Plant improvement by induced mutations

by A. Micke*

Better varieties of crop plants are a very fundamental contribution to improved agricultural and horticultural production. Better varieties mean genotypes or populations of genotypes that are well adapted to agroclimatic conditions and interact with the environment and farmers' inputs in a favourable way. They should have the capacity for high production of grain, bulbs, shoots, fruits, roots, or whatever is harvested. These products should be of good quality from nutritional and technological point of view depending upon the use of the product (milling, baking, cooking, extraction, etc.). The crop production should be stable, i.e. the varieties have to be tolerant to various stresses like draught, cold, heat, salinity, and resistant to pathogens and pests. They should be efficient in using the energy supplied from the sun, and the water and fertilizer supplied by the farmer. If crop plants belong to those species that are able to fix nitrogen, they should do so with high efficiency. If they are cultivated together with other plants, they should compete well and be adapted to intercropping. The period and duration of cultivation required should be adjusted to the climatic conditions and the crop rotation pattern, ensuring optimal production from farmer's land (or greenhouse space) throughout the year.

Man has since prehistoric times adapted plant species to his needs. However, man's population has increased dramatically, technological requirements are changing, and stress, diseases, and pests are ever present to threaten the outcome of farmers' work. So plant breeders have to improve cultivars and to do so at an accelerated pace to meet demands.

Genetic variability is required for the plant breeder to select the better traits. Mutation induction by radiation and other mutagens is a means of altering genes and creating genetic variability for the breeder.

Mutation induction techniques have been known for about 50 years, but only during the last 15 years have they become established as a valuable tool for crop plant improvement. Now an increasing number of varieties is released by breeders for cultivation by farmers and horticulturists

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Table 1. Mutant varieties

Species	Name	Direct	Cross
Allium cepa	onion	2	–
Arachis hypogaea	groundnut	4	2
Avena sativa	oat	4	3
Brassica sp	rape seed	4	–
Capsicum annuum	green pepper	3	–
Citrus sp	grape fruit	1	–
Corchorus capsularis	jute	4	–
Glycine max	soybean	6	–
Gossypium sp	cotton	3	–
Helianthus annuus	sunflower	1	–
Hordeum sativum	barley	25	32
Lactuca sativa	lettuce	2	–
Linum usitatissimum	linseed	1	–
Lupinus sp.	lupine	1	3
Lycopersicon esculentum	tomato	3	–
Malus pumila	apple	4	–
Mentha sp	mint	3	–
Nicotiana tabacum	tobacco	–	4
Ornithopus compressus	serradella	1	–
Oryza sativa	rice	28	9
Pennisetum sp	millet	–	1
Phaseolus vulgaris	bean	5	5
Pisum sativum	pea	4	1
Prunus armeniaca	apricot	1	–
Prunus avium	cherry	2	1
Prunus persicae	peach	1	–
Ribes	currant	1	–
Ricinus communis	castor bean	2	1
Saccharum officinarum	sugar cane	8	–
Secale cereale	rye	1	–
Sericea lespedeza	lespedeza	1	1
Sesamum orientale	sesame	1	–
Sinapis alba	mustard	1	2
Solanum tuberosum	potato	1	–
Solanum khasianum		1	–
Trifolium incarnatum	crimson clover	1	–
Trifolium subterraneum	subterranean clover	1	–
Triticum aestivum	bread wheat	12	5
Triticum turgidum	durum wheat	5	7
Zea mais	maize	–	3

Data for this and the other tables are taken from the issues of Mutation Breeding Newsletter published up to 17 March 1981

Table 2 Number of mutant varieties of agricultural crop plants released in different countries

India	35	Finland	6	Hungary	2
USA	26	Austria	5	Norway	1
Japan	21	France	5	Denmark	1
USSR	18	Bulgaria	4	Indonesia	1
Sweden	15	Australia	3	Pakistan	1
CSSR	15	Philippines	3	Ivory Coast	1
Italy	9	German Democratic Republic	3	Algeria	1
China	9			Egypt	1
Canada	7	Korea, Rep of	3	Greece	1
Germany, Fed. Rep of	7	Argentina	3		
United Kingdom	6	Netherlands	2		
Bangladesh	6	Burma	2		
		Thailand	2		

Table 3. Mutant varieties according to year of release

		before 1955	1955–59	1960–64	1966–69	1970–74	1975–79
Varieties developed through direct multiplication of selected mutant	Seed propagated crops	3	6	14	24	34	30
	Vegetatively propagated crops (without ornamentals)				4	13	4
Varieties developed through cross with mutant(s)		1	2	5	9	19	41

Tables 1 and 2 show that by using induced mutations, 227 improved varieties of agricultural crops have been developed and released to farmers in 35 different countries. Eighty of these cultivars were released by breeders in developing countries and contribute to the economic development of these countries. Table 3 shows the years of release, and it is clear that success of mutation breeding has mainly been reached during the last ten years. Of particular importance is the fact that breeders now recognize the value of induced mutants as parents in cross-breeding, and have had excellent results from such crosses (Table 3).

Ornamental plants are not generally looked upon as valuable for developing countries. However, they are an important source of income for the small farmer and horticulturist, and in addition may have enormous economic value for a country if the products are exported and earn convertible currency. Tables 4 and 5 give an idea of the use of induced mutations in breeding ornamental plants.

The Agency has been involved in fostering mutation breeding since its foundation as part of its mandate to support the peaceful applications of nuclear techniques. Through training and direct research support it has contributed to and certainly can be proud of its success. For the last nine years, the Joint FAO/IAEA Division has published the Mutation Breeding Newsletter which provides a unique opportunity to plant breeders all over the world to keep abreast with the development and achievements in this field.

Using radiation and mutation breeding techniques, Mr Shri S.H. Patil of the Bhabha Atomic Research Centre in Bombay, India, has developed more than twenty Trombay Groundnut varieties characterized by early maturity, higher oil content, larger kernels, and higher yields. In recognition of his work, Mr Patil was a joint winner of the 1978 Vasvik Award for agriculture.

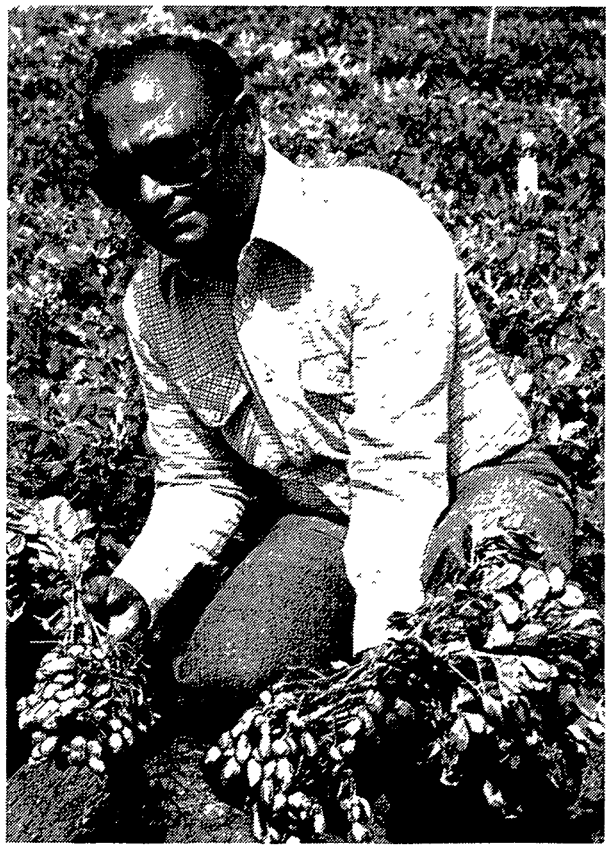

Table 4. Ornamental mutant varieties

Abelia	1
Achimenes	8
Alstroemeria	15
Antirrhinum	4
Azalea	10
Begonia	21
Bougainvillea	2
Chrysanthemum	98
Dianthus	2
Dahlia	34
Euphorbia	1
Guzmania	1
Hibiscus	4
Lilium	2
Malus	1
Polyanthes	2
Populus	1
Portulaca	7
Rhododendron	1
Rose	7
Streptocarpus	18
Tulipa	2

Table 5. Countries where ornamental mutant varieties were developed

Netherlands	100
India	53
USSR	18
USA	16
Japan	12
German Democratic Republic	12
Germany, Fed Rep of	11
Belgium	8
France	6
Canada	3
Hungary	1
CSSR	1
UK	1

NPT Newsletter

As of 31 July 1981, the International Atomic Energy Agency had negotiated safeguards agreements with **79** non-nuclear-weapon States party to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). Safeguards agreements were in force with **69** of these States. Safeguards agreements with a further **10** non-nuclear-weapon States which had been approved by the IAEA Board of Governors were awaiting entry into force. The date in parentheses after the name of the State indicates the time by which the NPT safeguards agreement should have entered or should enter into force.

NON-NUCLEAR-WEAPON STATES PARTY TO NPT

1 Afghanistan
2. Australia
3 Austria
4 *Bahamas (10 January 75)*
5 *Bangladesh (27 March 81)*
6 *Barbados (21 August 81)*
7 Belgium
8 *Benin (30 April 74)*
9. *Bolivia* (5 March 72)*
10. *Botswana (5 March 72)*
11 Bulgaria
12. *Burundi (19 September 72)*
13 Canada
14. *Central African Republic (25 April 72)*
15 *Chad (10 September 72)*
16. *Congo (23 April 80)*
17. Costa Rica
18. Cyprus
19 Czechoslovakia
20 *Democratic Kampuchea (2 December 73)*
21 *Democratic Yemen (1 December 80)*
22. Denmark
23. Dominican Republic
24 Ecuador
25. *Egypt (26 August 82)*
26. El Salvador
27. Ethiopia
28 Fiji
29 Finland
30 *Gabon* (7 August 75)*
31. Gambia
32. German Democratic Republic
33. Germany, Federal Republic of
34 Ghana
35. Greece
36. *Grenada (19 February 76)*
37. *Guatemala* (22 March 72)*
38. *Guinea Bissau (20 February 78)*
39. *Haiti* (2 June 72)*
40 Holy See
41. Honduras
42 Hungary
43. Iceland
44 Indonesia
45 Iran
46. Iraq
47. Ireland
48 Italy
49. *Ivory Coast (6 September 74)*
50. Jamaica
51 Japan
52. Jordan
53. *Kenya (5 March 72)*
54. Korea, Republic of
55 *Lao People's Democratic Republic (5 March 72)*
56. Lebanon
57 Lesotho
58 *Liberia (5 March 72)*
59 Libyan Arab Jamahiriya
60 Liechtenstein
61. Luxembourg
62. Madagascar
63 Malaysia
64 Maldives
65. *Mali (5 March 72)*
66. *Malta (5 March 72)*
67 Mauritius
68. Mexico
69. Mongolia
70 Morocco
71. Nepal
72. Netherlands
73 New Zealand
74. Nicaragua
75 *Nigeria (5 March 72)*
76. Norway
77 *Panama (13 July 78)*
78. Paraguay
79. Peru
80 Philippines
81. Poland
82. Portugal
83. Romania
84 *Rwanda (20 November 76)*
85. *St. Lucia (29 June 81)*
86 Samoa
87. *San Marino* (5 March 72)*
88 Senegal
89. *Sierra Leone* (26 August 76)*
90. Singapore
91. *Somalia (5 March 72)*
92 *Sri Lanka* (5 September 80)*
93. Sudan
94. Suriname
95 Swaziland
96 Sweden
97. Switzerland
98. *Syrian Arab Republic (5 March 72)*
99. Thailand
100. *Togo (5 March 72)*
101. *Tonga* (7 January 73)*
102 *Tunisia (5 March 72)*
103 *Turkey* (17 October 81)*
104. *Tuvalu (19 July 80)*
105. *United Republic of Cameroon (5 March 72)*
106 *Upper Volta (5 March 72)*
107. Uruguay
108. *Venezuela* (26 March 77)*
109. Yugoslavia
110. Zaire
[111. *"Republic of China" – 5 March 72*]
The "Republic of China" has ratified the NPT

Note:	**Bold:** States having NPT safeguards agreement in force.	*: Safeguards agreement approved by the IAEA Board of Governors and awaiting entry into force.
	Italics: States not having NPT safeguards agreements in force.	