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Reaction of Sweet Potato (*Impomoea batatas* L.) to Gamma Irradiation

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Abstract: Sweet potato is one of the most important food crops in the world. Vine cuttings of 50 to 100 cm with auxiliary buds were obtained. The cut portion included the middle to top portion of the vines from three varieties; Jukwa Orange, 199062 CRI and Ejunita CRI/E/Africa with code; 293, 322 and 296, respectively. The varieties were exposed to 15, 25, 35 and 45 Gy doses of cobalt 60 gamma irradiation. The direct effect of doses on the material was assessed on the basis of days to first sprouting of the vines and number of days to sprouting; shoot length, number of leaves per vine from the first week of leave emergence to the eight week. At maturity data on effect of gamma irradiation on yield such as length of tuber and width of tuber were taken and analysed using Genstat. Results showed that the response of sweet potato plant was affected by the variety and dose of exposure which revealed significant reduction in the average of most studied characteristics as the dose of gamma irradiation increased. Average plants height of variety 293 was significantly higher than the other varieties (62.0 cm) at 8th week. Reduction in the tuber formation at dose 45 Gy for all varieties was observed.

Key words: Sweet potato, gamma irradiation, sprouting, emergence

INTRODUCTION

Sweet potato (*Ipomoea batatas* L.) is one of the most important food crops in the world, especially in developing and undeveloped countries, where the sweet potato yields are the greatest. Increased in demand for sweet potato in almost all parts of the world, has led to rapid propagation of the sweet potato by means from the tubers or vine cuttings. However they are susceptible to mosaic virus disease and have inferior qualities. The control of these viruses is very difficult and therefore leads to great losses (Danso *et al*., 2008). The best option to control viruses is to develop resistant varieties. The use of mutation is one of the breeding methods (Wang *et al*., 2007).

The use of ionizing radiation, such as X-rays, gamma rays and neutrons and chemical mutagens for inducing variation, is well established. Many attempts in the field of mutation research have been made by different scientists to get desirable traits in most cultivated crops and in the determining the most effective mutagenic treatment (Reddy and Rao, 1988; Bansal *et al*., 1990; Pillai *et al*., 1993; Ahloowalia and Maluszynski, 2001; Sasikala and Kalaiyarasi, 2010; Cavatorta *et al*., 2011). Irradiation has also been successfully used for mutation breeding and has proven an adept means of encouraging the expression of recessive genes and producing new genetic variations (Schum, 2003; Song and Kang, 2003; Yoon *et al*., 1990). In this present study three genotypes of sweet potato were treated with different doses of gamma radiation.

MATERIALS AND METHODS

Three promising sweet potato genotypes namely, Jukwa Orange (293), 199062 CRI (322) and Ejunita CRI /E/Africa (296) were obtained from Crop Research Institute (CRI), Kumasi, Ghana. Vines with auxiliary buds (20 to 30 cm) were obtained. The cuttings after removing the leaves were exposed to 15, 25, 35 and 45 Gy doses of a ^{60}Co source. The irradiation was done using a gamma irradiation facility of cobalt 60 source at the Radiation Technology Centre (RTC) of the Ghana Atomic Energy Commission (GAEC).

The gamma-irradiated vines with auxiliary buds were cut to about 20-30 cm length and immediately planted in poly bags with diameter 500 by 500 mm filled to two third with loamy soil.

The experiment design was a completely randomized design (CRD). There were three varieties with five treatment (irradiation at 0 Gy (control), 15, 25, 35 and 45 Gy) and three replications.

Data collection covered three stages of the plant growth; the first data was recorded on the performance of the vines, which is first day of sprouting of the vines and number of days to sprouting. Secondly, data was taken on

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shoot length, number of leaves per vine from the first week of leave emergence to the eight-week. Thirdly, yield parameters, which include length of tuber, width of tuber and percentage tuber formation, were recorded.

The number of plants that developed tubers was counted according to each treatment at harvesting. Variety that was irradiated at 0, 15, 25, 35 and 45 Gy and had all vines developing tubers was noted as 100% tuber formation that is percentage calculated based on the number of vines that formed tuber out of the entire vines irradiated for each treatment.

RESULTS AND DISCUSSION

There was delay in sprouting with the raise of Gamma dose. Early sprouting was observed in control and those irradiated at lower dose (Table 1). Vines irradiated at 0 and 15 Gy sprouted in the 1st week while those irradiated at 25 and 35 Gy sprouted 2nd week. It was observed that those irradiated at 45 Gy sprouted in the 3rd week of planting. This shows that gamma irradiation at higher dose delay sprouting and this confirms the study of Al-Salihy *et al*. (2006) who reported that high dosage of irradiation delays sprouting of sweet potato vine and also supports the assertion made by Wang *et al*. (2007) that gamma irradiation has direct effect on sprouting of sweet potato with high doses delaying the number of days to first sprouting.

The effect of irradiation at different doses was evaluated in terms of plant height for 4th and 8th week as shown from Table 1. It was observed that significant difference exist between 0 and 15 Gy at 4th week with the value of 9.78 and 8.20 cm, respectively; however, it is interesting to note that, no significant different existed among 0 and 15 Gy at 8th week with values of 56.4 and 54.5 cm, respectively.

It was also observed that as the dose rate increased, the mean height also decreases with no significant differences among the doses Table 1. However in the 8th week, there was no significant difference between 35 Gy and (25 and 45 Gy) with the value of 35.5, 47.8 and 28.0, respectively. It was observed that as dose of irradiation increases mean plant height decreases except at dose 35 Gy. The increased in dose rate leading to decrease in plant height confirms the result of Al-Salihy *et al*. (2006).

Plant height was recorded at 4th and 8th week during the growth period of the plant Table 2. The result showed that variety 296 recorded the highest mean plant height of 7.71 cm with variety 293 and 322 recording the least value of 3.72 and 3.56 cm, respectively in the 4th week. However, in the 8th week, variety 293 recorded the highest mean value of 62.0 cm, with variety 296 and 322 recording values of 37.8 and 33.3 cm, respectively. The result showed that variety 293 had a lower initial growth rate of 3.37 cm but grew rapidly in the 8th week to the mean height of 62.0 cm as compared to the variety 296 that showed a rapid growth rate of 7.71 at the initial stages of growth but maintain a slower growth rate to the 8th week.

Table 1: Effect of irradiation on days to sprouting and plant height

		Plant height (cm)	
Irradiation (Gy)	Mean No. of days to sprouting	Week 4	Week 8
0	8.8	9.80^{c}	56.4^{b}
15	8.6	8.20^{b}	54.5^{b}
25	12.3	2.50^{a}	35.5^{a}
35	11.2	2.30^{a}	47.8^{b}
45	13.3	2.22^{a}	28.0^{a}

Values bearing same alphabet as superscript are not significantly different

Table 2: Varietal response to irradiation

	Plant Height		No. of leaves			
Variety/ genotype	Week 4	Week 8	Week 4	Week 8	Length of tuber (cm)	Width of tuber (cm)
293	3.72^{a}	62.0^{a}	2.57^{ab}	5.96^{a}	16.10^{a}	26.13^{b}
296	7.71^{b}	37.8^{b}	2.98^{b}	8.41^{b}	18.20^{a}	22.60^{b}
322	3.56^{a}	33.3^{b}	2.37^{a}	5.09^{a}	3.29^{a}	12.56^{a}

Values bearing same alphabet as superscript are not significantly different

The slower growth rate of variety 293 and 322 could be as result of the effect of gamma irradiation on the vines. It can therefore be deduced that gamma irradiation on vines led to rapid growth rate of variety 293 and slower growth rate of variety 296 and 322.

It was observed that there was no significant difference between 293 and 322 in the 4th week but there was significant difference between 296 and the other two varieties (293 and 322). However, variety 293 and 322 also demonstrated slow growth rate at the 8th week with no significant difference but there was significant difference between the two varieties 293 and 322 and variety 296 which showed a rapid growth rate at the 8th week.

The mean number of leaves is an indication of number of leaves produce from the vines of variety 293, 296 and 322 that were irradiated at 0, 15, 25, 35 and 45 Gy its effects observed at 4th and 8th week.

The highest mean for the number of leaves was recorded for variety 296 with values of 2.98 and 8.41 for 4th and 8th week, respectively as shown in Table 2. This shows that variety 296 had a good growth rate from the 4th to 8th week.

Variety 293 and 322 also recorded values of 2.57 and 2.96 for 4th week and values of 5.96 and 5.09 cm for the 8th week, respectively. From Table 2, it was observed that the mean number of leave increases as the plant grows in relation to increase in the number of weeks. This fact is true, because as a plant grows the number of leaves also

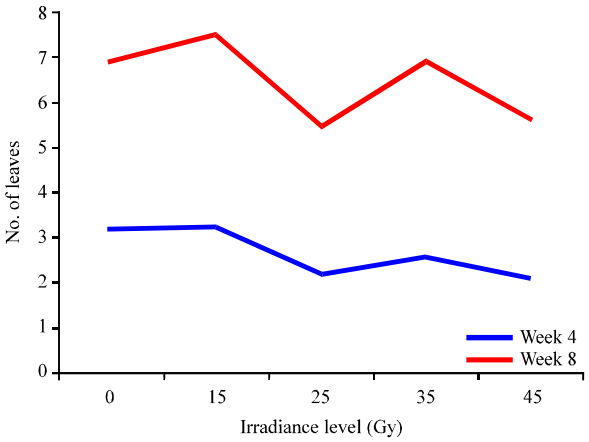

Fig. 1: Effect of irradiation on No. of leaves

Table 3: Percentage tuber formation

	Variety (%)			
Irradiation	296	293	322	Mean
0	100	100	100	100.00
15	100	100	60	88.67
25	100	100	0	33.33
35	100	60	20	60.00
45	60	60	20	46.67
Mean	92	84	40	

increase. Therefore it's not surprising the mean number of leaves for the three varieties increased from the 4th to the 8th week.

Also at the 4th week, it was clearly noted that significant difference existed between varieties 296 and 322; however, no significant difference existed between 296 and 293 as well as that of 322 and 293. But then, at the 8th week, no significant difference existed between 293 and 322 but significant difference existed between variety 296 and the other two varieties (293 and 322). This could be due to the high increased in the mean number of leaves for Vines of *Ipomoea batatas* being exposed to gamma irradiation at 0, 15, 25, 35 and 45 Gy. The effect of the irradiation was observed on the mean number of leaves at the 4th and 8th week as indicated from Fig. 1. It was also observed that 15 Gy recorded the highest mean number of leaves of 3.22 and 7.47 cm for the 4th and 8th week, respectively followed by 0 Gy with the value of 3.18 and 6.94 for the 4th and 8th week, respectively with high dose of 45 Gy recording the least value of 2.08 and 5.62 for the 4th and 8th week, respectively. The least value recorded for 45 Gy could be due to delay in rooting and sprouting of the vine which in turn leads to reduction in the mean number of leaves as observed from Fig. 1. This is in line with the findings of Lage and Esquibel (1992) who indicated that high doses of gamma irradiation in sweet potato caused a delay in the initiation and sprouting of shoot leading to reduced number of leaves.

It was observed that, there was no significant difference between 25 and 45 Gy with the values of 2.18 and 2.08, respectively and also non-significant difference between 0 and 15 Gy with the values of 3.18 and 3.22 cm for the 4th week, respectively. However, there was significant difference among (35 and 45 Gy), (0 and 15 Gy) and 35 Gy at the 8th week.

There was significant difference between 0 and 15 Gy at the 8th week but there was no significant difference between the two (0 and 15 Gy) in the 4th week as observed in Fig. 1. This could be due to the rapid increase in the mean number of leaves of the 15 Gy from 3.22 cm in the 4th week to 7.47 cm in the 8th week. There was however no significant difference between 45 and 25 Gy in the 8th week as observed in the 4th week.

Regardless of the amount of gamma received by sweet potato, the yield of 15 and 25 Gy were not different from non-irradiated vine for variety 296 and 293. Table 3 illustrate, mean percentage tuber formation of varieties combined with the various dose rates at 0, 15, 25, 35 and 45 Gy for variety 296, 293 and 322.

It was observed that variety 296, 293 and 322 recorded 100% tuber formation at 0 Gy. Also variety 296 further recorded 100% for vines irradiated at 15, 25 and 35 Gy whiles vines of variety 293 recorded 100% at 15 and 25 Gy.

The results showed that variety 296 performed better even under high dose of 35 Gy irradiation until its get to 45 Gy where the performance recorded a least percentage of 60. However, variety 322 had poor performance under the different irradiation levels. This observation shows that variety 296 and 293 gives a better tuber performance even when the vines are irradiated but the vines of variety 322 does not perform better when irradiated.

The control was the best for all the three varieties irradiated. It can be concluded that even though the variety bombarded had low performance of tuber formation, the next generation might perform better because of the genetic variability that has been created through bombarding the vines with gamma irradiation.

The most used index of tuber shape is the length: width ratio (Al-Salihy *et al*., 2006). Thus the width of a tuber is affected by its length and vice versa. Table 2 shows the effect of gamma irradiation on the mean root length and width of variety 293, 296 and 322.

It was observed that variety 322 recorded the highest length of 32.9 cm with a width of 12.56 which is the least width recorded for the three varieties.

This was followed with variety 296 recording values of 18.2 and 22.60 cm for the length and width, respectively

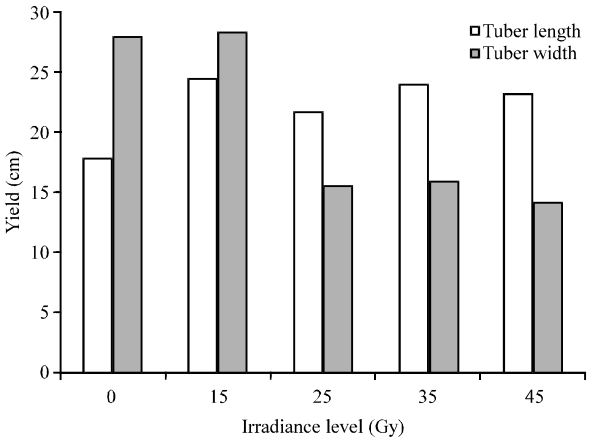

Fig. 2: Effect of irradiation levels on yield

with variety 293 recorded the highest width of 26.13 cm and a length of 16.1 cm. The result showed that the shorter the length of the tuber, the wider the tuber width and vice versa.

It can be deduced that variety 296 had the most uniform tuber size as compared to variety 293 and 322, because the different between its width and length is almost equal, that is 18.2 cm for the length and 22.60 for the width. And also variety 322 is the longest in size but slimmer while variety 293 is the shortest tuber in size but bulky due to its width.

There was no significant difference among variety 293, 296 and 322 in relation to the length of tuber. Also, there was no significant difference between Variety 293 and 296 but there was significant difference between variety (293, 296) and variety 322 in relation to tuber width.

The effect of irradiation at 0, 15, 25, 35 and 45 Gy on yield of three varieties of sweet potato based on the tuber length and width, it can be observed from Fig. 2 that, irradiation at 15 Gy recorded the highest tuber length of 24.6 cm followed by 35, 45, 25 and 0 Gy with the values of 24.0, 23.4, 21.9 and 18.0 cm, respectively; however, there was no significant differences among them.

From Fig. 2, 15 Gy recorded the highest value of 28.44 cm for tuber width, followed by 0, 35 and 25 Gy with width values of 20.11, 16.11 and 15.67 cm, respectively, with 45 Gy recording the least value of 14.32 cm.

The results showed that higher doses of irradiation on sweet potato vines lead to increase in length of tuber but decrease in the width of the tuber thereby reducing the size of sweet potato tubers. This is in agreement with the findings of Wang *et al*. (2007) that exposure of vines to higher doses of irradiation lead to reduction in tuber size.

CONCLUSION

It was observed that apart from the control, the effect of irradiation on 15 Gy was significantly different from 35, 45 and 25 Gy on yield. There was no significant difference between the height of 25, 35 and 45 Gy; however there was a significant difference between (25, 35 and 45 Gy) and (0 and 15 Gy). High doses of irradiation reduce/lead to decrease in yield.

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REFERENCES

Ahloowalia, B.S. and M. Maluszynski, 2001. Induced mutations-A new paradigm in plant breeding. Euphytica, 118: 167-173.

Al-Salihy, A.A., A.J.M. Al-Jibouri, S.K. Al-Bayati and M.J. Awad, 2006. Effect of gamma radiation on growth of four potato (*Solanum tuberosum* L.) varieties propagated *in vitro*: 1. Effect on plant height and number of branches and leaves. Jordan J. Agric. Sci., 2: 283-289.

Bansal, V., P.C. Katoch and P. Plaha, 1990. Mutagenic effectiveness of gamma rays, ethyl methanesulphonate and their combined treatments in rice. Crop Improvement, 17: 73-75.

Cavatorta, J., K.W. Perez, S.M. Gray, J. van Eck, I. Yeam and M. Jahn, 2011. Engineering virus resistance using a modified potato gene. Plant Biotechnol. J., 9: 1014-1021.

Danso, K.E., O. Safo-Katanka, Y. Adu-Ampomah, V. Oduro, H.M. Amoatey *et al*., 2008. Application of induced mutation techniques in Ghana: Impact, challenges and the future. Proceedings of the FAO/IAEA International Symposium on Induced Mutations in Plants, August 12-15, 2008, Vienna, Austria, pp: 108-108.

Lage, C.L.S. and M.A. Esquibel, 1992. Developmental changes induced by ã irradiation in *Ipomoea batatas* L. Lam (Sweet Potato). Radiat. Res., 132: 237-241.

Pillai, M.A., M. Subramanian and S. Murugan, 1993. Effectiveness and efficiency of gamma rays and EMS for chlorophyll mutants in upland rice. Ann. Agric. Res., 14: 302-305.

Reddy, T.V.V.S. and D.R.M. Rao, 1988. Relative effectiveness and efficiency of single and combination treatments using ã rays and sodium azide in inducing chlorophyll mutations in rice. Cytologia, 53: 491-498.

Sasikala, R. and R. Kalaiyarasi, 2010. Sensitivity of rice varieties to gamma irradiation. Electron. J. Plant Breed., 4: 885-889.

Schum, A., 2003. Mutation breeding in ornamentals: An efficient breeding method? Acta Horticult., 612 : 47-60.

Song, H.S. and S.Y. Kang, 2003. Application of natural variation and induced mutation in breeding and functional genomics. Korean J. Breed. Sci., 35: 24-34.

Wang, Y., F. Wang, H. Zhai and Q. Liu, 2007. Production of a useful mutant by chronic irradiation in sweetpotato. Sci. Horticult., 111: 173-178.

Yoon, K.E., Y.H. Park and B.G. Im, 1990. Effect of gamma radiation on seed germination and androgenesis in *Nicotiana tabacum* L. Korean J. Breed. Sci., 21: 256-262.