STUDY ON THE EFFECT OF NEUTRON AND GAMMA IRRADIATION ON SOME RICE SAMPLES

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ABSTRACT

The effect of gamma and neutron irradiation on Manawthukha and Yezin-2 rice grain were investigated by successive cultivation. The second generation Manawthukha rice was obtained from cultivation and harvesting of first generation [(i) non-irradiated (control), (ii) gamma-irradiated, (iii) neutron-one hour irradiated, (iv) neutron one-day irradiated rice]. Studies on the effect of gamma and neutron irradiation on Yezin-2 rice grain were investigated through successive cultivation, First generation (M_1) to fourth generation (M_4) by using pure line selection and mass selection methods. First generation (M_1) rice obtained from cultivation and harvesting of Yezin-2 rice [(i) non-irradiated (control) (ii) neutron one hour irradiated (iii) neuron one day irradiated (iv) gamma 25 krad irradiated (v) gamma 35 krad irradiated]. Radioactivities monitoring of first and second generations both rice grains before cultivations were carried out. It was found out that there were no induced activities. Hence rice samples were safe for consumption. Agronomical characteristics were studied. Morphological characteristics studies such as plant height, leaf width and panicle length, for Manawthukha there was no large variation between three generations of rice. Phenotypes were found to be stable. Yield improvement was calculated. Grain yield from generation to generation was not stable. This suggested that it was phenotypically stable, genotypically was not stable yet at third generation. In Yezin-2 case, it was observed that the agronomical characteristics of all radiation cases in M_1 to M_4 were some distinct variation in M_2, no distinctive variation in M_3 and almost the same in M_4 generation. Hence it can be inferred that phenotypic character to be stable at M_4 generation. Yield improvement of Yezin-2 was also calculated. With references to control, genotypic character of mutant rice was not stable yet even at the fourth generation. Elemental analysis on Manawthukha and Yezin-2 were carried out by Neutron Activation Analysis (NAA) with SLOWPOKE-2 reactor at the Dalhousie University, Canada. From these result, it can be found out that five elements such as Mg, Mn, Na, K and Cl were have been detected in both samples through generations by using a Ge(Li) gamma ray spectrometer.

***Keywords*: Manawthukha, Yezin-2, induced mutation plant breeding, NAA**

1. INTRODUCTION

This work intends to study on the long term effect of irradiation on yield and associated characteristics of Manawthukha and Yezin-2 rice samples. Rice is a staple food for a large part of the world's human population, especially in east and Southeast Asia, making it the most consumed cereal grain. In our country rice is an essential for daily meal. it is the daily staple food for the Myanmar people. Hence Rice is the main staple food crop and declared as the national crop.

Variety of Manawthukha has been widely grown throughout Myanmar. It belongs to one of Malaysian varieties. The original name is Mahsuri-M. It is a hybrid of indica and japonica variety. Local one is high yielding. It is one of the species of the; Letywezin; grain type. It has a fairly good cooking quality and market acceptability. It matures in about 130-

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135 days, so belong to the Thet-lat group. It has an average height of about 3.0 to 3.5 feet. One paddy seed gives rise to about twelve tillers. It weighs about 19 g for thousand seeds and 46 lb for one basket. The paddy grain has whitish yellow color. The grain appearance is translucent. it can be cultivated all year round (Myanmar Agriculture Service, 2001)

Most of the Myanmar Quality rice is Emata type. The variety was introduced from Bangladesh and was released as Yezin-2 in 1998. The original name is Esternetgori. It is a short-lived Emata variety. It has a good and palatable eating quality and market acceptability. It matures about 100-105 days, so belongs to the Kauk Yin group. It has an average height of about 2.5 to 3 feet. One paddy seed gives rise to about ten tillers. It weighs about 23.2 g for thousand seeds and 46 lb for one basket. The grain appearance is translucent it is soft when cooked. It is responsive to fertilizer application and the high yield. (Rice varieties in Myanmar, 2004)

Nuclear radiation and radioisotopes are proving very helpful in agriculture. Because of their availability, X –rays, thermal neutrons, fast neutron and gamma rays are employed as radiation sources for irradiation of seeds (Diehl,1995).In this work, both Co-60 with 1173 keV and 1332 keV and Cs-137 with 662 keV were used as Gamma source and for neutron irradiation Am (Be) neutron source with 10^4 n cm^{-2} s^{-1} neutron flux was used.

2. EXPERIMENTAL

Experimental comprises of three parts. The first part is concerned with monitoring of induced radioactivity of "Manawthukha" and “Yezin-2” rice. The second part is related to investigation of agronomical characteristics and estimation of grain yield. The third part is concerned with elemental investigation on both rice samples by Neutron Activation Analysis.

3. RESULTS & DISCUSSION

In the earlier part of this work, monitoring any induced activity in first and second generation rice samples were made. From (Table 1 to 2), it can be observed that, there is no distinctive activity above background in the first and second generation rice samples before cultivation. Thus it can be concluded that there is no induced activity in there rice samples and thus it is safe for consumption.

Two studies are involved in investigation of agronomical characteristics. These are morphological characteristics and estimation of grain yield. From this study for Manawthukha rice (Table 3 to 5), it can be observed that there is no large variation in three types of generation for morphological characteristics. Plant height was 101-110 cm, leaf width was between 1.20 – 1.60 cm and panicle length was 21.84 – 24.16 cm for three types of generation. This observation is summarized in (Table 6), it can be found out that yield is not stable in three types of generation. Therefore, gamma irradiated case is the best in three types of generation. From these observations, it may be concluded that phenotype of rice is almost stable. But genotype of rice is not stable yet between first generation to third generation. Therefore genotypes of irradiated Manawthukha rice are not stable yet.

Tables 7 to 11 are concerned with the study of agronomical characteristics of 1^{st}, 2^{nd}, 3^{rd} and 4^{th} generation of Yezin-2.From these results, it can be observed that in M1, agronomical characteristics of all irradiation cases were almost the same except plant height and number of tillers with panicle compared to that of non- irradiation case (Control). In M3 there was no distinctive variation of agronomical characteristics except grain per panicle. Comparison with M2 generation indicated that phenotypic character was not stable yet between M2 and M3. It can be seen that the agronomical characteristics were almost the same in M4 generation and thus phenotypic character to be stable at fourth generation from this result, in most of the irradiation cases, the yield were always higher than the non- irradiation cases and the yield of neutron one day irradiation case always give highest yield. It can be inferred that yield of rice was not stable yet. Hence studies on further generation should be conducted on both samples.

(Figure 1) shows qualitative analysis of elements by NAA on "Manawthukha" rice. From these results it can be found out that six elements have been detected. They were Mg, Mn, Na, K, Cl and Al. The result of the quantitative determination of first generation rice by NAA is reported in (Table 12). From these results, elements such as Cl, K, Mg, Mn and Na were detected. Similar results of first generation were detected in second generation. Except Na, all elements in previous detection were detected in third generation. Also there is no distinctive variation in elemental content between different mutant types of first, second and third generations. In elemental analysis by NAA of Yezin-2 rice, five elements such as Cl, K, Mg, Mn and Na were detected using with gamma ray spectrometer (Table 13 and Figure 2). In M2 generation it can be observed that except Na, Cl, K, Mg, and Mn elements were

detected quantitatively by HP (Ge) gamma spectrometer. It is obvious that there was no distinctive variation in elemental content.

Table 1. Monitoring of Radioactivity of First and Second Generation of Manawthukha (weight of paddy grain samples before cultivation = 2.00 g)

No.	Condition	Activity relative to background (± 10%) (cp 1000s)	
		First generation	Second generation
1	Gamma irradiated	1.80	1.68
2	n-1 hr irradiated	3.63	0.48
3	n-1 day irradiated	1.88	1.86

Table 2. Monitoring of Induced Radioactivity of First and Second Generation Yezin-2 (Before Cultivation) (weight of paddy grain samples @ 3.00g)

No	Samples	Radioactivity relative to background (±%) (CP 1000s)	
		First generation (M_1)	Second generation (M_2)
1	YN1H	0.36	0.86
2	YN1D	0.06	0.18
3	YG25	2.50	1.18
4	YG35	0.79	0.12

Table 3. Agronomical Characteristics of Manawthukha First Generation Rice

Description	Control	Gamma irradiated	n-1 hr irradiated	n-1 day irradiated
Plant height (cm)	103.29	103.29	110.07	105.83
Leaf width (cm)	1.33	1.50	1.60	1.60
Panicle length (cm)	21.84	22.18	22.69	21.51

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Table 4. Agronomical Characteristics of Second Generation Manawthukha Rice

Description	Control	Gamma irradiated	n-1 hr irradiated	n-1 day irradiated
Plant height (cm)	101.64	104.69	103.17	104.69
Leaf width (cm)	1.28	1.34	1.34	1.34
Panicle length (cm)	23.46	24.16	24.04	23.4

Table 5. Agronomical Characteristics of Third Generation Manawthukha Rice

Description	Control	Gamma irradiated	n-1 hr irradiated	n-1 day irradiated
Plant height (cm)	105.19	107.73	106.72	108.41
Leaf width (cm)	1.23	1.47	1.26	1.27
Panicle length (cm)	22.72	23.90	22.81	23.65

Table 6. Summary of Estimated Manawthukha Yield Based on Control 100 Baskets

	Relative Yield (basket / acre)								
	Control	Gamma irradiated			n-1 hr irradiated			n-1 day irradiated	
First generation (M_1)	100	147.98			124.81			127.51	
Second generation (M_2)	100	135.67			122.64			128.86	
Third generation (M3)	100	133.16			116.72			121.28	
Yield increase (%)		M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3
		47.98	35.67	33.16	24.81	22.64	16.72	27.51	28.86	21.28

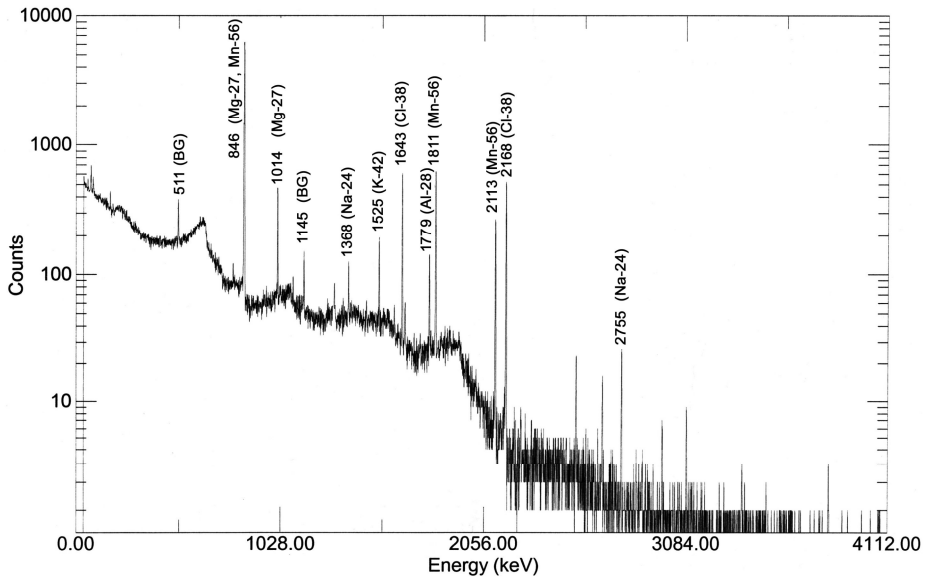

Figure 1. Gamma spectrum of Manawthukha rice (neutron-1 day case, second generation)

Table 7. Agronomical Characteristics of Yezin-2 First Generation Rice

Characteristics	Samples				
	YC	**$YN1HM_1$**	**$YN1DM_1$**	**$YG25M_1$**	**$YG35M_1$**
Plant height (cm)	101.13	95.03	95.51	94.02	95.54
No. of tiller with panicle	19	17	17	16	16
Panicle length (cm)	20.53	20.28	20.48	20.33	21.09
Grain per panicle	113	110	110	112	115
1000 grains weight (g)	21.46	21.75	21.67	22.52	21.01
Grain fertility (%)	64.14	61.97	60.54	62.17	61.96

Table 8. Agronomical Characteristics of Yezin-2 Second Generation Rice

Characteristics	Samples				
	YC	$YN1HM_2$	$YN1DM_2$	$YG25M_2$	$YG35M_2$
Plant height (cm)	81.31	70.62	77.52	88.09	80.46
No. of tiller with panicle	23	18	20	16	27
Panicle length (cm)	19.45	21.71	21.21	21.47	19.68
Grain per panicle	83	108	116	93	84
1000 grains weight (g)	20.69	21.87	22.39	22.17	19.02
Grain fertility (%)	73.90	61.23	73.24	64.69	82.84

Table 9. Agronomical Characteristics of Yezin-2 Third Generation Rice

Characteristics	Samples				
	YC	$YN1HM_3$	$YN1DM_3$	$YG25M_3$	$YG35M_3$
Plant height (cm)	87.08	85.86	87.14	86.39	86.50
No. of tiller with panicle	13	11	12	11	12
Panicle length (cm)	17.66	18.70	19.48	19.38	18.97
Grain per panicle	62	64	82	82	69
1000 grains weight (g)	24.19	25.71	25.85	25.21	24.75
Grain fertility (%)	77.41	82.26	78.09	74.19	83.38

Table 10. Agronomical Characteristics of Yezin-2 Fourth Generation Rice

Characteristics	Samples				
	YC	$YN1HM_4$	$YN1DM_4$	$YG25M_4$	$YG35M_4$
Plant height (cm)	80.46	80.04	80.46	80.63	80.25
No. of tiller with panicle	16	17	19	16	18
Panicle length (cm)	19.26	19.68	19.69	19.97	19.66
Grain per panicle	109	110	112	112	111
1000 grains weight (g)	22.87	22.84	22.46	22.96	22.82
Grain fertility (%)	74.89	74.38	80.95	73.42	75.10

Table 11. Summary of Estimated Grain Yield of Yezin-2 Rice Based on Control 100 Baskets

Descirptions	Relative Yield (basket/acre)											
	YC	YN1H			YN1D			YG25			YG35	
Second generation (M_2)	100	90.85			131.08			72.06			123.78	
Third generation (M_3)	100	101.17			133.57			112.06			114.11	
Fourth generation (M_4)	100	114.57			136.71			108.39			122.73	
Increase in Yield (%)	M_2	M_3	M_4	M_2	M_3	M_4	M_2	M_3	M_4	M_2	M_3	M_4
	-	1.17	14.57	31.08	33.57	36.71	-	12.06	8.39	23.78	14.11	22.73

Table 12. Determination of Elemental Content in First Generation Manawthukha Rice (M_3) by NAA (based on raw sample)

No.	Element	Isotope	Half-life	r-ray Energy (keV)	Elemental Content (%) of first generation (M_1)			
					Control	r-ray	n-1 hr	n-1 day
1.	Chlorine	Cl-38	37.24 min	1642.28	5.36×10^{-2}	4.34×10^{-2}	5.39×10^{-2}	4.85×10^{-2}
2.	Potassium	K-42	12.36 hr	1525.90	2.06×10^{-1}	2.01×10^{-1}	1.89×10^{-1}	1.85×10^{-1}
3.	Magnesium	Mg-27	9.46 min	1014.22	1.26×10^{-1}	1.22×10^{-1}	1.21×10^{-1}	1.11×10^{-1}
4.	Manganese	Mn-56	2.58 hr	1810.29	2.03×10^{-3}	2.03×10^{-3}	2.09×10^{-3}	2.12×10^{-3}
5.	Sodium	Na-24	14.96 hr	1368.15	1.07×10^{-3}	1.25×10^{-3}	1.11×10^{-3}	1.26×10^{-3}

Table 13. Determination of Elemental Content in Yezin-2 Rice (Control) By NAA Method (Based On Milled Rice Sample)

No	Element	Isotope	Half-life	g -Ray Energy (keV)	Elemental Content (%)
1	Chlorine	Cl- 38	37.24 min	1642.28	7.00×10^{-2}
2	Potassium	K - 42	12.36 hr	1525.90	1.64×10^{-1}
3	Magnesium	Mg - 27	9.46 min	1014.22	1.06×10^{-1}
4	Manganese	Mn - 56	2.58 hr	1810.29	3.45×10^{-3}
5	Sodium	Na - 24	14.96 hr	1368.15	2.24×10^{-3}

Table 14. Determination of Elemental Content in Yezin-2 Second Generation Rice by NAA Method (Based on Milled Rice Sample)

Generation	Samples	Elemental Content (%)			
		Cl	K	Mg	Mn
Second (M_2)	YC	7.34×10^{-2}	1.70×10^{-1}	1.05×10^{-1}	3.35×10^{-3}
	YN1H	7.11×10^{-2}	1.71×10^{-1}	1.08×10^{-1}	3.21×10^{-3}
	YN1D	7.22×10^{-2}	1.69×10^{-1}	1.09×10^{-1}	3.37×10^{-3}
	YG25	6.95×10^{-2}	1.75×10^{-1}	1.11×10^{-1}	3.18×10^{-3}
	YG35	7.00×10^{-2}	1.74×10^{-1}	1.07×10^{-1}	3.23×10^{-3}

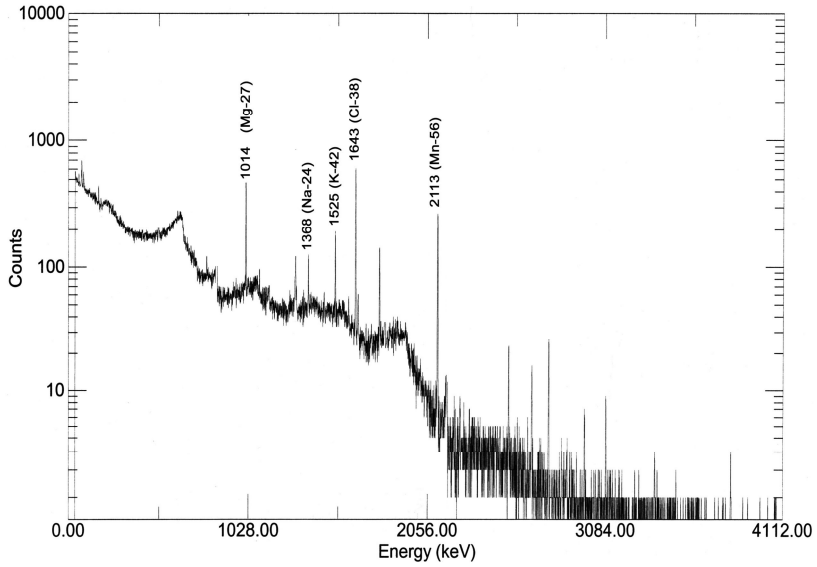

Figure 2. Identification of elements in Yezin-2 rice (control) by gamma spectrometry

CONCLUSION

This work had found out that**:** In monitoring of induced radioactivity, there was no distinctive activity above background in the first and second generation of Manawthukha and Yezin-2 rice grain samples before cultivation. That is, there was no induced activity. Hence, it follows that cultivated rice were safe for consumption.

In agronomical characteristics, morphological characteristics results were similar in three stages of Manawthukha rice generation. But grain yield from generation to generation was not stable. This suggested that although it was phenotypically stable, genotypically was not stable yet at third generation**.** Generally there was no distinctive variation in M_1 generation, distinctive variation in M_2 generation and no distinctive variation in M_3 generation for Yezin-2 rice grain. The agronomical characteristics were almost the same in M_4 generation. This suggested that phonotypical character to be stable at fourth generation. Gamma and neutron irradiation had definitely effect on yield of Yezin-2 rice. The yield was always higher than non-irradiation case (control), the yield of neutron one day irradiation case gave the highest yield. The yield varies for one generation to another for each of the irradiation cases.

In elemental determination, this work had identified five elements in Manawthukha rice such as Mg, Mn, Na, K, Cl, are observed by NAA. From first to third generation, there was no distinct variation of nutritional value of Manawthukha rice. Higher K content and lower Na content than other elements in first and second generations rice are observed by NAA method. A total of five elements (Mg, Mn, Na, K, Cl) were observed of Yezin-2 normal life span rice by NAA methods and Na was not detected in second generation. However, there was no distinctive effect on elemental content. Therefore effect of gamma and neutron irradiation on Manawthukha (Mahsuri-M) and Yezin-2 rice grain led to increase in yield without health risks.

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REFERENCES

Coffman, W.R. and R.M. Henrera. (1980). "Rice". American Society of Agronomy-crop Science of America

Dalrymple, D.G. (1972). "Imports and Plantings of High Yielding Varieties of Wheat and Rice in the Less Developed Nations". Foreign Economic Development Service

Diehl, J.F. (1995). "Safety of Irradiated Foods". 2nd edition, Marcel Dekker, Inc., New York

FAO. (2001). "Speciality Rices of the World", Science Publishers, Inc. Po box 699, Enfield, New Hampshire 03748, USA, pp: 1-310

Fao. (2004). "Rice in Global Markets", Rome, Italy

FAO. (2006). "International Rice Commission Newsletter". vol. 35, p. 35

FAO/ IAEA. (2005). "Plant Breeding and Genetic Newsletter". vol. 15, p. 5

FAO/IAEA. (2006). "Genetic Improvement of Long Grain Aromatic Rice through Mutation Approach". Plant Mutation Reports, vol. 1, no.1

Josephson, E.S., M.H. Thomas and W.K. Calhoun. (1978). "Nutritional Aspects of Food Irradiation": *An Overview. Journal of Food Processing and Preservation*, vol. 2, pp. 299-313

Mc.dolnald. (1978). "Rice and Its Adptation to World Environment". Farmer Memorial Oration, *The journal of the Australian Institute of Agricultural Science*

Ministry of agriculture and irrigation, union of myanmar, (2004), "rice varieties in myanmar"

Myanmar Academy of Agricultural, Forestry, Livestock and Fishery Sciences, International Year Rice. (2004). "Rice Research Activities in Myanmar"

Myanmar Agriculture Service. (2001). Ministry of Agriculture and Irrigation (In Myanmar)

Tin Tin. (2005). "Studies on the Effect of Radiation on Manawthukha Rice (Mahsuri – M)", Ph.D Dissertation, Department of Chemistry, University of Yangon, Myanmar

WHO. (1996). "Trace Elements in Human Nutrition and Health", Geneva