitational force of the moon, hence sprouting is accelerated[3].

2. **To produce and alter the fragrance of flowers:**
   Fragrance is an important trait in flowers, especially for the perfume industry. The terpene pathway is required to be activated. *Cyperus rotundus* (nut grass), *Anogeissus latifolia* (button tree), *Vetiver zizanioides* (vetiver), etc., are included in the manure as raw materials as they contain a higher percentage of terpenes. It is claimed that even non-fragrant flowers can be made fragrant by following the prescribed techniques[10].

3. **To alter tastes of fruits:**
   As fruits are generally eaten raw, the combination of various flavours, including sweetness, is required for complete culinary enjoyment. However, flavour is a complex interplay of many traits. Many of the treatises have elaborately described procedures to convert sour, bitter, and pungent fruits into sweet ones. Similarly, a method has been prescribed by Sūrapāla to make fruits more pungent as may be required for chillies[10].

4. **To alter the colour of flowers and fruits:**
   Apart from adding to the visual appeal of a flower, colours have an important role in attracting pollinators, and warding off pests. Moreover, flavonoids (the molecules responsible for colour) are known to have therapeutic value and aid in increasing immunity.

   The raw materials vary as per the required colour. Sūrapāla has described methods for production of black, red, green and golden coloured fruits. Conversion of flowers into white, red and golden colours was also reported[10]. In the modern context, the possible commercial application of alteration of colours is the production of coloured cotton. This would help to circumvent the process of chemical dyeing which is hazardous to health and the environment.

5. **To produce flowers and fruits on other species of plants and trees:**
   The term *drumavichītrikaranam* obtains its true meaning in the literal sense through this objective. Some of them are described in the Upavanavinoda of Sārngadhara, as given below:

   i. To grow *Michelia champaca* (Champak) flowers on *Mimosops elengi* (Spanish cherry).
   ii. To grow *Nelumbo nucifera* (Indian lotus) from seeds of *Nypmphaea caerula* (blue water lily).
   iii. To grow *Nymphaea* sp. (lilies) from seeds of *Cordia dichotoma* (Indian cherry) – this is a transformation of a terrestrial tree into an aquatic herb.
   iv. To grow *Hemionitis cordifolia* (heart fern) from fruit of *Nymphaea* sp. (lily). – this is a transformation of an aquatic herb into a terrestrial fern.
   v. To grow *Punica granatum* (pomegranate) fruits on *Musa paradisiaca* (plantain tree).
   6. To grow *Mangifera indica* (mango) fruits on *Musa paradisiaca* (plantain tree).
   vii. To grow *Momordica charantia* (bitter gourd) fruits on *Ricinus communis* (castor plant).

8. To grow *Solanum melongena* (brinjal) fruits from seeds of *Azadirachta indica* (neem tree).
ix. To grow *Nerium indicum* (Indian oleander) from *Nymphaeae* sp. (lily)- an aquatic herb would bear flowers of a terrestrial shrub.
x. To grow *Solanum indicum* (poison berries) from *Mangifera indica* (mango) seeds.
xi. To growing *Solanum melongena* (brinjals) on *Cucurbita maxima* (red gourd) climber.

The primary mutagenic agent used to achieve most of the transformations is the oil of *Alangium salvifolium*[10].

6. To induce flowers on trees and creepers:
The only raw material required is soft ash[10]. Soft ash has a high content of potash which is known to induce flowering[9].

7. To transform trees into creepers and vice-versa:
This transformation causes an alteration in the physical structure of the plant. It is noteworthy that transformation of trees and creepers requires the use of unconventional raw materials such as a golden rod, ivory powder and human flesh. In order to transform creepers into trees, adequate nutrition has to be supplied so that their mass increases[10].

8. To dwarf the trees:
Akin to the Chinese art of bonsai, dwarf trees can be obtained by restricting the spread of roots. Hollow pits are layered with bricks on all sides to prevent the roots from spreading[10].

9. To produce multiple species of fruits or flowers on a single plant/tree/creeper:
Multiple species of fruits and flowers on a single plant/tree/creeper can be easily obtained by the process of grafting. Currently, India's own 'Mango Man' Haji Kalimullah Khan from Malihabad (Uttar Pradesh, India) is as an authority in the technique of grafting. He has successfully grown 300 varieties of mangoes of different shapes, sizes and hues on a single mango tree[10].

10. To selectively ripen fruits as well as to delay or accelerate fruit dropping:
Harvesting and fruit dropping are critical factors which can alter the shelf-life and the taste of the fruit by the time it reaches the end-user, the customer. If they are harvested late, then their shelf-life is shortened. They may even get spoilt before they reach the end-user and may result in financial loss to the farmer. Harvesting too early may not be easy as plucking may be very hard or the fruits may not ripen completely once plucked. In the latter case, the taste of the fruits may not be appealing to the end user. A number of queer raw materials such as wet hides of animal, bones of a monkey, ichor (elephant's rut) and nose bone of elephant have been prescribed in the treatises to delay ripening.

In order to accelerate fruit dropping concoctions of *Tamarindus indicus* (tamarind), *Ziziphus mauritiana* (Indian jujube), *Terminalia arjuna* (arjuna) and *Citron limon* (lemon) are prescribed[10].

11. To destroy trees:
Since trees have been traditionally worshipped in India as abodes of various Gods. It is said in the scriptures that trees should be reared just as one would rear one's own offspring. Killing them incurs sins. Despite these injunctions, methods are described to destroy trees. These include sprinkling extracts of *Dolichos biflorus* (horse gram), placing a piece of asafoetida at the roots, or sprinkling salt water at the roots[10].

12. To enhance sprouting of seeds and hasten production of fruits:
The primary raw materials required to induce quick sprouting and fruiting are oil of *Alangium salvifolium*, coconut water, and the marrow of

boar and the Gangetic porpoise. Pomegranate seeds require cock-blood as a special need[10].

13. To increase the size of fruits and flowers as well as to alter the shape of fruits:

The objective here is to obtain the same effects as would be achieved by polyploidy. Once again, the use of uncommon raw materials such as ivory powder, sand, ichor (elephant's rut), hollow tooth of a monkey or a boar, and a hot needle is prescribed[10].

14. To produce seedless fruits:

Seeds often impart a bitter taste, thereby causing an unpleasant experience while eating the fruit. Seeds also accelerate fruit deterioration. Hence seedless varieties of fruits have greater economic value Use of *Abrus precatorius* (jequirity), *Madhuca indica* (butter tree), *Saussurea lappa* (costus), *Glycyrrhiza glabra* (liquorice), honey, sugar, and clarified butter is said to cause seedless-ness[10].

15. To cure barrenness:

Barrenness, which results in negligible or poor output, causes huge economic losses. Hence methods to cure barrenness especially in coconut and sweet orange include application of *Emblic myrobalan*, etc[10].

16. To increase production, quality and to cause trees to bear fruits/flowers in bunches:

With increase in demand, various means have to be devised to increase supply. The yield per tree can be increased by inducing the tree to bear fruits and flowers in bunches. Another factor is to ensure complete fruiting of all flowers. Complete fruiting can be induced by use of fish meal manures to grow mango, tamarind, and champa (*Michelia champaca*) in bunches. Manures have also been devised to increase the quality of fruits in terms of their aroma and juiciness[10].

17. To get jack-fruits at the ground level

The *Lokopakāra* states that covering a jack fruit tree from the top to bottom with paddy straw can cause jack fruits to develop at the bottom of the trees[10].

18. To hasten the flowering of jasmine:

Mulching with hay can hasten the flowering of jasmine, according to *Lokopakāra*. This can be of great use to the perfume industry, where jasmine has a high demand due to its fragrance[10].

19. To avert/ delay the fading of *Barleria cristata* flowers

Increasing the life span of desired plants/tree can be achieved by appropriate manures specific to the desired plant/tree. For example, horseflesh is required for *Barleria cristata* and Indian coral tree for *Benincasa hispida*[10].

From the above, it can be seen that the objectives mentioned in our ancient treatises continue to be relevant even in the present times. More exhaustive studies of these objectives and the raw materials used for mutagenesis could lead to breakthroughs and solutions for modern times.

4. Raw Materials

The study of the raw materials and their active ingredients proposed in the above treatises will throw light on the nature and rationale of the mutagenic agents. This knowledge would further aid in devising new formulations on the same principles, while adhering to the concepts of sustainable agriculture. This study enumerated nearly a hundred different raw materials across the entire topic. The most commonly used raw materials are cow dung, barley, butter, honey, ghee, sugar, jaggery, milk, coconut water, ash, oil cake, bone marrow, blood, fish meal, *Embelia ribes*, *Sesamum indicum*, *Saccharam officinarum*, *Alangium salvifolium*, *Curcuma longa*, etc. It was also noted

that there were a few unconventional raw materials such as scorpion sting, ichor (elephant's rut), ivory, python's skin, monkey skull, etc. No literature could be obtained regarding the functioning of these ingredients[10].

5. Future Applications

Science and technology has to offer scope for future application that can help mankind. The technique of *drumavichītrikaranam* has potential to address sustainability, as well as the needs relevant to the future world, and hence remains a knowledge system worth re-examination and exhaustive study. There would be many applications of science for the future. A few such possible applications hypothesized are: Food supply, Aposematic warning, Plant resistance to insect pests, Drought and salinity tolerance, Biofortification, Phytoremediation, Biofuels, Reduction in Greenhouse gases, Speciality products, and Food in outer space.

Food Supply: This will include technologies to reduce the demand-supply gap, such as growing fruits out of season and throughout the year, increasing the size of fruits, and methods to increase production and quality of fruits, to alleviate the shortage of food supply and reduced availability of arable land[10].

Aposematic Warning: Aposematic warning refers to colouration adopted by animals to ward off predators. The use of chemical pesticides could be avoided if plants too can exhibit aposematic colouration. Some of the principles in *drumavichitrikaranam* can be used to alter the colour of fruits/flowers[10].

Plant Resistance to Insect Pests: Unlike animals, plants lack a well-developed immune system, whose main feature is memory. However, they are known to release certain volatile compounds in response to a pest attack by warning the neighbouring plants, and by attracting predators of these pests[12]. Using *drumavichītrikaranam*, the plants could be made to release the volatile compounds constantly to avoid pests[10].

Drought and Salinity Tolerance: In view of the rapidly increasing soil and water pollution, as well as decreasing rainfall, drought and salinity tolerance will be essential for future agriculture. Drought-tolerance in *Triticum sphaerococcum* (a relative of cultivated wheat) has been reported[10]. Similarly, scientists have been able to develop a salinity tolerant variety of mangoes[2].

Biofortification: Bio-fortification refers to fortification of plants with essential vitamins and minerals, so that these become easily available for human consumption[7]. Biofortication can be enhanced by agronomic management by soil and foliar application of fertilisers[7]. Based on the principles of *drumavichītrikaranam,* organic fertilisers may be formulated to stimulate bio-fortification[10].

Phytoremediation: *Drumavichītrikaranam* can be also designed for phytoremediation and phytomining. Phytoremediation is used to remove toxic waste and pollutants using plants (including algae and bacteria). Phytomining is the harvesting of mineral nutrients in plants[7]. Phytochelatins, such as glutathione, have an important role in these processes[5]. The principles of *drumavichītrikaranam* can help in excess production of phytochelatins in a manner similar to production of fragrance.

Biofuels: Non-renewable fossil fuel resources are decreasing rapidly. However, biofuels do offer some hope. Plants that can produce high quantities of ethanol, which then lends itself to easy extraction. Alternately, plants should be able to produce large quantities of biomass that can be fermented to extract ethanol[1]. Applying the principles of *drumavicitrīkaranam* plants could be induced to produce the required products in excess[10].

Reduction in Greenhouse Gases: Greenhouse gases have been identified as one of the major causes of global warming. One of the prominent greenhouse gases is methane which is released by animals[4]. Genetically modified forages are able to prevent/ reduce the formation of methane. Forage crops also need to be modified to contain more phytase so that phosphorus discharge is also reduced[10].

Speciality Products: Speciality products include biodegradable products such as paper, speciality fibres, adhesives, boards, etc. These would be cellulose and starch based products. It remains to be seen if this could be achieved through *drumavichītrikaranam*[10].

Food in Outer Space: The scientific community is all eager to colonise other planets. If this happens, then it would also be essential to grow food there. A special type of wheat called Apogee has been developed that is a dwarf variety growing in hydroponic cultures and having a growth cycle of just 23 days[13]. *Drumavicitrīkaranam* has some of the techniques to dwarf trees as well as shorten the germination period. The methodology of growing plants in a soil-less medium, could be explored using this ancient method[10].

6. Conclusion

There is enough evidence to conclude that plant mutagenesis did exist in ancient India. In view of the possible health hazards caused by chemical pesticides and fertilisers as well as genetically modified crops today, it may be timely to revive the ancient techniques of *drumavichītrikaranam*, which are safe for human consumption and the environment. One can safely conclude that much remains to be unravelled about the wonder that is *drumavichītrikaranam*.

7. References

1. ACOBA (Applications Committee on Opportunities in Biotechnology for future Army). Opportunities in Biotechnology for future Army Applications. Washington D.C.: National Academy Press; 2001. p. 57.
2. Prema B. Kesar farmers to reap fruits of Israel technology. Times of India; 2017. Available from: http://timesofindia.indiatimes.com/city/ahmedabad/kesar-farmers-to-reap-fruits-of-israel-tech/articleshow/59451835.cms
3. Catterall C. How does lunar planting work? Gardening by the Moon; 2009. Available from: http://www.gardeningbythemoon.com
4. Gary H. Genetically modified plants and animal feed. Tri-state Dairy Nutrition Conference; Monsanto. 2009. p. 116.
5. GMO. Compass. Stress Resistant Crops; 2006. Available from: http://www.gmo-compass.org/eng/agri biotechnology/breeding aims/151.sress_resistance.html
6. Jugnu S. Visvavallabhavrksh ayurveda of Chakrapani-mishra. New Delhi: New Bharatiya Book Corporation; 2005.
7. Kralova K, Masarovicvova E. Plants for the future. Ecological Chemistry and Engineering. 2006; 13(11): 1179–207.
8. Nene YL. Kunapajala- A liquid organic manure of antiquity. Asian Agri-History. 2006; 10(4):315–21.
9. Preston GH. Handbook of horticulture. Dehradun: Reprint Publication; 2004. p. 59.
10. Ranganathan N. Drumavicitrīkaranam- Plant Mutagenesis in Ancient India [PhD thesis]. Mumbai, India: University of Mumbai; 2012.
11. Sadhale N. Vrkshayurveda of Surpala. Asian Agri-History Bulletin No.1. Secunderabad: Asian Agri-History Foundation; 1996. p. 56.
12. Stout MJ. Types and mechanisms of rapidly induced plant resistance to herbivorous arthropods. Walters AN, Gary L, editors. Induced resistance for plant defence. Oxford: Blackwell Publishing; 2007. p. 95. https://doi.org/10.1002/9780470995983.ch5
13. USU Apogee Wheat. USU Dwarf Apogee Wheat: From Plant Earth to Outer Space; 2007. Available from: http://www.edu/apl/PDF/SpaceWheat SLT041596.pdf

"In a day when you don't come across any problems, you can be sure that you are traveling on the wrong path"
- Swami Vivekananda