MEJORAMIENTO GENETICO DE ALSTROEMERIA (*Alstroemeria* L.)

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ALSTROMOERIA
En este mes de enero la alstromoeria,
la sepultura flor, la sumergida,
de su secreto sube hacia los páramos.
Y amaneció rosado el roquerío.
Mis ojos reconocen
su marca triangular sobre la arena.

Cómo donde no había sino pólvo,
pedruscos o ceniza
surgió incitante, pura aderezada,
encrespando en la vida su hermosura?

y donde piedra y páramo
estuvieron
pasa el viento en su nave navegando
las olas olorosas.

PABLO NERUDA
Plenos Poderes, (1962)

RESUMEN. Alstroemeria como flor de corte es una especie nueva. El primer cultivar Walter Fleming (sinónimo 'Orchid') apareció en 1948. Hoy en día la Alstroemeria se ubica entre las más importantes flores de corte de Europa. En la actualidad el número de cultivares crece rápido y excede a 200. Estos se han obtenido por medio de cruzas convencionales o vía mutaciones. Los principales centros de mejoramiento genético son Holanda y Polonia. Las mutaciones son generadas utilizando rayos X, gamma y los neutrones rápidos. Se han producido mutaciones de color de flores, diseño de pétalos, forma de pétalos, cambio de tamaño de flores, vigor de la planta, productividad y la época de floración. El intervalo de la dosis óptima de la radiación gamma para inducción de mutaciones útiles es de 3 a 7 Grays. En caso de cultivares triploides 60 Gy de la radiación gamma fue letal. En Polonia hasta 1993 se obtuvieron 7 cultivares vía mutaciones y 4 cultivares de cruzas; 3 del tipo mariposa, uno con flores amarillas de fragancia de vainilla, de floración todo el año.

PALABRAS CLAVE. Especies, historia, cruza-polinización, mutaciones, dosis óptima, cultivares nuevos.

BREEDING OF ALSTROEMERIA (*Alstroemeria* spp. L.)

SUMMARY. Alstroemeria, as a cut flower is a very new plant. The first cultivar Walter Fleming (synonym 'Orchid') was bred in 1948. Today, alstroemeria is one of the most important cut flowers in Europe. The number of cultivars grows very fast now, exceeds 200. They have been developed by conventional and mutational breeding. The main centers of breeding new cultivars are Holland and Poland. For the induction of mutations, X- and gamma rays as well as fast neutrons are used. Mutations of flower colour, petal design, petal shape, change of flower size, plant vigour, productivity and season of bloom were recorded. The range of optimal doses of gamma rays for induction of useful mutations was 3-7 Gy. In the case of triploid cvs. 60 Gy of gamma rays was a lethal dose. As the result of mutation breeding 7 new Polish cvs were registered to the end of 1993 and 4 from cross-breeding: 3 of Butterfly type and one with yellow flowers with vanilla fragrance, blooming all the year round.

KEY WORDS: Species, history, cross-breeding, mutational breeding, optimal doses, new cultivars.

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INTRODUCTION

The end of this century is a scene of authentic breeding phenomenons. To such phenomenon belongs Alstroemeria, that first cultivar assigned for cut flower production was bred in 1948. The cv was named "Walter Fleming" and is presently named "Orchid". Nowadays, the number of cultivars grows very fast and exceeds 200.

What is the reason for such great interest in Alstroemeria? This is a plant outstandingly energy-sparing; in the climatic conditions of the majority of European countries this fact has basic importance. For proper development Alstroemeria demands a range of substrate temperatures not exceeding 15°C. Flowers of Alstroemeria are exceptionally long lasting-they can survive for two weeks in a vase without substances prolonging their life. Probably it is due the presence of tuliposide A, the substance with a strong fungicidal effect (Slob *et al.*, 1975). This is also plant of low susceptibility to diseases and pests, and relatively easy to cultivate. Yield of this plant is very high, on an average, in European conditions to 200 and more flower shoots per 1 m^2, depending on the cultivar. Flowers of Alstroemeria have an unconventional shape and are characterized by a wealth of colours and unusual desingn on the flower petals. Some cultivars bloom all the year round. Besides, thanks to different agrotechnical manipulations and cultivation in different climatic regions of the world (Kenia, Columbia, Guatemala) flowers of Alstroemeria are attainable on the market through the full year. It is cultivated in Europe, Asia, Africa, Australia and New Zealand, and both Americas (Przybyla, 1989).

Taxonomy and biotope

Genus *Alstroemeria* belongs to the subclass of Monocotyledonae, to family *Alstroemeriaceae* (de Hertog *et al.*, 1993). The number of species of Alstroemeria still is not precisely fixed. Buxbaum (1964) says about 60 species exist. Alstroemeria is diploide and its chromosome number is 2n = 16 (Darlington *et al.*, 1945).

The homeland of Alstroemeria is South America: Chile, Argentina, Paraguay, Bolivia, Peru, Ecuador, Brasil (Baker, 1888; Uphof, 1952; Robinson, 1963; van Raalte, 1971; Koorneef, 1972) and also Venezuela (Ravenna, personal communication). The ecological amplitude of *Alstroemeria* genus is wide: from the lower boundary of snows on the high, mountainous plateau of the Andes (*A. nivalis* Phil. in Linn.), higher 3.000 m above sea level (*A. spathulata* Presl.), across mountain

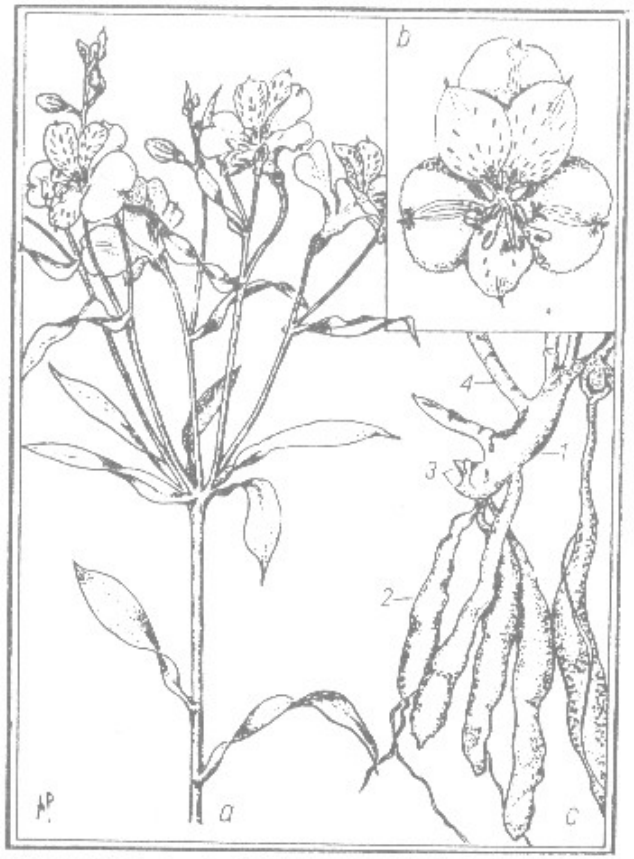

Fig. 1. Plant of Alstroemeria: a- fragment of a shoot with inflorescence, b- single flower, c-underground part; 1- rhizome, 2- storage roots, 3- buds on the rhizome, 4- generative shoot (A.Przybyla).

forests down to the coastal deserts of Chile and coasts of the Pacific (*A. pelegrina* L.), from Patagonia and Tierra del Fuego (*A. patagonica* Phil.), across edge of Atacama desert to circumequatorial, swampy territories of Brasil (Przybyla, 1989). Species *A. amasonica* and not classified yet species growing on the Orinoko river are found most to the north (Ravenna, personal communication). On the Alpine level of the Andes (3.700 m above sea level) Alstroemeria belongs to the plants stabilizing screes (Walter, 1976) (*A. crispata*). The map below shows the genus *Alstroemeria* distribution:

Some species are very widely spread, such as *A. pelegrina* and *A. ligtu*; the others are endemic plants - such as *A. patagonica* and *A. nana* Rendle. There are species that prefer swamps and tropical regions of Brasil, such as *A. campaniflora* or shady Brasilian forest, such as *A. piauhyensis*. The other species adopted to the desert regions of Atacama in Chile, such as *A. polyphylla* and *A. graminea*. The supplay of plants in water is almost completely subordinated to the coastal ocean vapours in this location. One from the most common species is *A. aurantiaca* with yellow flowers. On newly cultivated areas it commonly appear among the wheat.

Several dozen of Alstroemeria species, growing in very differentiated biotopic conditions of South America, constitute a considerable genetic potential, with significant importance for breeding.

History

With Alstroemeria in a special way is connected the name of the French monk, father R.P. Louis Feuillet. From 1707 to 1712 he traveled across South America and he described his observations in two volumes entitled: "Journal of physical, mathematical and botanical observations in the West Indias and South America". In his Journal there are the first descriptions of three species: *ligtu, pelegrina, salsilla* of the plant, which in later times was named by Linnaeus *Alstroemeria*.

Alstroemeria appeared in Europe in 18th century. In 1754 Klas von Alströmer, who studied under the guidance of Linnaeus in Uppsala (Sweden), disembarked in Spain. In the house of the Swedish consul in Cadiz he saw a bouquet of flowers "a certain liliaceous plant of exceptionally rare beauty" (Linnaeus, Amoenitates Academiae). In this city von Alströmer got to know also a noblewoman, that husband sent the aforementioned plants residing in Peru. Alströmer collected seeds from those plants and sent them to Sweden to Linnaeus. Linnaeus, on the base Feuillet's descriptions identified the received plant as *pelegrina,* and for memory of Alströmer named it *Alstroemeria. Alstroemeria pelegrina* is also called Inca's Lily, or Lily of Lima. Feuillet, because of the unusual beauty of this plant, wrote in his Journal, that it was cultivated in the king's gardens of the Incas.

Breeding

Breeding of Alstroemeria was started in Europe. In the beginning it consisted of selection for cultivation of this plant in gardens. First of all plants were chosen, which differed from the mother species in the colour of flowers, vigour of plants or in the number of flowers in the inflorescence. It was not difficult, because wind and insects, transfering pollen from one plant to another produce every now and again new hybrids, often difficult to classify for a species. For almost 200 years Alstroemeria was cultivated in Poland: *A. ligtu* and *A. pelegrina* in the palace gardens (Zamoyski lord of manor gardens, catalogue of 1815) and in England (*A. aurantiaca, A. pelegrina*). In Poland Alstroemeria was known under the name "krasnolica" (beautiful face). Two species: *A. versicolor* Ruiz. et Pav. - "krasnolica róznobarwna" (many-coloured beautiful face) and *A. aurantiaca* D. Don. - "krasnolica pomarańczowa" (orange beautiful face) have been described for the first time in the Polish botanical literature by Polish botanist, professor Edmund Jankowski (XIX century) in his book "Flowers of our Gardens".

In order to obtain a bigger variability, crossing of different species has been started. From the cross *A. pulchella* L. fil. with the other species, hybrid A.x Rembouttii with white, purple spotted flowers was obtained. Hybrids, whose one parent was *A. inodora* or *A. pulchella* (Brasilian species), and the second *A. pelegrina* (Chilean species) were named in England "Butterfly"

type, because of unique beauty of their flowers. This name is used till now. To this type belong Polish cultivars registered in 1993: "Faustina", "Leonor", "Lucia" with white flowers and purple design on their petals, and also the Dutch cultivars, e.g. "Ohio", "Ontario", "Rosario". As the result of breeding work within the *A. aurantiaca* species in 1993 new Polish cultivar was registered: "Margarita" with large, light-yellow flowers with vanilla fragrance, blooming all the year round (Fig. 2).

The first significant achievment in breeding of Alstroemeria, assigned for cut flower production, was cultivar "Walter Fleming" (synonym "Orchid") bred in 1948. It has exceptionally big, beautiful white-yellow flowers. According to the breeder, the cultivar originated from the cross *A. violacea* Phil. and *A. aurantiaca* Don. (Anonymus, 1949). At present, cytogenetic studies are calling in question, if indeed those species were used, because in the past species very often were incorrectly classified (Koorneef, 1972).

Breeding of Alstroemeria to a great extent was carried on by Goemans in England. He started his breeding work after the II world war. Crossing 3 different species, also *A. aurantiaca,* he received in 1959 the cultivar Ballerina with pink flowers, "Parigo's Charm" with pink-yellow flowers and "Parigo's Pride" with bright pink flowers (Goemans, 1962). In the next years he bred "Pink Attraction" and "Pink Perfection" with pink flowers, "Carmen". "Marina", "Pimpernel" with red flowers, and "Sussex Gold" with yellow flowers. The above mentioned cultivars are included to the "Parigo"group. After 1960 those cultivars were introduced to Holland by firm of Wülfinghoff.

In Holland breeding of Alstroemeria was started by the firm of van Staaveren since 1962 and later by Wülfinghoff in cooperation with Goemans. Van Staaveren used in that time species: *A. pelegrina, A. psittacina, A. aurantiaca* and several others bought in England. The result of breeding was the introduction on the market of the following cultivars: Regina, Starosa, Beauty in 1970-71. The red colour of some of van Staaveren cultivars originate from Brasilian species. The cultivars of the firm van Staaveren have the trade name "Vasa".

With time other Dutch firms started breeding of Alstroemeria, such as Könst (cvs La Paz, Paloma, Rio etc.), Cor van Duyn - now called PhytoNova (cvs Ohio,

Fig. 2. "Margarita": Polish cultivar with large, light-yellow flowers with vanilla fragrance, blooming all the year round.

Ontario, Westland etc.), van Zanten (cvs Advendo, Flamengo, Tango etc.), and also private breeders, who sell their cultivars to the well-known horticultural firms.

Besides conventional breeding, consisting in crossing of species, methods of mutational breeding were applied. It was a necessity, because the majority of cultivars cultivated nowadays are sterile and using them for cross-breeding is not possible. First mutational works in Alstroemeia were started in Holland with X-rays (Broertjes and Verboom, 1974). The results of that breeding programme were such cultivars as a.g. "Canaria", "Zebra" (mutants of "Orchid"), "Harmony", "Rosita" (mutants of "Regina").

In 1980 mutational breeding of Alstroemeria was started in Poland, in the Research Institute of Pomology and Floriculture,Skierniewice (Przybyla, 1982). For induction of mutations gamma rays and fast neutrons were applied on over 10 cultivars commonly cultivated in Poland; as well mutants and hybrids were used. There were diploid cvs, e.g. "Orchid" 2n = 16 as well as triploid, e. g. "Regina" 2n = 24. The gamma rays doses ranged from 2.5 to 100 Gy and fast neutrons from 3 to 6 Gy (the unit of radiation dose absorbed in tissue etc. is defined in the present SI system as gray - abbreviation Gy.1 Gy = 1 Joule (J)/kg. In the past the unit rad (radiation absorbed dose) was commonly used (1 Gy = 100 rad)). In March of each year from 1980-1993, actively growing rhizomes were irradiated. After irradiation they were divided in cuttings containing few buds. The source of gamma rays was ^{60}Co and the source of fast neutrons was U-120 cyclotron. In most cases irradiated plant material was observed for two years and mutations were isolated. Mutants with very attractive flowers or other interesting features were cloned. Stable clones were planted on beds in the glasshouse for evaluation of their productivity and usefulness of production.

Among MV_1 shoots grown out from the irradiated rhizomes the following morphological changes were observed: bifurcations, trifurcations, quadrifurcations, growth inhibition, leaf underdevelopment and deformations, and chlorophyll changes (table 1).

The dose increase caused a decrease of normal shoot numbers, an increase of mortality and an increase of mutations (Przybyla, 1992 a). Fast neutrons, especially doses 5 and 6 Gy strongly inhibed plant development and caused a high mortality of plants (table 1). No differences were observed in the spectrum of mutations induced by gamma rays or fast neutrons. In the second year of vegetation the number of mutations was still high (table 1). The most common, depending on cv, were (table 2): mutations of colour of flowers (5 to 80%) and mutations of design on the flower petals (20 to 93%). Less frequent were mutations of flower petal shapes (3 to 63%), enlargement of flower size (2 to 13%), diminution of flower size (4 to 10%). Also mutations of plant vigour, productivity and season of bloom were recorded (Przybyla, 1992 a).

Relatively frequent mutations were back mutations, e.g. "Harmony", mutant of "Regina" mutated to "Regina", "Appelbloesem" - mutant of "King Cardinal" mutated to "King Cardinal". Also "Regina" mutated to "Harmony", "King Cardinal' to "Appelbloesem", "Orchid" to "Canaria". Often "Regina" and "Harmony" gave identical mutants, e.g. plants with yellow coloured flowers. Back mutations occurred at the lowest dose 3 Gy of gamma rays as well as fast neutrons with the following frequency: 2.1 and 5.7% in the first year and 0.3 to 1.7% in the second year respectively (Przybyla, 1992 a).

Based on these experiments it was concluded, that the range of optimal doses for gamma rays for induction of useful mutations was 3-7 Gy. These doses

TABLE 1. Morphological changes of MV_1 shoots and mutations caused by radiation (in %); Harmony cv, 1982.

Kind of radiation	Dose (Gy)	More important morphological changes				Mortality	Mutations of flowers: year of bloom	
		Normal shoots	Bifurcations	Leaf deformations	Chlorophyll changes		I	II
gamma rays	3	36.3	10.2	36.9	15.7	4.8	17.0	1.9
	4	30.2	20.6	50.8	22.2	13.0	13.0	2.0
	5	18.2	18.2	18.2	32.7	7.7	19.5	7.6
	6	14.5	15.9	31.9	17.4	38.3	24.4	3.7
fast neutrons	3	27.5	22.5	40.0	15.0	51.4	19.5	3.5
	4	27.3	9.1	54.5	27.3	78.1	18.0	1.2
	5	-	-	-	-	91.3	11.1	-
	6	-	-	-	-	96.8	-	-

TABLE 2. The frequency of particular kinds of mutations (in %); 1983

Cultivar	Dose (Gy)	Colour of flowers	Design on the flower petals	Shape of flower petals	Enlargement of the flower size	Diminution of the flower size
Harmony	3	26.3	68.4	-	5.3	-
	4	63.6	36.4	-	-	-
	5	44.4	50.0	-	5.6	-
	6	46.3	49.7	3.7	5.6	3.7
	7	32.3	51.6	3.2	3.2	9.7
Mona Lisa	3	33.3	66.7	-	-	-
	4	80.0	20.0	-	-	-
	6	33.3	66.7	-	-	-
	7	5.3	89.5	5.3	-	-
Red Sunset	3	28.6	71.4	-	-	-
	4	7.1	92.9	-	-	-
	6	16.7	83.3	-	-	-
	7	12.5	25.0	62.5	-	-
Regina	3	37.5	50.0	-	12.5	-
	4	25.0	75.0	-	-	-
	5	34.8	30.4	32.6	2.2. -	
	6	27.3	72.7	-	-	-

are generally similar to those suggested by Broertjes and Verboom (1974) for X rays. In the case of triploid cvs Regina and Harmony 50 Gy of gamma rays was a lethal dose (Przybyla, 1992 a).

As the result of mutation breeding the following new cvs were obtained (Przybyla, 1992 b):

Name of the new Polish cultivar	Attributes of the new cultivar	Kind of irradiation	Year of registration	Mother form	Attributes of the mother form
CATALINA	bright violet flowers	gamma rays	1990	sterile, triploid mutant	bright brown flowers
CARLOTA	orange brown flowers with violet blushes on the outer petals	fast neutrons	1993	sterile, triploid mutant	bright brown flowers
INES	salmon-pink flowers, all the year bloom	gamma rays	1990	sterile mutant	dark red flowers
ISABEL	yellow flowers with celadon shadow	gamma rays	1993	sterile, triploid hybrid	pink flowers
JUANITA	orange-red flowers	gamma rays	1990	sterile hybrid	dark red flowers
MATILDE	bright cherry-red flowers	gamma rays	1993	sterile hybrid	dark red flowers
PAULA	pink flowers with violet bluses on the outer petals	gamma rays	1993	sterile, triploid hybrid	pink flowers

Sectorial chimeras were not very frequently found. This generally confirms the statement of Broertjes and van Harten (1988) that nearly all mutants of Alstroemeria seem to be solid. Whether they are homogeneous mutants or periclinal chimeras, so common in vegetatively propagated plants, needs further studies. However, occasionally shoots of the mother cv are found in stabilised mutants (Przybyla, 1992 a). This

phenomenon is probably a consequence of different stresses and indicates that some mutants are periclinal chimeras.

Utilization of mutants for further mutational breeding seems to give new possibilities to obtain the interesting forms that are different from those received from hybrids. Examples for this are cultivars Catalina, Carlota, Ines, being mutants of mutants. This method was also used by Broertjes *et al* (1980) on Chrysanthemum.

Fig. 3. "Juanita" : Polish cultivar with bright orange-red flowers (gamma rays)

Fig. 4. "Catalina": Polish cultivar with bright violet flowers (gamma rays).

Fig. 5. "Carlota": Polish cultaivar with orange-brown flowers with violet blushes on the outer petals (fast neutrons).

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