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Study on The Long Term Effects of Radiation on Irradiated Manawthukha Rice Grain (Mahsuri-M)

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Abstract

Radioactivity monitoring of first and second generations Manawthukha paddy grain before cultivations were carried out. It was found out that there were no induced activity. Therefore it can be concluded that similarly it will be the same for third generation rice. The second generation 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]. Agronomical characteristics of three different types of generation of rice were studied. Morphological characteristics studies such as plant height, leaf width and panicle length, there was no large variation between three generations of rice. Phenotypes were found to be stable. Yield improvement was calculated. Nutritional values of rice generation were studied. They were (i) element analysis by different methods (NAA, EDXRF & AAS), vitamin determination and protein percent determination. There was no distinctive difference between first, second and third generation rice. In element analysis, eleven elements such as Mg, Mn, Na, K, Cl, Al, Ca, Fe, Zn, P and Cu were observed by NAA, AAS and EDXRF methods. Vitamin content (B_1, B_2) and protein content were also studied. Determination of amylose content, gel consistency and gelatinization temperature were involved in grain quality study. There was no large variation in three generations. Surface texture of first, second and third generation Manawthukha rice were studied by Scanning Electron Microscope (SEM). It was observed that the change of texture from generation to generation tend to become more distinctive in third generation.

Keyword: Manawthukha rice, genetic mutation, food irradiation.

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Introduction

Rice is the most important grain in the world. Rice is an annual grass in the grass family. Of the twenty known species of rice, only two are cultivated - the widely grown Asian rice and harder African rice. Asian rice is classified as Oryza sativa L and African rice as Oryza glaberrima. (Microsoft®Encarta®2006). There are three major types of Oryza sativa L such as "indica", "japonica" and "javanica". Indica type is the major group grown throughout south and southeast Asia (Dalrymple, 1972 and Mc. Donald, 1978).

Radioactive tracer and radiation sources have become indispensable to all the agricultural research problems. Because of their availability X-ray, thermal neutrons, fast neutrons and cobalt 60 gamma rays are employed as radiation sources for irradiation of seeds (website 1). Mutation breeding involves the use induced beneficial genetic changes for practical plant breeding purpose. It is a technique to create a new characteristics, such as draught resistence and higher yield of the crops. Four major types of vitamins are composed in rice. These are Thiamine (Vitamin B_1), Riboflavin (Vitamin B_2), Niacin (Vitamin B_3) and Vitamin E (website 2). Moreover, rice contains inorganic trace elements. These elements include Ca, P, K, Mg, Fe and Zn (Microsoft®Encarta®2006). The parameters such as amylose content, gelatinization temperature, gel consistency and elongation ratio are involved in the investigation of cooking and eating quality of rice (website 3) (Mackill *et. al.*, 1979).

Experimental

Experimental comprises of five parts. The first part is concerned with monitoring of induced radioactivity of "Manawthukha" rice. The second part is related to investigation of agronomical characteristics and estimation of grain yield. The third part is concerned with investigation of nutritional value of "Manawthukha" rice by various methods. The fourth part is related to rice-quality determination. The last part is dealth with other related investigations.

Results & Discussion

In the earlier part of this work, monitoring of any induced activity in first and second generation rice samples were made. From Table 1, 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 these 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, it can be observed that there is no large variation in three types of generation for morphological characteristics. Plant height was between 101-110 cm, leaf width was between 1.20 – 1.60 cm and panicle length was between 21.84 – 24.16 cm for three types of generation. But 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. This observation is summarized in Table 2 and Figure 1. From Figure 1, it can be found out that yield is not stable in three types of generation. Therefore genotypes of irradiated Manawthukha rice is not stable yet. Hence studies on further generation should be conducted.

Figure 2 shows qualitative analysis of elements by NAA on "Manawthukha" rice. From these results it can be found out that six elements had been detected. They were Mg, Mn, Na, K, Cl and Al. The results of the quantitative determination of first generation rice by NAA is reported in Table 3. 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. Some additional elements were determined by AAS and EDXRF methods (Table 4, 5). Therefore, a total of eleven elements in Manawthukha rice such as Mg, Mn, Na, K, Cl, Al, Ca, Fe, Zn, P and Cu were observed by NAA, AAS and EDXRF methods.

Vitamins involved in this rice such as vitamin B_1 and vitamin B_2 were detected (Table 6). From these results, can be found out that amount of vitamin B_1 is higher than amount of vitamin B_2 in control and gamma irradiated cases of three types of generation. It may be inferred that there is no distinctive variations between non-irradiated (control) and irradiated gamma cases in three types of generation. From Table 7, it can be observed that, in three types of generation, protein content ranges from 5.64% to 8.66%. According to literature protein content less than 14% is considered to be low.

From the result, it is evident that there is no regular pattern of protein content of Manawthukha rice for different cases.

In Table 8, as regard amylose content, it is found to be in the range of 24% to 30%. According to literature, range between 25% to 30% is considered between high and intermediate in amylose content (Tin Tin, 2005). From this (Table 8) gelatinization temperature, it can be found out that it has the values between high and intermediate (70 to 74°C for 90% of starch ganule dispersion). That is the cooked rice was obtained as a result of moderate dispersion of the rice granules. The gel consistency test gave indication of cooked rice. From Table 8, it can be observed that second and third generation gave similar results with first generation. From the overall results of amylose content, gelatinization temperature and gel consistency test, it may be concluded that long term effect of radiation has no pronounced changes in grain quality.

Elongation ratio was calculated by measuring the length of cooked and uncooked milled rice by slide calipers. The elongation ratios obtained are reported in Table 9. It can be found that, the elongation ratio of second generation (1.77) and third generation (1.61) were found to be greatest in gamma cases. That is, the relative increase in length of cooked rice were highest in gamma cases of second and third generations.

For taste of cooked rice, it was investigated at Myanma Agriculture Service, Bago Division (West), Pyay. It was observed that taste of cooked rice for control and irradiated cases of three types of generations were equally good.

Preliminary study of surface texture by SEM on this rice sample is shown in (Plate 1, 2). It can be clear that rice becomes more organise orientation in gamma case at third generation.

Table 1. Monitoring of Radioactivity of First and Second Generation Paddy Grain.

(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 Summary of Estimated Grain 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

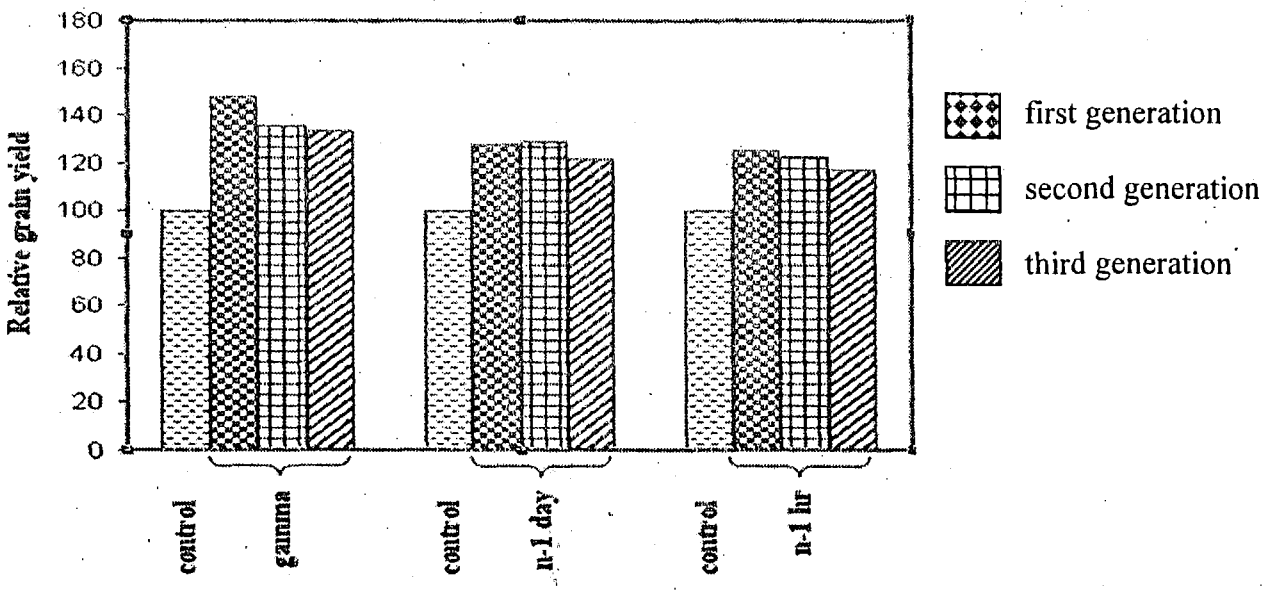

Figure 1. Bar graph of relative yield of Manawthukha rice for various generations with respect to each type of irradiation

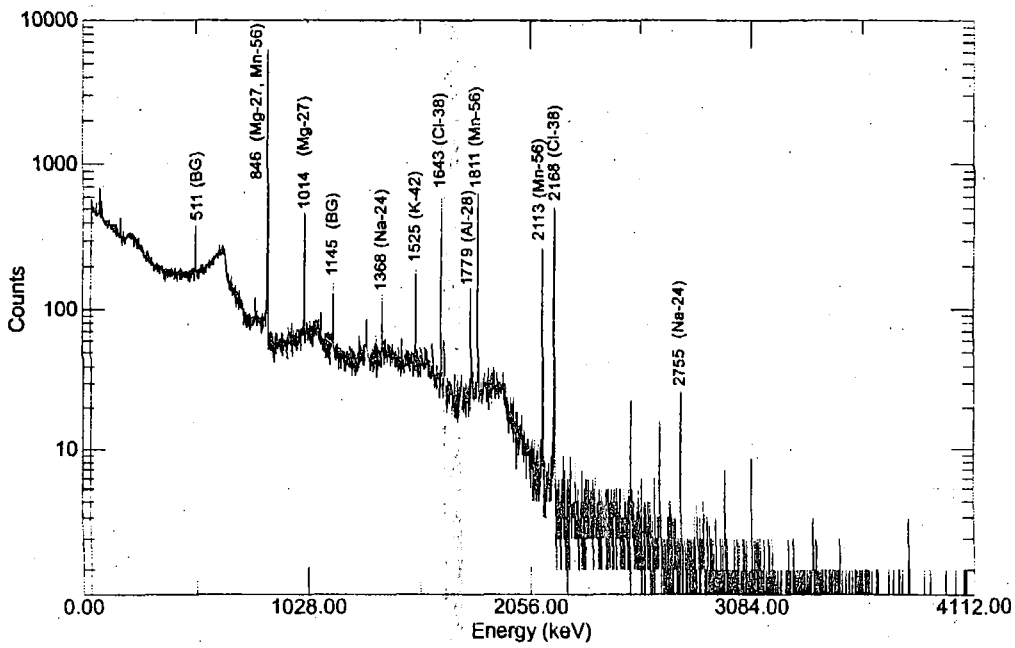

Figure 2. Gamma spectrum of Manawthukha rice (neutron-1 day case, second generation)

Table 3. Determination of Elemental Content in First Generation Manawthukha Rice (M_1) 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 4. Determination of Elemental Content in First, Second and Third Generation Manawthukha Rice by AAS Method (based on raw sample)

No.	Generation	Treatment	Elemental Content (%)		
			Ca	Fe	Zn
1.	First (M_1)	control	1.0026	0.0172	0.0002
		r-ray irradiated	0.0033	0.0171	0.0005
		n-1 hr irradiated	0.0036	0.0176	0.0009
		n-1 day irradiated	0.0030	0.0117	0.0005
2.	Second (M_2)	control	0.0077	0.0228	0.0195
		r-ray irradiated	0.0083	0.0175	0.0168
		n-1 hr irradiated	0.0087	0.0217	0.0184
		n-1 day irradiated	0.0085	0.0193	0.0178
3.	Third (M_3)	control	0.0091	0.0275	0.0010
		r-ray irradiated	0.0082	0.0267	0.0009
		n-1 hr irradiated	0.0084	0.0253	0.0009
		n-1 day irradiated	0.0089	0.0283	0.0010

Table 5. Determination of Elemental Content of First, Second and Third Generation Manawthukha Rice by EDXRF Method (based on raw sample)

No.	Generation	Treatment	Elemental Content (%) (normalized)	
			P	Cu
1.	First (M_1)	control	0.6683	0.0020
		r-ray irradiated	0.5116	0.0016
		n-1 hr irradiated	0.6314	0.0041
		n-1 day irradiated	0.441	0.0018
2.	Second (M_2)	control	0.3259	0.0016
		r-ray irradiated	*	*
		n-1 hr irradiated	0.2853	*
		n-1 day irradiated	0.3238	*
3.	Third (M_3)	control	0.2682	*
		r-ray irradiated	0.1230	*
		n-1 hr irradiated	0.1410	*
		n-1 day irradiated	0.1452	*

Note: * not detected

Table 6. Determination of Vitamin in Manawthukha Rice (based on raw sample)

No.	Vitamin	Content (mg/g)			
		non-irradiated	gamma-irradiated		
		Control	M_1	M_2	M_3
1	B_1	5.63	5.92	6.27	6.04
2	B_2	0.06	0.04	0.06	0.4

M_1 = First generation M_2 = Second generation M_3 = Third generation

* = result not available from DCPT

Table 7. Determination of Protein Content in Manawthukha Rice

No.	Treatment	Protein (%)		
		M_1	M_2	M_3
1	gamma irradiated	7.12	8.15	6.88
2	n-1 hr irradiated	6.38	6.93	7.10
3	n-1 day irradiated	5.64	8.66	7.10

control = 7.09 ± 1.61% M_1 = First generation M_3 = third generation
M_2 = Second generation

Table 8. Evaluation of Cooking and Eating Qualities for Harvested Manawthukha Rice

No.	Treatment	Amylose (%)			Gelatinization Temperature			Gel Consistency		
		M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3
1.	control	28.98	24.29	26.13	H/I	I	H/I	H*	H*	H*
2.	r-irradiated	25.06	24.79	25.92	H/I	I	H/I	H*	H*	H*
3.	n-1 hr irradiated	29.18	25.92	25.43	H/I	I	H/I	H*	H*	H*
4.	n-1 day irradiated	29.90	26.16	26.43	H/I	I	H/I	H*	H*	H*

H* = Hard (26 - 40 mm) M_1 = First generation
I = Intermediate (70 - 74°C) M_2 = Second generation
H = High (75° - 79°C) M_3 = Third generation
H/I = Between high and intermediate (74 - 75°C)

Table 9. The Appearance of Harvested Rice of Three Types of Generation

No.	Treatment	Elongation ratio		
		M_1	M_2	M_3
1	MTK (control)	1.59	1.60	1.47
2	MTK (r-ray)	1.29	1.77	1.61
3	MTK (n-1 hr)	1.73	1.43	1.44
4	MTK (n-1 day)	1.70	1.57	1.53

* = average length (mm) of cooked rice to length (mm) of raw rice

** = no result obtained yet

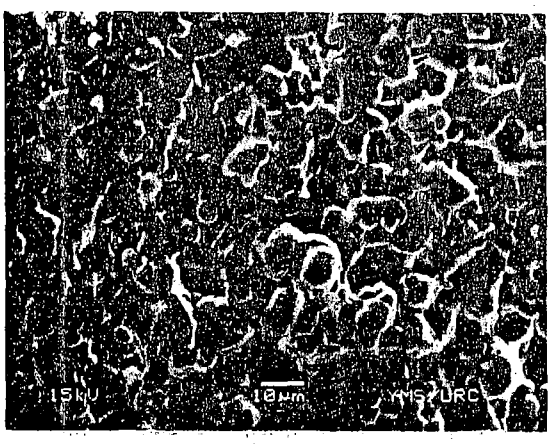

Plate 1. SEM Photomicrograph of non irradiated (control) Manawthukha rice

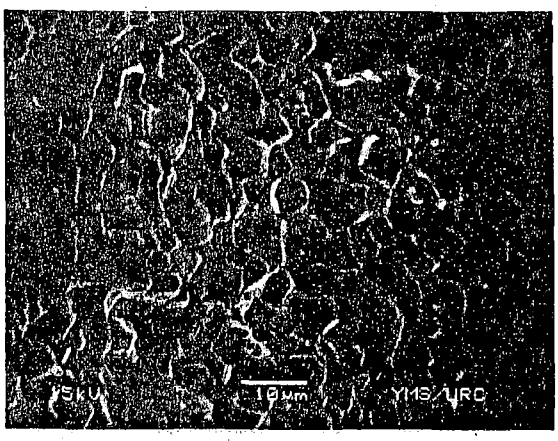

Plate 2. SEM Photomicrograph of third generation Manawthukha rice (gamma case)

Conclusion

This work had found out that: In Agronomical characteristics, morphological characteristics results were similar in three generation. 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 elemental determination, a totally of eleven elements such as Mg, Mn, Na, K, Cl, Al, Ca, Fe, Zn, P and Cu were observed by NAA, AAS and EDXRF methods. From first to third generation, there was no distinct variations of nutritional value of Manawthukha rice. Vitamin B_1 was higher than vitamin B_2 in three stages of Manawthukha rice generation. Protein content of rice of

different generations does not exhibit any definite trend. The rice quality of three types of generation does not change from generation to generation. Preliminary study of surface texture by SEM on Manawthukha rice for first, second and third generation tend to exhibit that rice becomes more organized orientation in gamma case at third generation. Overall, grain yield, nutritional values, eating and cooking qualities of first, second and third generation Manawthukha rice do not differ significantly. Results indicate that Manawthukha is a good quality rice and is suitable for consumption.

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