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Mutation Breeding- A Tool to Achieve Sustainable Development

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ABSTRACT

Sustainable Development (SD) has got a great attention in the present dynamic environment and has changed the outlook and way of thinking of people worldwide towards the subject. The focus is on the optimum utilization of limited resources with a great concern for the future generation/s. In this background, the present paper highlights the SD goal-2 "End hungers, achieve food security, improve nutrition, and promote sustainable agriculture". For the attainment of this goal, the nations across the globe are putting together a lot of efforts. Significantly, it depends on the integration of modern technology with agriculture. As long as world population is showing an increasing trend, the threats to the food security would consistently be imposed. Mutation breeding across the globe has played a role in fighting against the hunger and malnutrition by improving the crop varieties for the traits like yield, adoptability in varying and stressful environments, resistance to diseases with nutritional enhancement and modifications in oil, protein and starch quality. In this direction, the present paper also evaluates the various mutagenic crops and to what extent they have been able to address the SD goal-2.

***Key words:* Mutation Breeding, Mutagenic Crops, & Sustainable Development.**

I.INTRODUCTION

Sustainable Development (SD) is the development that meets the needs of present without compromising the ability of future generations to meet up their own needs. Inside, it contains two important concepts; concept of need in meticulous, the vital needs of the world's deprived, to which the overriding precedence should be given and the thought of curb imposed by state of technology and societal organizations on environments ability to meet present and future needs. SD is a system approach to growth and development and to deal with natural produced and social capital for the wellbeing of their possess and future generations. The term SD as used by UN incorporates both issues linked with land development and border issues of individual development such as education, public health and standard of living. In 2015, UN general assembly formally adopted 20 to 30 items for sustainable development with a set of seventeen sustainable development goals built on Millennium Developmental goals previously set in 200 AD. These goals are adopted by all 193 member states of UN to be implemented and achieved in each country from year

2016-2030, aiming at ending the severe poverty, caring the earth and ensuring the wealth/prosperity for every one by 2030 [1].

Fig-1. Comparing MDGs & Proposed SDGs

MDGs	Proposed SDGs
1.Eradicating extreme poverty & Hunger.	Goal 1: End poverty in all forms. Goal 2: End hunger, achieve food security and improved nutrition, and promote sustainability agriculture. Goal 3: Ensure healthy lives and promote well-being for all at all ages.
2. Achieve Universal primary education	Goal 4: Ensure inclusive & equitable quality education & Promote lifelong learning opportunities for all. Goal 5: Achieve gender equality & empower all women and girls.
3. Promote gender equality & empower women	Goal 6: Ensure availability and sustainable management of Water and sanitation for all. Goal 7: Ensure access to affordable, reliable, sustainable and Modern energy for all.
4. Reduce child mortality.	Goal 8: Promote sustained, inclusive and sustainable economic growth, full productive employment and decent work for all.
5. Improve maternal health	Goal 9: Build resilient infrastructure promotes inclusive and sustain industrialization and foster innovation. Goal 10: Reduce inequality within and among countries. Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable.
6. Combat HIV/AIDS, malaria and Other diseases.	Goal 12: Ensure sustainable consumption and production Patterns. Goal 13: Take urgent action to combat climate change and its impact.
7. Ensure environmental sustainability	Goal 14: Conserve and sustainably use the ocean, seas and marine resource sustainable development. Goal 15: protect, restore and promote sustainable use of terrestrial ecosys sustainably mange forests,
8. Develop a global partnership for development	combat desertification, and halt and reverse land degradation and biodiversity loss. Goal 16: promote peaceful and inclusive societies for Sustainable development, provide access to justice for all and build effec

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	accountable and inclusive institutions at all levels. Goal 17: Strengthen the means of implementation

Source: UNSTT (2012), Realizing the future we want: A report to the Secretary General, New York: UN

MDGs: Millennium Developmental Goals SDGs: Sustainable Developmental Goals.

In this paper, our focus will remain on role of mutation breeding in achieving sustainable developmental goal 2 "End hunger, achieve food security, improved nutrition and promote sustainability agriculture".

This goal seeks a sustainable solution to the existing hunger in the world in all its forms by 2030 and to achieve food scarcity. The aim is to ensure that every one , everywhere has enough good quality of food to live a healthy life.

The struggle against hunger has seen some development over the last 15 years. The ratio of malnourished people declined from 15% to 11% from 2000-2002 to 2014-2016. Still more than 790 million people lack regular access to food [2]. Besides the food that is nutritionally sound is accessible to those, who live in the developed world while as the rural people who live in the developing countries usually remain deprived of it. They usually feed on the repetitive diet in which a single crop usually rice predominates [3]. If such trends persist, zero hunger targets would largely be missed by 2030. Not only have this additional two billion people who are expected by 2050 been to be nourished with the present 815 million hunger. Let us have a brief look on some of the globally observed facts:

- One in the nine people in the world today is hungry.
- The huge bulk of the world's hungry people exist in the developing countries, where 13% population is malnourished.
- Asia is the continent with most hungry people accounting to 2⁄3 of the total.
- Out of the total 280 million under nourished people of Southern Asia, Indian population accounts 39% of the total hunger record in it..
- Malnutrition is the prime cause of deaths amongst children, wherein 3.1 million children die each year, with 57% children deaths under five.[4]
- One in four children in the world suffers from retarded growth. However in developing countries the proportion can rise to one in three.
- Across the developing countries, 65 million children in primary school attend classes hungry.
- 50% of women in India between the age of 14-48 years of age are anemic , followed by China, Pakistan ,Nigeria and Indonesia [5].
- Over 75% of infants and young children do not get minimum dietary diversity.
- Each year vitamin A deficiency victimizes 3 million pre school children causing eye damage in them. Of these around 1⁄2 million become blind and 2⁄3 million would die shortly afterwards [3].

When we look at the challenges in front of us, one needs to consider that besides providing food security to 9 billion people on earth by 2050, we have to meet the varying food needs also. It is not meeting the hunger demands of explosive human population but also feed them differently. How can we grow, and consume our food, has a significant impact on the global hunger. Farming and forest could be a smooth source to meet the needs of the worldwide population. We cannot deny the agriculture/farming is the largest employer in the world employing 40%

of its population. In India, agriculture accommodates 54.6% of its total workforce that contributes India's 15% of GDP. Thus the govt. of India has prioritized on strengthening the agriculture through irrigation, crop insurance and superior varieties. But the big question is still there that, "would it end the hunger"? For our soil, forests, oceans, freshwater and the biodiversity all is rapidly debasing. Climate change is putting up a pressure on the resources we depend on and more challenges to the food growers. Escalating risk by the disasters like droughts, floods and wide spread diseases on crops have come up more swiftly. People engaged with agriculture face a psychological chaos migrating from rural areas to urban for new opportunities. Agriculture land is now converted in horticulture practices to avoid low yield, leaving the targets of sustainable goal 2 still challenging. Further , low agriculture yields have led Indian formers to go for suicide than to bear the losses and the hunger. Thus raising the yield of the agricultural crops and enhancing the quality of the food by virtue of the nutritional components that include acids, proteins, fatty acids etc in it are equally important. The aged conventional practices/methods in agriculture have failed in combating the rapid environmental changes. They would never allow us to meet the targets as set by the SDGs, not only by 2030, but never. But we have always reasons to be hopeful .At one time in 1960, a common fear of global scarcity, deprivation , mass starvation, and collapse in social order amongst the large number of population was predicted to occur on earth by the academicians, policy makers and all because the world population had just crossed 3-billion people [6]. But that did not happen actually. It was the outstanding contribution of Dr. Norman Borlaug in the field of scientific research to bring green revolution to the world.

II.ROLE OF MUTATION IN CROP IMPROVEMENT

Genetic variation is the spine, which plant breeding requires producing novel and improved crop cultivars. Providentially, mutation breeding gives us hope to generate food crops that are high-quality in yield, nutritionally enhanced to improve the content as well as the bio-availability of essential nutrients. They also produce crop varieties that are disease resistant, drought resistant and salt tolerant.

As the role and profusion of variations of transgenic crop in human food systems and their effect on ecology, human health and agriculture biodiversity is better understood and well documented but the role of mutagenic plants and their role in human food systems is less understood. One of the journalist writes in New York Times as "though poorly known radiation breeding has produced thousands of useful mutants and a sizable fraction of the world crops including varieties of rice wheat, barley, pears, peas, cotton, sunflower, peppermint, peanuts, grape fruits, sesame, bananas, sorghum and cassacava "[7]. Canada poses the regulations and testing to mutagenic crops same as to the crops obtained through genetic engineering [8,9]. In contrast to the commercial plant varieties or germ plasma, that has restrictions on their use, the mutagenic varieties should be freely be made available for plant breeding [10]. Unlike to genetically modified crops which typically involve insertion of one or two target genes, the plants developed through mutagenic processes are improved with random, unspecified and multiple changes [7], though have been discussed as a matter of concern [11], but still not prohibited by any nation's organic standards. UN-National Academy of Science reports that there is no scientific justification for prohibiting mutagenically bred crops and regulating the genetically engineered crops [12].

Several organic foods that are developed through chemical and physical mutagenesis are promoted by various food and seed companies [13]. The companies which would otherwise ban the marketing of GM-crops would market their use like branded wheat and other mutagenically developed varietal strains without any mention of their genetic manipulation [13]. These organic products like wheat and barley are particularly used by these companies for the production of organic beers. Mutagenically produced grape fruits are directly sold to the consumers without any fear. Unlike GM-products, the end products of mutation breeding do not have alien genes.Thus, leaving no issues detrimental to human health, bio safety and public acceptance. Mutation breeding therefore, has worldwide acceptance [14].

Mutation breeding which is natural process to bring about the heritable changes in the characteristics of an organism to create new variants (alles). Natural selection that operates to bring out the evolution of new species is caused by natural mutations and then further amplified by subsequent recombinations of genes during hybridization and sexual reproduction. Crop improvement programmes through induced mutation were initiated around nine decades back. Since then 3250 mutant varieties belonging to about 175 plant species that are officially registered with FAO/IAEA, have been developed and released worldwide [14] for crop improvement that includes 1468 varieties in cereals and 370 verities of legumes. In cereals maximum cultivars were released from rice (434), Barley (269) and Wheat (197) [15] .Of the total mutant varieties developed globally, 776 mutants have been induced for nutritional quality (www.mdv.iaea.org). The first disease resistant mutant was reported in Barley as early as 1942 [16] that sparked the desire amongst the scientists to work on mutagenesis to release further mutagenically improved crop varieties.

Ever since the discovery of mutation effects of X-rays [17], the mutation breeding has proved to be a potential and unparalleled technique for the improvement of crops. New and advanced techniques in the mutation induction though have come up but every time they have served the basic cause of the crop improvement for providing the sustainable nutrition ,food security ,enhancing the nutritional quality and to help the ever increasing demands of population .The heritable variability caused by the mutations also helps to overcome the general decline in the genetic diversity that has been occurring continuously in the crop species.

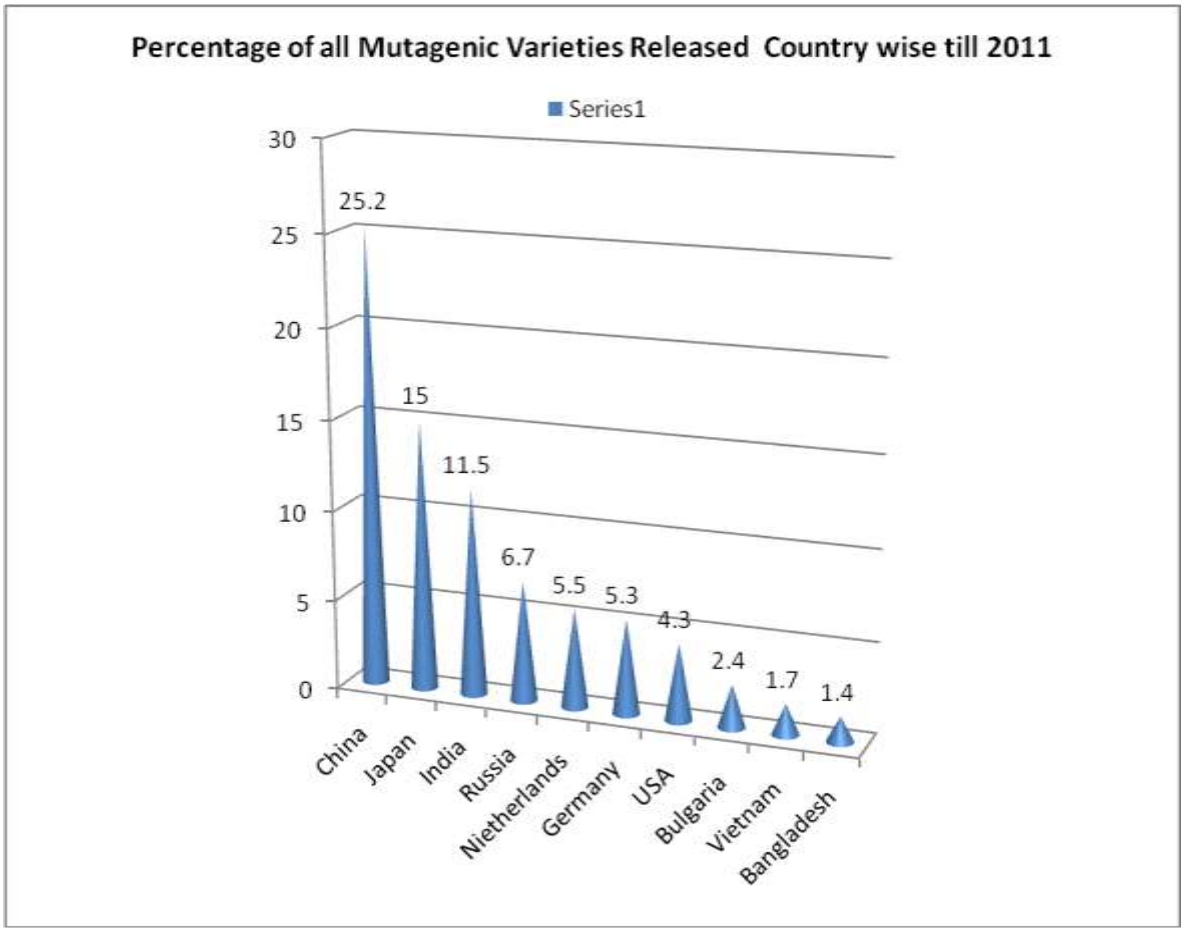
Collaborative research programmes by FAO/IAEA have been focusing on crop improvement by induced mutations using nuclear techniques [18], with the intention to produce varieties of cereals with high concentration of micronutrients and improvement of their bioavailability by reduction in the concentration of phytic acids [19]. .

III.ACHIEVEMENTS IN THE FIELD OF MUTATION BREEDING

Rice and Wheat has been a special focus of mutation breeders. Over the last fifty years some 800 improved varieties of rice have been released globally either directly through mutation or by crossing these mutants with other breeding lines [20]. KT 20-74 and SH 30-21 are the first rice varieties to be developed and released in China in 1957. Then Yenhsing-1 was developed through cross breeding programme with a mutant [21]. Zhefu 802, a gamma irradiated rice mutant besides being a high yielding even in the poor conditions is resistant to rice blast also. It was the most widely planted rice variety between 1986-1994 in Republic of China [22].This variety gained so popularity in the country that within a short span of 10 years, it was cultivated over more than 10.6 million hectares of land. Five rice giant embryo mutants that are characterized by enlarged embryo than of its wild type were found to have increased protein, vitamin B1,B2,E and essential amino acids like arginine, aspartic acid , glutamic acid ,lysine, methionine and mineral elements such as calcium ,iron, potassium, phosphorus and zinc [23]. Japan released a semi dwarf rice variety “Reimi” that is a potential lodging resistant and high yielding mutant [24]. Most rice varieties grown in Japan and the world elsewhere have the sd1 mutant allel .Calrose-76 and Basmati-370 which are also semi dwarf varieties of rice were developed and released in USA and Pakistan respectively. These varieties though revolutionized the production of rice in their respective countries [20] but the apprehensions of loosing the genetic diversity in the world rice varieties because of the repeated and excessive use of the same mutant allel are foreseen .

In India, several high yielding mutant varieties of rice were released under the series of PNR by IARI,New Delhi during 1970s and 1980s.These mutants being high in yield are short and early in maturity [25].This series provides us the PNR-381 and PNR-162 that are two aromatic and early ripening varieties of rice popularly cultivated in Haryana and Uttar Pradesh [24]. Similarly gamma irradiated varieties of rice RD-6 and RD-15 released in Thailand in 1977 and 1978 were cultivated extensively on 2.4 million hectares and 0.2 million hectares of land respectively during 1994-95. RD-6 which is an aromatic variety has a valuable glutinous endosperm and RD-15 is an early ripening variety. Thailand is the largest exporter of aromatic rice in the world [20]. PL-12,a Thermo sensitive Genic Male Sterile(TGMS) mutants of Japonica rice is controlled by a single recessive gene has a huge contribution for the production of hybrid rice varieties [26]. Australia did a remarkable job of releasing nine rice varieties in a short span of one decade that gave a boost to the production of rice in the country. These nine rice varieties are Amaroo(1987), Bogan(1987), Echua(1989), Harra(1991), Illabong(1993), Jarrah(1993), Langi(1994), Millin(1995) and Namaga(1997) [24]. In 2001 60-70% of rice cultivated in Australia was Amaroo. In Bangladesh, three mutant varieties of rice, Iratom-24, Binasail and Binadhan-6 are the rice mutants widely cultivated on a combined area of 795,000 ha and Bina moong which is a moong bean mutant is cultivated on 15,000 ha of land [20]. In Vietnam, mutant rice varieties VND 95-20, VND99-3, VN-121 are under cultivation on a huge area of land with wide acceptability among the local farmers with a yield increase by 30% compared to the local control varieties [27]. Vietnam also achieved an outstanding success by developing the four soybean mutants (DT-84,DT-96,DT99 and DT-2008) through gamma irradiations. These outstanding mutants of soybean that are resistant to diseases, cold as well as tolerant to heat are cultivated there to harvest three crops in a single year [28]. In 2014 Vietnam produced 17 mutant varieties in rice, 10 in soybean, 2 in maize and 1 in chrysanthemum, that are officially and successfully released to Vietnam farmers. 50% of soybean and 15% of rice are produced from mutant varieties only [27] GINES is a rice mutant created by proton irradiation in Cuba, which thrives good in salty conditions, Giza-176 and Sakha-10 are high yielding rice mutants produced in Egypt, and further irradiating IR-5 rice in Myanmar gave a mutant “Shwewartun” which matures early with better yield and good grain yield [20].

Sharbati Sonara wheat having amber grain colour with early maturity and high yield protein content was developed through 200 Gy gamma irradiation in India. It was officially approved in 1967 and released to the farmers for cultivation. This wheat variety played a major role in green revolution in India. Durum wheat, which is a creso mutant, was especially created with thermal neutrons in Italy [29]. Yangmai-156 wheat mutant was developed in China. Stadler wheat, which is high yielding and early maturing variety with resistance to lose smut and leaf rust, was released in united states [20]. “Balder J barley” mutant has a better sprouting yield and drought resistance is released in Finland [20]. Golden Promise barley is a gamma irradiated semi dwarf & salt tolerant mutant released in United Kingdom [30], which is used to make whisky and beer [7]. Luther and Pennrad barley are two high yielding mutant varieties in USA. Pennrad is resistant to winters [20], In Peru, UNA La Molina 95 barley is a mutant variety developed in 1995 mainly growing above the heights of 3000 m, Centenaria II is another barley mutant in Peru that has been developed to grow in Andean highlands with hail resistance, high yield and better quality of flour [31].



Source: Mutation Breeding. www.wikipedia.org

Successfully Produced Mutants in India

- Mung Bean Mutants

Co-4, plant Mung-2 and TAP mung bean mutants [20].

- Cotton Mutants

MA-9 Cotton. It is world's first mutant in cotton that is drought tolerant and high yielding, developed through X-ray irradiation and released for cultivation in 1948 [20].

- Black Gram Mutants

MUM-2, BM-4, LGG-407, LGG-450, CO-4, Dhauli (TT9E) & Pant-moong-1. They are virus resistant varieties of black gram and Tau-1 [10]

- Chick Pea Mutants

Pusa-408 (Ajay), Pusa-413 (Atul), Pusa-417 (Girnar) & Pusa-547. They are all high yielding varieties of chickpea with resistant to Ascochyta blight & wilt diseases [20].

- Ground Nut Mutant

TG-24 and TG-37

IV.CONCLUSION

To ensure peace, everyone in the world should have access to food. United Nations General Assembaly-2015 ensures to end malnutrition and hunger by 2025-30. All countries of the world took it a common responsibility to address the issue.

Ending hunger and malnutrition, both are absolutely achievable and feasible tasks in the present era of scientific and technological advancement. Mutation breeding has significantly contributed towards this goal of sustainable development by improving crops globally. However special focus and attention of the scientists has been grabbed mostly by the major crops like rice and wheat. There is more scope to attain this goal by exploring the under nourished and orphan crops, as they are generally more adapted to the extreme climatic conditions of a region, with resistance to diseases. If the orphan crops like Millets, Cowpea, Grasspea, Groundnut, Yam, Cassava etc are genetically improved by mutation breeding, I am sure that hunger and malnutrition both will be eradicated from the world much before then 2030.

REFERENCE

[1] United Nations general Assembly (UNGA), Transforming the world, agenda for sustainable development, *Resolution adopted by the General Assembly 25th September 2015.*

[2] United Nations Department of Economics & Social Affairs (UNDESA), Sustainable Development Goals-overview, *Statistical Division Report 2016.*

[3] K. L Hefferon, Nutritionally enhanced food crops; Progress & Perspectives, *Int. J. Mol.Sci, (16), 2015, 3895-3914.*

[4] D. L. Pelletier, Jr E A Frongillo, D. G Schroeder & J.P Habicht, A methodology for estimating the contribution of malnutrition to child mortality in developing countries*, J. Nutr 124(10), 1994*.

[5] R.Mukherjee, 51% of women in India anaemic, most in world .*Times of India,November7,2007*.

[6] www.cargill.com/story/in -4-charts: The past , present and future of the food security.

[7] W.J Broad, useful mutants bread with radiations, New York Times 28th August 2007.

[8] G.G Rowland, *"Chapter-110, The effects of plants with novel traits (PNT) Regulations on mutation breeding in Canada*". In Q Y Shu, induced plant mutation in Genomics Era, Plant breeding section, Joint FAO/IAEA Division of Nuclear Techniques in Food & Agriculture, International Atomic Energy Agency, Vienna-Austria (2009), ISBN- 9789251063248, 423-424.

[9] B.Evans and M. Lupescu ,Canada Agricultural Biotechnology Annual ,Global Agriculture Information Network .GAIN report no CA12029;2012.

[10] B.S. Ahloowalia ,M. Maluszynski and K.Nichterlein,Global impact of mutation derived varieties , Euphytica 135(2),2004,187-204.

[11] National Organic Standards Board,GMO ad hoc subcommittee,Discussion document,GMOs and seed purity, February 6, 2013.

[12] J.Kashy ,The scariest veggies of them all .*Bloomberg Businessweek, Organic consumer association,* November 21 ,2013.

[13] N.Fedroff and N.M.Brow, Mendel in the kitchen-A scientists view of genetically modified foods,Joseph Henry Press (2004) ,page 17.

[14] M.C.Kharkwal, Mutatuin breeding for crop improvement ,*Geography and you ,October 10,2017.*

[15] Maluszynski, M.K Nichterlein, L Van Zantene & B S Ahloowali, Officially Released Mutant Varieties, *The FAO/IAEA programmes & nuclear techniques in food & agriculture, IAEA Agency, Vienna, Austria (88) 2000.*

[16] R A Friesleben & A Lein, Plant mutagenesis in crop improvement-Basic terms & applications-1942, In Q Y Shu, B. P Forster & H Nakagawa (eds.), published jointly by CAB international & FAO ISBN 9789251070222 (FAO), 9781780640853 (CABI), 2012, 15.

[17] H J Muller, The Production of mutations by X-rays, proceedings of National Academy of Science 14(9), 1928, 714-726.

[18] S M Jain, Mechanism of spontaneous & induced mutations in plants, In: M. Moriarty, C. Mothersill, C. Seymour, M. Edigton, J F Ward & R J M Fry (eds.), *Radiation Research, International Association for Radiation Research Lawrence (2), 2000, 255-258.*

[19] S. M Jain, chapter-14 Radiation induced mutations for date palm improvements, *Date Palm Biotechnology, Springer 2011,271-286.*

[20] M. C Kharkwal & Q Y Shu, the role of induced mutations in world food security. *In: Q Y Shu (ed.), Induced Plant Mutations in Genomics Era, Food & Agriculture Organization of the United Nations, Rome-2009, 33-38*

[21] J N Rutger, Searching for apomixes in rice, *ARS ,Clay centre,Neb.,US Dept. of Ag.1992,36-39.*

[22] B.S.Ahloowalia & M.Maluszynski,Induced mutations-A new paradigm in plant breeding ,*Euphytica 118(2) ,2001 ,167-173*

[23] L.Zhang,X.L.Shu,X.Y.Wang,H.J.Lu,QY Shu &D.X Wu,Characterization of indica type giant embryo mutant rice enriched with nutritional component ,.*Cereal Res.Comm (35) ,2007 ,1459-1468*

[**24**] A.Raina , R.A.Laskar , S.Khursheed , R.Amin , Y.R.Tantray , K.Parveen & S.Khan ,Mutation breeding in crop improvement – past ,present and future , *Asian Research Journal of Agriculture 2(2) ,2016 ,1-13*

[25] S.N.Chakrabarti ,Mutation breeding in India with particular reference to PNR rice varieties , *Journal of Nuclear Agriculture and Biolog , 24 ,1995,73-82.*

[26] K.Maruyama, H.Araki and H.Kato ,Thermosensitive genic m ale sterility induced by irradiation.*In: Rice genetics II (1991).IRRI, Manila, Philippines, pp. 227-235*

[27] *Joint FAO/IAEA programme, Successful mutation breeding programmes in Vietnam, 2014.*

[28] M.Q.Vinh , D.K.Think , D.T.Bang , D.H.At & L.H.Ham , Current status and research directions of induced mutation application to seed crops improvement in Vietnam , *Food and Agriculture Organization of the United Nations. vol 42(1), 2009 , issue32(1).*

[29] A.M.Van Harten ,Mutation breeding –Theory and practical applications ,*Cambridge University Press , 1998,p.239..ISBN 978-0521470742*

[30] B.P.Forster , Mutation Genetics of salt tolerance in barley: an assessment of golden promise and other semi dwarf mutants, *Euphytica , 120(3), 2001 , 317-218.*

[31] Joint FAO/IAEA programme, Improved barley varieties- feeding people from the equator to the arctic, Joint *FAO/IAEA programme, nuclear techniques in food and agriculture.2012.*