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Mutation Breeding and its Application in Crop Improvement under Current Environmental Situations for Biotic and Abiotic Stresses

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Abstract: *The envisaged in food production is daunting because of limited available arable land, depleting water resource and varying climatic condition. The difficulties are also compounded by urbanization, salinization, biotic stress, drought and desertification that result in a reduction of arable land. There are different mechanisms for harnessing the heritable variations encoded in the genetic makeup of existing crop plants so as to use them in the crop improvement programs. The incorporation of desired traits from non-adapted landraces/crop wild resources can speed up crop improvement. Among the different strategies to enhance crop improvement programs, induced mutagenesis has contributed immensely by creating mutant varieties with improved and desirable genetic changes in agronomically important traits of the crop plants. Such genetic changes can occur spontaneously naturally at a very low rate or experimentally induced by physical and chemical mutagens. The related with mutation induction mechanisms, Role of mutation breeding in crop improvement and some highlight of mutant varieties, Mutation breeding strategy for obtaining mutants and Economic impact of a new mutant variety were reviewed well.*

Keywords: *Mutation, Breeding, Improvement, Stresses, environmental.*

1. INTRODUCTION

Globally, the current human population is increasing day by day and expected to reach 9 billion by 2050 and that will lead to food scarcity on earth. To overcome this increasing demand for food and proper nourishment, an improvement in food production is urgently needed (Ronald, 2014). The envisaged in food production is daunting because of limited available arable land, depleting water resource and varying climatic condition. The difficulties are also compounded by urbanization, salinization, biotic stress, drought and desertification that result in a reduction of arable land. Moreover, changing climatic conditions and subsequent variations also limit food production (UNEP, 2002).

There are different mechanisms for harnessing the heritable variations encoded in the genetic makeup of existing crop plants so as to use them in the crop improvement programs. The incorporation of desired traits from non-adapted landraces/crop wild resources can speed up crop improvement. Putative parental material can also be induced to mutate so as to obtain new genes that control desired traits for new crop variety development (Suprasanna *et al.*, 2009). Among the different strategies to enhance crop improvement programs, induced mutagenesis has contributed immensely by creating mutant varieties with improved and desirable genetic changes in agronomically important traits of the crop plants. Mutagenesis has become more efficient in combination with advanced molecular biology techniques and in vitro culture methods that result in enhancement of crop improvement/breeding program particularly under the global climate change (Jain, 2010a). Such induced mutagenesis also helps in the mining of new gene alleles that do not occur in the germplasm (Roychowdhury and Tah, 2013).

2. LITERATURE REVIEW

2.1. Mutation Definition

Mutation is a term coined by De varies (1901) upon the appearance of anew phenotype he noted in the common evening primrose (*Oenothera lamarkiana*) to describe the sudden heritable change in the

genotype of an organism; the organisms with such heritable changes are known as mutants (Mba, 2013). Mutation is the ultimate source of all genetic changes which provide the raw material for evolution and it is a valuable approach for improvement of economic characters of plants. Such genetic changes can occur spontaneously naturally at a very low rate or experimentally induced by physical and chemical mutagens (Jain, 2002; 2010a; Mba *et al.*, 2007).

2.2. Spontaneous Mutation

Spontaneous mutations in crop plants occur naturally during adaptations and evolutionary processes at an extremely low rate i.e. 10^{-5}-10^{-8}. This frequency is in adequate for creating variations in the genetic architecture of a crop for improvement of desirable traits (Zhong- hua *et al.*, 2014). Wheat, peas and barley are the notable example of mutants derived through heritable permanent change i.e, spontaneous mutation during the course of domestication. Spontaneous mutation in these plants resulted in eradicated pod or head shattering and the reduction in seed dormancy periods. Other examples of spontaneous mutants include those found in almond, lima bean, watermelon, potato, eggplant, cabbage and several types of nuts (Mba, 2013). High yielding and lodging resistance in wheat varieties were developed by the incorporation of Spontaneously-mutated alleles of the genes that resulted in the green revolution and subsequently secured food for millions of people around the world. Other examples include utilization of dwarf germplasm Dee-geo-woo-gen from china and the release of rice variety IR8 developed in the Philippines by the international rice research institute(IRRI) from a dwarf line (Mba *et al.*, 2012b).

2.3. Induced Mutation

Many phenotypes important in plant domestication and improvement have resulted from human selection for novel alleles of structural or regulatory genes (Olsen and Wendel, 2013). Since the 1920s, plant breeders have taken advantage of physical and chemical mutagenesis to introduce genetic variation (Stadler, 1928). Mechanistically, mutations in plant DNA have the same effect on plant phenotype whether they result from natural or human directed processes. In both cases, gene activity can be altered by nucleotide substitution, the deletion or insertion of DNA sequence, or modification of cis - regulation. Some traits in crop species have been obtained from naturally or deliberately induced mutation s in the same genes. For example, semi-dwarf varieties of rice that enabled the Green Revolution were derived independently from natural and induced mutations in the gene for gibberellin 20-oxidase (Ashikari *et al.*, 2002). In hexaploid wheat, natural and induced mutations in waxy homologs have been combined by breeding to modify starch quality (Dong *et al.*, 2009; Slade *et al.*, 2005). Mutations were first induced in plants with physical mutagens and this methodology has produced the majority of the varieties (77 %) listed in the FAO/IAEA Mutant Varieties Database (Maluszynski, 2001). Physical mutagenesis is most commonly conducted with ionizing radiation produced directly by gamma and X-rays or indirectly by fast neutron bombardment (Roychowdhury and Tah, 2013).

It is generally assumed that gamma radiation causes less chromosomal damage and more point mutations and short deletions compared to X-rays and fast neutrons (Sikora *et al.*, 2011). However, a genome wide analysis of mutations induced by fast neutron bombardment in Arabidopsis thaliana found a higher frequency of novel single nucleotide polymorphisms (SNPs) than deletions (Belfield *et al.*, 2012). The number of possible mutations induced in a gene by EMS can be predicted by its GC content (Harloff *et al.*, 2012). Codon usage, therefore, could affect mutation frequency. In addition to physical and chemical methods, mutations can be induced in plants through the introduction of active transposable elements, such as mPing (Hancock *et al.*, 2011).

2.3.1. Chemical Mutagenesis

Induction of mutations by chemical agents was attempted by many people over a long period, but there were no clear or convincing positive results until 1939 when Thom and Steinberger found that nitrous acid was effective in causing mutations in Aspergillus. The work of (Altenburg and Browning, 1961) and (Muller *et al.*, 1961) argues strongly in f'avour of mutation involving a change in al1 already existing gene. Multiple markers were used which enable themosaic or fractional individuals to be scored reliably. Chemical mutagens were found to be highly effective in inducing true gene mutations and the specificity of action could be investigated through analysis of their reaction with

different DNA bases. Chemical mutagenesis has become a widely adopted approach because it does not require special facilities and the resulting mutations are primarily SNPs. Ethyl methane sulfonate (EMS) is currently the most commonly used chemical mutagen , but methylnitrosourea, sodium azide,diethyl sulfate and diepoxybutane have also proven effective (Sikora *et al*., 2011). The modes of action of a chemical can influence the mutations induced. For example, EMS selectively alkylates guanine bases, leading primarily to GC to AT transitions (Greene *et al*., 2003).

Development of high-yielding peanut mutants through chemical mutagenesis of flower injection of ethyl methane sulfonate (EMS). Many authors reported that through injection of 0.3% EMS into flowers of Huayu 16 and subsequent selection, it was able to develop a high yielding peanut cultivar - Huayu 40 (wang *et al*., 2010, wang *et al*., 2011). The improved variety, Huayu 40 has an erect growth habit and sequential branching pattern. As compared with its wild type (Huayu 16), Huayu 40 possesses faster growing and darker green foliage (Wang *et al*., 2011). In addition, (Wang *et al* ., 2010) also reported that leaf water content, chlorophyll a and b content of Huayu 40 were significantly higher than those of Huayu 16. Mutagenesis through EMS yielded a very high frequency of mutants for intraspecific differentiation in groundnut (Gowda *et al*., 1996). Improvement in seed yield and its components through induced mutation have also been reported in chickpea and mung bean (Kharkwal *et al*., 2005; Khattak *et al*., 2007). "Golden" manifested improvement in the form of increase in seed size and pods per plant. Large seeded mutant breeding lines was also detected in the "Georgia Browne" cultivar of peanut (Branch, 2002). Earlier many seed coat colors have been identified through induced mutations in groundnut (Suvendu *et al*., 2007). A number of workers (Mashenkov, 1986) have reported the role of chemical mutagens in enhancing genetic variability in higher plants because it is the fundamental characteristics to successful breeding programs in vegetative and sexually propagated plants (Kleinhofs *et al*., 1978).

2.3.2. Physical Mutagenesis

Physical mutagens include electromagnetic radiation, such as gamma rays, X-rays and UV light and particle radiation such as fast and thermal neutrons, ß and alfa particles. The mutagenic efficiency of physical mutagen depends not only on the properties of the physical agent, but also on the genotype (Ramanathan, 1979). On gamma irradiation of small seeded, high yielding and disease resistant variety Georgia Brown several large-seeded lines with high variability for disease incidence, pod yield, total sound matured kernels, pod weight, seed weight and seed size distribution were isolated (Branch, 2002). Early maturing types have been obtained on mutagenesis and in crosses involving mutants (Mouli and Kale, 1982). Studies on induced mutation in groundnut were first carried out by X rays by some scientists. Few physical mutagens had been tested for groundnut mutagenesis during the past 50 years. The recommended optimum doses could vary significantly from one study to another since mutagenic effect can be influenced by genetic susceptibility and its physiologic status. The successful dose for groundnut varies from 100-450Gy, both for X and gamma rays. Several mutagens have been tried and proven to be capable of inducing mutations in groundnut. Gamma rays have so far been the most widely used mutagen; more than 80% of the mutant varieties were developed from mutants induced through gamma irradiation (http://www-mvd.iaea.org). According the FAO/IAEA Mutant Variety Database (http://www-mvd.iaea.org) from the total number of registered mutant varieties, a number of 71 varieties are only for Arachis hypogaea species. From these, by physical mutagenesis it were obtained 65 varieties: 10 varieties (X-rays), 41 (gamma rays), 12 (beta rays) and 2 varieties with laser influence. Physical mutagens include radiations such as α-rays, β-rays, fast neutrons, thermal neutrons, X-rays, Y-rays, and ultraviolet radiation.

2.4. Role of Mutation Breeding in Crop Improvement and Some Highlight of Mutant Varieties

2.4.1. Genetic Enhancement of Rice

The impact of induced rice mutants in applied research is best exemplified by the development of improved rice varieties through mutation breeding. The first rice varieties KT 20-74 and SH 30-21, developed through induced mutation, were released in China in 1957 and the first variety Yenhsing-1, developed by a cross- breeding programme with a mutant (Rutger, 1992). Soon afterwards, the semi dwarf mutant Reimei was released in Japan which have significantly increased yield because of their lodging resistance. Calrose 76 and Basmati 370, semi dwarf varieties of rice with short and stiff straw have revolutionized the rice production in USA and Pakistan respectively. In Pakistan, anew variety

'Kashmir Basmati' which matures early and has cold tolerance, and retains the aroma and cooking quality of the parent, was derived from induced mutation in Basmati 370 (Awan, 1991). Several high yielding rice mutants were released in India under the series PNR and some of these were early in maturity and had short height (Chakrabarti, 1995). Among these, two early ripening and aromatic mutation-derived rice varieties, 'PNR- 381' and 'PNR- 102', are popular for cultivation in Haryana and Utter Pradesh. A Rice mutant, 'Zhefu 802' was cultivated on more than 10.6 million ha in China in a span of ten years. In Thailand, gamma ray irradiations expedite the release of an aromatic indica variety of rice 'RD6'in 1977. It was extensively grown on 2.4million ha during the year 1994-95. Similar mutant 'RD15', released in 1978, was grown over 0.2 million ha, equivalent to 3.2% of the area under rice (Anonymous, 1995). In Australia nine rice mutant varieties 'Amaroo' (1987), 'Bogan' (1987), 'Echua' (1989), 'Harra'(1991),'Illabong' (1993), 'Jarrah' (1993), 'Langi' (1994), 'Millin' (1995) and 'Namaga' (1997) have been developed. The induction of thermo sensitive genic male-sterile (TGMS) mutant in Japonica rice mutant PL-12, which is controlled by a single recessive gene has an immense contribution in designing the strategies for the production of hybrid rice varieties (Maruyama *et al*., 1991).

2.4.2. Developing Draught and Salinity Tolerance in Wheat Crop

'Sharbati Sonora', a semi dwarf and non-lodging mutant variety has made a significant contribution to wheat production in India. 'Sharbati Sonora' produced from red grained Mexican variety 'Sonara 60' by gamma irradiation at the Indian Agriculture Research Institute, New Delhi, India. A high yielding mutant Stadler, developed in Missouri, USA had resistance to leaf rust and loose smut, better lodging resistance and early maturity (Anonymous, 1977). In Italy Durum wheat cultivation area was significantly expanded due to the cold tolerant mutant varieties.

2.4.3. Enhancing Lodging Resistance in Barley Crop

Mutation breeding has been very successfully used in breeding barley, the introduction of 'Diamant' and 'Golden Promise' a gamma-ray induced semi-dwarf mutant revolutionized brewing industry in Europe. A large number of barley cultivars were developed from crosses involving 'Diamant' in Europe. Since decades these high yielding mutants have been used as the parents of many leading barely varieties released in Europe. Centenario, high yielding, high protein content, early maturity and resistance to yellow rust, was released in 2006 contributes significantly to the food security of the country (Gomezpando *et al*., 2009). 'Luther', gamma ray induced mutant had 20% increased yield, higher tillering and lodging resistance and 'Pennrad', had winter hardiness, better lodging resistance and early ripening (Anonymous, 1977).

2.4.4. Developing Early Maturing Varieties of Peanut

Several peanut mutants (Yueyou No. 5, Yueyou No. 22, Yueyou No. 33, Yueyou 551, Yueyou 187) induced with gamma radiation were released in China as high yielding varieties under the series 'Yueyou', some (Changua No. 4, Lainog, Yueyou 551-38 and Yueyou 551) of those were early in maturity with improved yield. A Mutant peanut variety 'TG 26' developed at Bhabha Atomic Research Centre, Bombay. It is a semi-dwarf plant habit, early maturity, compact pod setting, greater pod bearing, higher harvest index and field tolerance to major diseases (Kale *et al*., 2007).

2.4.5. High Yielding and Wilt Disease Resistant Chickpea Mutants

A series of High Yielding and Wilt Disease Resistant Chickpea Mutants such as Pusa – 408 (Ajay), Pusa – 413 (Atul), Pusa – 417 (Girnar), and Pusa – 547, developed at I.A.R.I., New Delhi, are based on the direct use of induced micro-mutants in a legume crop in the world. Mutant variety Pusa – 547, released in 2006 has thin testa, attractive bold seeds, better cooking quality and high yield performance under late sown conditions of North-Western region of India (Kharkwal *et al*., 2005; Kozgar and Kans, 2009).

2.5. Mutation Breeding Strategy for Obtaining Mutants

Any mutation breeding strategy requires several sequential steps. The first step in mutation breeding is to reduce the number of potential variants among the mutagenized seeds or other propagules of the first (M1) plant generation to a significant level to allow close evaluation and analysis. Determination of the target population size in the first generation of mutants is a prerequisite for potential success in

any mutation breeding programme. The targeted population should be fixed so as to allow a high number of mutation measurements. Thus, the population size should be managed effectively by the breeder. It should be noted that the population size depends on the inheritance pattern of the target gene (Roychowdhury and Tah, 2013). Therefore, it is advisable to select mutagens that give a high mutation frequency so as to reduce the population size of the M1 generation. Genetically, Ml mutant plants are heterozygous. This is because only one allele is affected by one mutation during treatment. However, the probability of having a mutation on both the alleles concurrently is a product of individual probability of mutation. Moreover, in Ml, only dominant mutations can be identified, while it is impossible to identify a recessive mutation expression at this stage. In this case, a plant breeder should attempt screening mutations in subsequent generations where segregation will occur (Roychowdhury and Tah, 2013). Caution should be taken to prevent cross pollination among the M1 population as this would lead to generation of new variation which will be difficult to differentiate from the effect of mutation (Roychowdhury and Tah, 2013, Roychowdhury *et al*., 2011). Screening and selection start in the M2 generation and discuss three main types of screening/selection techniques. These are physical/ mechanical, visual/phenotypic and other methods. Physical or mechanical selection can be used efficiently to determine the shape, size, weight, density of seeds, etc., using appropriate sieving machinery. Visual screening is the most effective and efficient method for identifying mutant phenotypes. Visual/phenotypic selection is often used in selection for plant height, adaptation to soil, growing period, disease resistance, colour changes, earliness in maturity, ion-shattering, climate adaptation, etc. In the category of 'others', physiological, biochemical, chemical, physiochemical procedures for screening may be used for selection of certain types of mutants (Roychowdhury *et al*., 2012).

When a mutant line appears to possess a promising character, the next stage is seed multiplication for extensive field trials. In this case, the mutant line, the mother cultivar and other varieties will be tested. Prior to release as a commercial variety, the promising mutant should be studied for combinations of different characters like growth habit, structure and yield components in a wide range of environments under varying water availability, plant density, sowing dates, etc. (Roychowdhury and Tah, 2013).

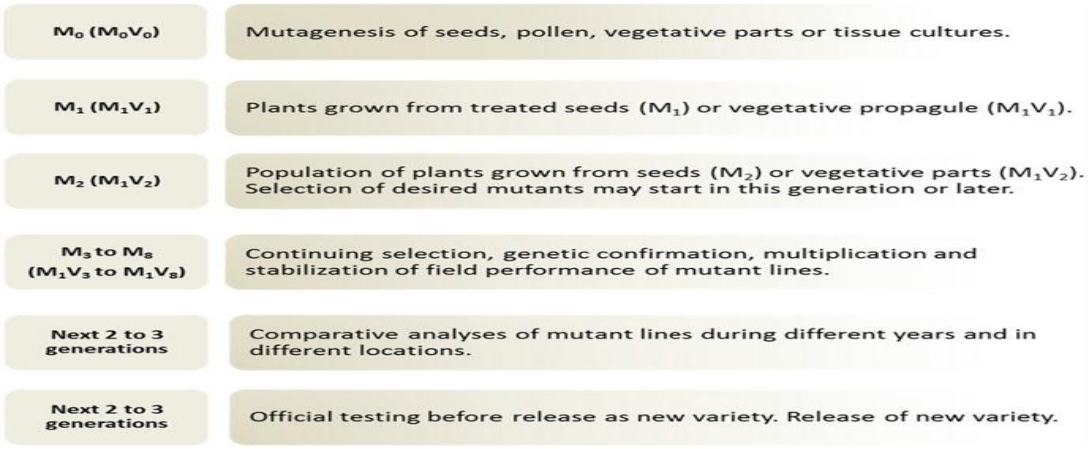

Fig1. *Traditional mutation breeding scheme. Each row describes the steps for a specific generation*

The generation nomenclature starts with M0 for seed or pollen mutagenesis and M0V0 for vegetative organs, where M stands for the meiotic and V for the vegetative generation. All materials are labelled with a '0' prior to mutagenesis and with a '1' after mutagenesis is performed. The first generation is not suitable for evaluation when multicellular material is mutagenized because resulting plants will be genotypically heterogeneous (chimeric). The first non-chimeric (homohistont) generation in a seed-mutagenized and seed-propagated material is the M2. It may take several cycles to make a vegetatively propagated material genotypically homogeneous and to stabilize the inheritance of mutant alleles. Screening and selections can begin as early as the first non-chimeric generation. Subsequent generations typically involve selection and evaluation of mutant phenotypes to ensure that the traits are reproducible. Once this is complete, the materials can enter trials for varietal release. Alternatively, materials can be used as parents in breeding programmes. Officially released mutant

crop varieties which are reported to the Joint FAO/IAEA Programme are recorded in the searchable Mutant Variety Database (MVD 2016).

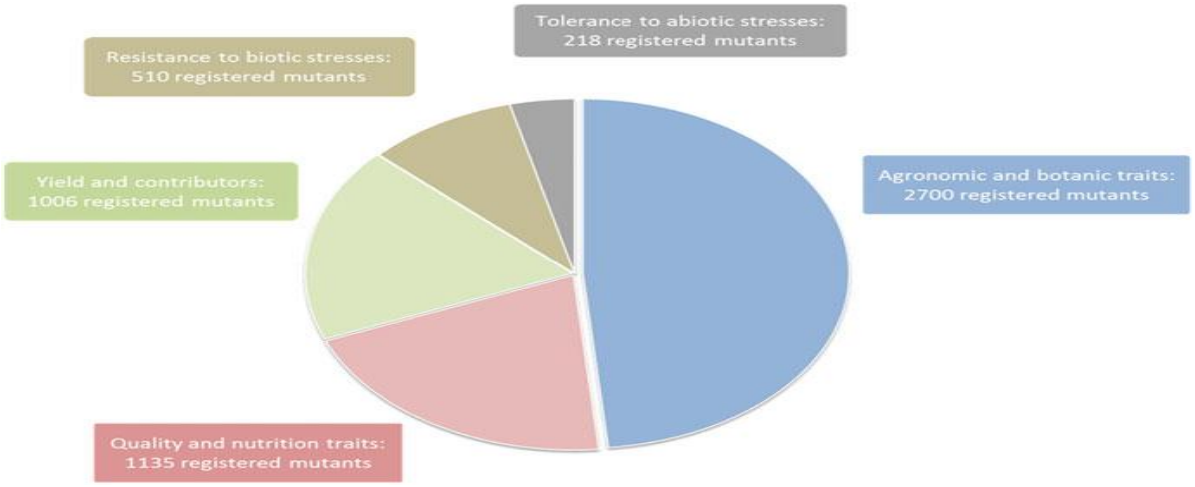

Fig.2. *Mutants registered in the MVD classified according to improved characters (traits*).

Source: *Jankowicz et al., 2017*

In total, improved characters are described 5569 times for 3222 varieties. These are classified in five general categories: 'agronomic and botanic traits' (48 %), 'quality and nutrition traits' (20 %), yield and contributors' (18 %), 'resistance to biotic stresses' (9 %) and 'tolerance to abiotic stresses' (4 %). Agronomic and botanic traits include maturity, flowering time and plant structure.

Table1.*GM crop research in Africa*

Country	Crop	Traits	Institution undertake	Status
Cameroon	Cowpea	-	IARD*	Laboratory
Egypt	Barley	Abiotic stress tolerance	AGERI	Laboratory
	Cotton	Heat and salt stress tolerance Bt	AGERI	Laboratory
	Maize	Bt	AGERI/Pioneer	Laboratory
	Melon	Virus resistance	AGERI	Field test
	Potato	Tuber moth resistance	AGERI	Field test
	Squash	Virus resistance	AGERI	Field test
	Tomato	Virus resistance	AGERI	Field test
	Wheat	Salt and drought tolerance	AGERI	Laboratory
Ethiopia	Noog		Addis Ababa University	Laboratory
	Tef		AddisAbaba University	Laboratory
Kenya	Cotton	Bt	KARI/Monsanto	Laboratory
	Maize	Bt	KARI/CIMMYT/Novartis	Application
	Maize	Herbicide resistance	KARI/CIMMYT	Laboratory
	Sweet Potato	Virus resistance	KARI/Monsanto	Field test
Morocco	Tomato			Field test
Nigeria	Cowpea	Virus and insect resistance		-
South Africa‡	Barley	Malting	CSIR	-
	Cotton	Bt cotton	Monsanto	Commercial
	Cotton	Herbicide resistance	Monsanto	Commercial
	Maize	Disease resistance, drought tolerance	University of Cape Town	Laboratory
	Maize	Bt	Monsanto	Commercial
	Maize	Disease resistance, drought tolerance	ARC Roode plaat°	Field test
	White Maize	Disease resistance	CSIR	Field test
	White Maize	Bt	Monsanto	Commercial
	White Maize	Bt	Pioneer, Pannar	Field test
	Millet	Lysine and methionine content	CSIR	Laboratory
	Ornithogalum	Virus resistance	ARC Roodeplaat	-

	Potato	Virus resistance, drought tolerance	ARC Roodeplaat	Field test
	Sorghum	Enhanced protein	CSIR	Laboratory
	Soya bean	Drought tolerance	ARC Roodeplaat	-
	Soya bean	Herbicide resistance	Monsanto	Commercial
	Sweetpotato	Disease resistance	ARC Roodeplaat	-
	Tomato	Delayed ripening, virus/disease resistance	ARC Roodeplaat	-
	Wheat	Herbicide resistant	Monsanto	-
Tunisia	Potato	-	-	-
Uganda	Banana	Black sigatoka disease, nematode, and weevil resistance	NARO/IITA§	Field test
	Cassava	Starch content	Makerere University	Laboratory
	Cotton	Bt	Monsanto	Application
	Maize	Drought tolerant and striga resistant	NARO	Laboratory

‡ Crops not listed in the table that South Africa is pursuing GE research on include lupins, sunflowers, sugarcane, cucumbers, ornamental bulbs, cassava, apricot, strawberry, peach, apple, table grapes and banana.

** Institute of Agricultural Research for Development*

º Agriculture Research Centre Roodeplaat

§ National Agricultural Research Organization/International Institute of Tropical Agriculture

Source: Devlin, 2002

2.6. Economic Impact of a New Mutant Variety

The economic value of a new variety can be accessed from several parameters. These include: Area planted to the variety and percentage of the area under the crop in the region; increased yield; enhanced quality; reduced use of pesticides and fungicides; savings in water (short duration of growth and drought tolerance); increased land use through early maturity to facilitate crop rotation; improved/intensified cropping systems with changed maturity or response to photoperiod; improved processing quality and value of the products (e.g., oil, starch, malt, beer and whisky); quality preference by the consumer (new flower and foliage colour in ornamentals, skin and flesh colour in root and tuber crops and fruit crops, aroma and glutinous nature in rice, and kernel colour in wheat); increased nutritive value, high lysine and vitamins, increased oil-shelf life, reduced toxins; increased yield of essential oils; new specialty and designer crops; ease of harvest, threshing; increase in export earnings; reduction in imports(Nichterlein *et al*.,2004**)**.

Table2. *Economic impact of mutant varieties*

Crop	Country	Mutant variety	Basis of value assessment	Value or area
Cereals				
Rice	Thailand	RD6 and RD15	Total crop value at farm gate for the period 1989–98	US$ 16.9 billion
	China	Zhefu 802	Cumulative planted area between 1986–1994	10.6 million ha
	Japan	18 varieties	Total crop value in 1997	US$ 937 million
	India	PNR-102 and PNR-381	Annual crop value	US$ 1,748 million
	Australia	Amaroo	Current annual planted area	60–70% rice growing area in Australia
	Costa Rica	Camago 8	Current annual planted area	30% rice growing area in Costa Rica
	Vietnam	TNDB100 and THDB	Total planted area in 1999	220,000 ha
	Myanmar	Shwewartun	Total planted area in 1993	800,000 ha
Bread wheat	Pakistan	Jauhar 78, Soghat 90 andKiran 95	Additional income to farmers during 1991–99	US$ 87.1 million

Durum wheat	Italy	Creso	Additional income to farmers during 1983–93	US$ 1.8 billion
Barley	UK-Scotland	Golden Promise	Crop value (1977–2001)	US$ 417 million
	Numerous European countries	Diamant and derived varieties	Area planted in 1972	2.86 million ha
Legumes				
Chickpea	Pakistan	CM 88; CM 98	Additional annual income to the growers	US$ 9.6 million
Blackgram (urdbean)	India, Maharashtra State	TAU-1	Value of increased production in season 1998–1999	US$ 64.7 million
Oil and industrial crops				
Cotton	Pakistan	NIAB-78	Total value of crop from 1983–1993	US$ 3 billion
		NIAB-78	Additional income to growers from 1983 onwards	US$ 486 million
Sunflower	USA	NuSun_	Grown area in 1994	50,000 ha
Fruit trees				
Japanese pear	Japan	Gold Nijisseiki	Additional annual income to growers	US$ 30 million
Grapefruit	USA, Texas	Rio Star	Grown area (year 2000)	7,300 ha (75% of total area)

Source: *Nichterlein et al.,2004*

3. Summary And Conclusion

World agriculture sustainability is threated by increasing human populations, reduced availability of cultivated land and changing climate patterns. Plant mutation breeding is a major component in addressing these concerns in developing novel germplasm in a relatively short time. Mutation breeding is one of the breeding methods used in improving crop plants for human benefit. Different types of mutation breeding were used in the improvement of crop plants. Physical mutagenesis like electromagnetic radiation, such as gamma rays, X rays and UV light and particle radiation such as fast and thermal neutrons, ß and alfa particles have been used so far. Out of this physical mutagenesis, radiation was the most commonly used mutagen in improving the crop. Chemical mutagens like of ethyl methane sulfonate (EMS), treatment of seed with sodium azide (NaN3), diethyl sulphate (DES) were also used in improving crop plants. Chemical mutagens are widely used in enhancing genetic variability in higher plants because it is the fundamental characteristics to successful breeding programs in vegetatively and sexually propagated plants. Induced mutagenesis has played an important role by creating several mutants in different crop plants. These mutant varieties with specific character/trait such as high yield, resistance to biotic and abiotic stresses, have been grown globally bringing a significant positive economic impact and contribute to global food and nutritional security and improved livelihoods. Despite the available mutant resources, challenges still lie ahead to feed an ever-increasing population. To speed up crop production, mutant resources for different crop plants have to be established which can be used to create new mutant cultivars which are high yielding, resistant to biotic and abiotic stresses , enhanced uptake of specific metal, deeper rooting systems and modified oil, starch and protein content that can boost industrial processing.

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