

Impact of Gamma irradiation and Storage Time on the Sprouting of Cocoyam Corms

Abstract

Cocoyams are cultivated in Nigeria for their edible corms. Post harvest losses in cocoyam are attributed to its short sprouting time during storage. Planting of sprouted corms reduces the total yield leading to financial loss by the farmers. Colocasia esculenta (NCe 001 and NCe 011) and Xanthosoma sagittifolium (NXs 001 and NXs 002) Nigeria cultivars were subjected to gamma irradiation at doses of 20, 40, 80, 120 and 150Gy for one hour and stored. The effect of radiation dose and storage time on the sprouting of these cocoyam varieties was studied. Statistical analysis of the experimental results was conducted. The results of the study indicated that the control samples sprouted more than the irradiated samples during storage. The results also showed that there was a dose-dependent decrease in the irradiated samples, with 150Gy samples having the least number of sprouted corms. A significant difference between the control samples and irradiated samples at $p \leq 0.05$ was observed in the study. The result of the study thus showed that gamma irradiation can be used as a processing method to improve the storability of cocoyam by inhibiting the sprouting of cocoyam corms.

Key words: sprouted, irradiated, radiation dose, storage time

Introduction

Cocoyam, a member of the Araceae family, is one of the oldest crops grown for its edible corms and leaves and as an ornamental plant (Alabi *et al.*, 2019). It is widely grown in tropical and sub-tropical countries (Samaa, 2019). In Nigeria, cocoyam has remained a very minor crop produced by farmers in selected locations. Despite being grown on a smaller scale, cocoyam is known to have a high content of tiny, easily digestible starch grains ranging in content between 22 and 40%, making it a good source of starch (Ejoh *et al.*, 2013). Cocoyam has nutritional advantages over other root and tuber crops (Amadi *et al.*, 2018). It has more crude protein than root and other tubers—and its calcium, phosphorus, and vitamin A and B content is reasonable (Owusu-Darko *et al.*, 2014). All these are lost nutrition because of the ease of sprouting during storage. Sprouting is one of the avenues of high physiological losses. Stored cocoyam usually sprouts and starts normal growth within four (4) weeks (NRCRI, 2010). After harvest about 50% loss was reported after two months, and 95% after five months, as a result of sprouting.

Sprouted cocoyam seedlings are poor-quality planting materials because their vigour is reduced at the time of planting (Ejoh *et al.*, 2013). The consequence is a reduction in total yield. Traditionally, farmers apply ashes from burnt woods to inhibit sprouting but this method is not effective in reducing postharvest loss due to sprouting. The economic importance of cocoyam as a food is being limited by the non-application of improved postharvest technologies, such as radiation processing to minimize sprouting (Falade and Okafor, 2015).

Food irradiation is a postharvest technology that brings food and food products into contact with radiation. These radiations have the ability to remove electrons bonded in an atom and molecule with their high, making them electrically charged and thus known as ionising radiations (Zanardi *et al.*, 2018). The function of food irradiation is to control insect infestation and the numbers of pathogenic or spoilage microorganisms. It also helps to arrest or reduce ripening in fresh fruits and vegetables; sprouting in tubers and germination that occurs in bulbs (Madu *et al.* 2020). Therefore, this study aims to examine the effect of gamma irradiation and storage time on the sprouting of four varieties of cocoyam corms.

Materials and methods

The four cocoyam varieties used in this study were NXs 001 and NXs 002 of the *Xanthosoma sagittifolium* species and NCe 001 and NCe 011 of the *Colocasia esculenta* species and cultivar. The corms were supplied by the Cocoyam Programme of the National Root Crops Research Institute (NRCRI), Umudike, Abia State, Nigeria.

Forty-two kilogrammes (42kg) each of fresh and healthy corms of the four cocoyam varieties were sorted. The 42kg samples of corms were divided into six different groups, one group served as the control, which was analysed immediately after harvest to determine the acidity content. The other five groups were packaged in polyethene bags of 2mm thickness and labelled accordingly. Each package containing 7kg of corms was treated with Gamma irradiation using five different doses of 20Gy, 40Gy, 80Gy, 120Gy and 150Gy for 1 hour. The absorbed doses were confirmed using Alanine dosimeters (Bruker Biospin USA (Billerica MA), Lot T030901). The irradiated cocoyam corms were marked for easy identification based on the dose of gamma irradiation they received and observed in an open shed at ambient temperature for seven months (28 weeks). The corms were carefully examined every week for the appearance of fresh shoots to indicate sprouting and weighted (Figure 1). The weights were taken in the three times (morning, afternoon and evening) and the mean records were taken for the number of sprouted corms.

The sprouting loss was calculated as:

$$\% \text{ sprouting loss} = \frac{\text{Initial weight of corms (Kg)} - \text{Weight of sprouted corms (Kg)}}{\text{Initial weight of corms (Kg)}} \times 100$$

Statistical analysis of the experimental results was conducted for Analysis of variance and Regression coefficient.



Figure 1: Irradiated samples (A) and Weighing of samples (B)

Results and Discussions

The mean loss (%) due to sprouting is presented in Table 1. The result from Table 1 indicates that *Colocasia esculenta* (NCe 001 and NCe 011) varieties sprouted more than *Xanthosoma sagittifolium* (NXs 001 and NXs 002) varieties during storage. The results of effect of gamma irradiation on the sprouting of the four varieties of cocoyam after 28 weeks of storage are shown in Figure 2 – 5. It shows the means of irradiated cocoyam corms that sprouted during storage. Figures 2 – 5 showed that as the storage period increased, the number of sprouted corms increased. It can be seen from the results in Figures 1 – 4 that more of the control samples sprouted than the irradiated samples during storage. The results also showed that samples irradiated at 150Gy had the least number of cocoyam corm sprouts. A close look at the results in Figure 1 – 4 also revealed that as the dosage of gamma irradiation increased, the rate of cocoyam sprouting during storage decreased.

Table 1: Mean loss (%) due to sprouting

Variety	Control	20Gy	40Gy	80Gy	120Gy	150Gy
NCe 001	100	74	54	24	20	14
NCe 011	87	76	60	46	30	22
NXs 001	52	31	27	10	8	4
NXs 002	40	20	19	14	9	7

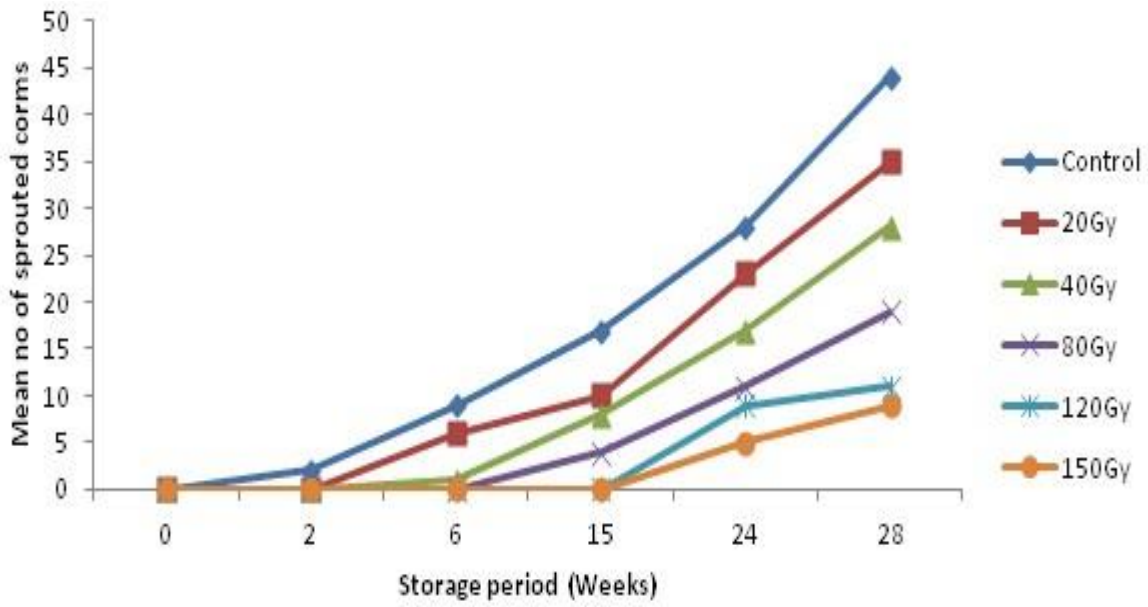


Figure 2: Mean number of sprouted NCe 001 corms irradiated at different doses

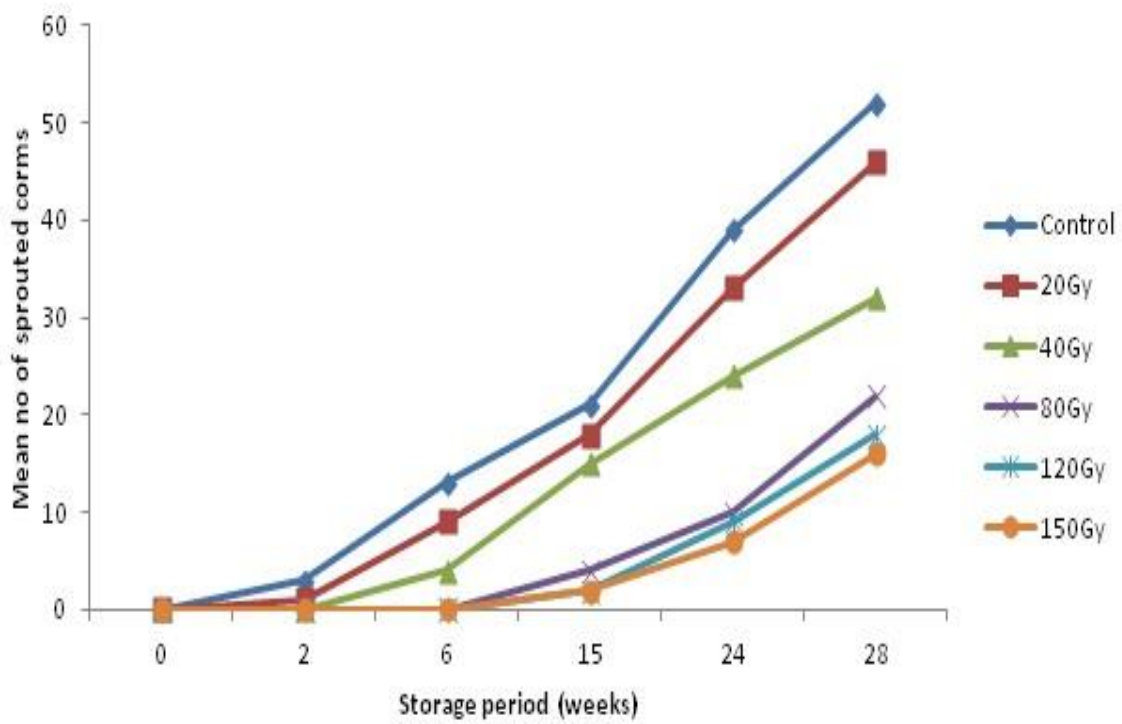


Figure 3: Mean number of sprouted NCe 011 corms irradiated at different doses

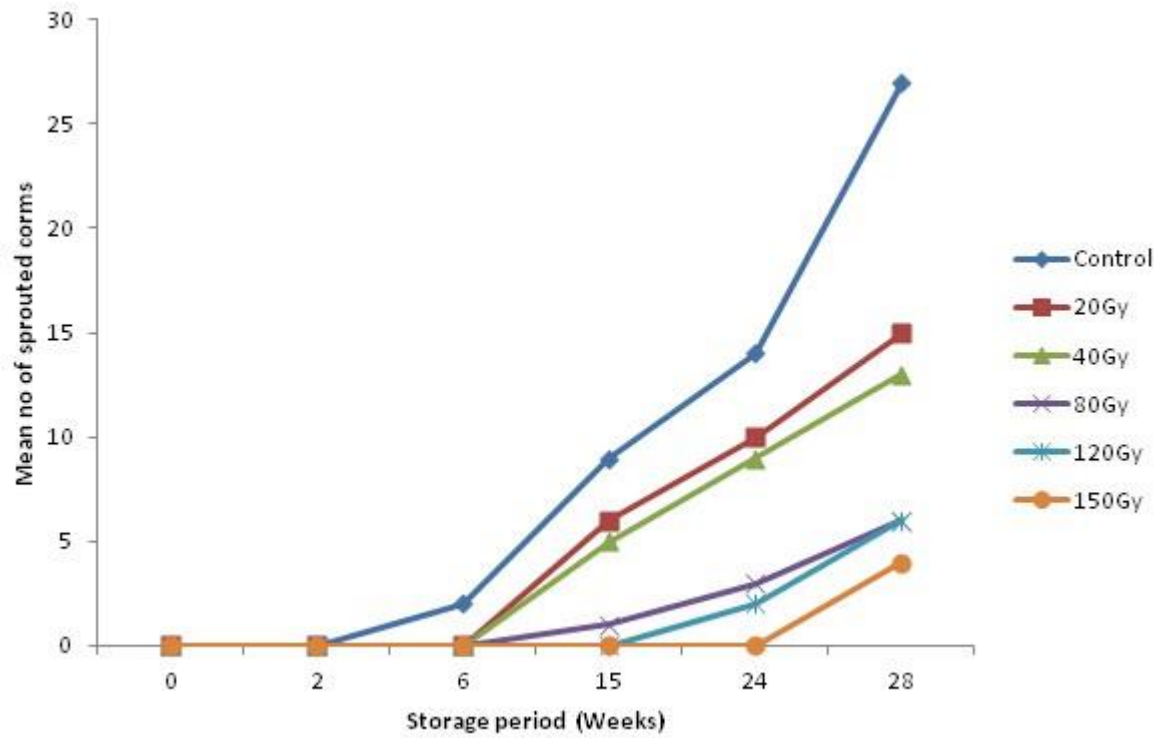


Figure 4: Mean number of sprouted NXs 001 corms irradiated at different doses

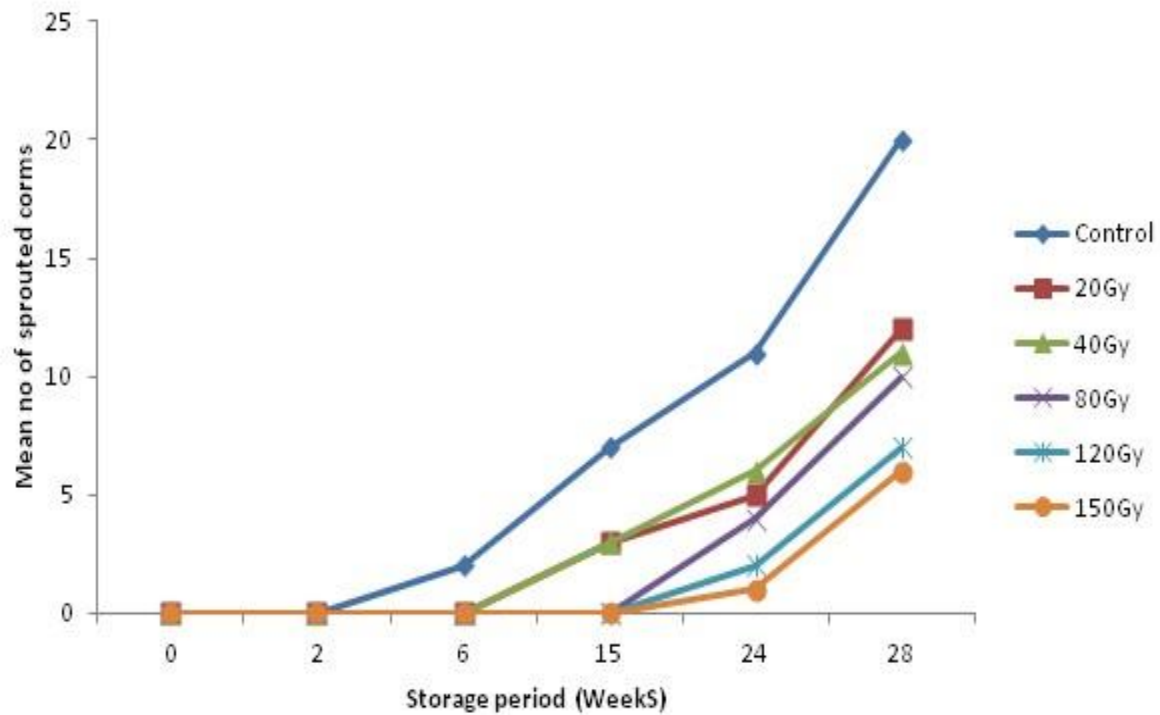


Figure 5: Mean number of sprouted NXs 002 corms irradiated at different dose

The statistical analysis of variance (ANOVA) for sprouting is presented in Table 2. The no significant difference terms were identified at $p \leq 0.05$. Table 2 indicates that there was a significant difference between the control samples and irradiated samples at $p \leq 0.05$ from the model term p -value. Table 2 also presents that the interaction of dosage and storage (0.131) as well as storage and variety (0.900) had no significant differences at $p \leq 0.05$. But the interaction between dose and variety (0.010) had a significant difference at $p \leq 0.05$.

Table 2: Analysis of Variance for Sprouting

Source	DF	SS	MS	F-Value	P-Value
Model	14	428.910	30.636	6.26	0.000*
Linear	5	283.289	56.658	11.58	0.000*
D	1	201.030	201.030	41.09	0.000*
ST	1	23.950	23.950	4.90	0.040*
V	3	70.913	23.638	4.83	0.012*
Square	2	91.468	45.734	9.35	0.002*
D*D	1	40.698	40.698	8.32	0.010*
ST*ST	1	3.163	3.163	0.65	0.432**
2-Way Interaction	7	90.019	12.860	2.63	0.047*
D*ST	1	12.250	12.250	2.50	0.131**
D*V	3	75.000	25.000	5.11	0.010*
ST*V	3	2.838	0.946	0.19	0.900**
Error	28	88.060	3.145		
Total	67	516.970			

D = Dose (Gy); ST = Storage (weeks); V= Variety; *significant difference ($p < 0.05$); **no significant difference ($p < 0.05$); DF (Degree of Freedom) = $n - 1$ (n = sample size); SS = Sum of Squares; MS (Mean of Squares) = $SS \div DF$

Table 3 presents the statistical regression coefficients obtained for this study. A positive regression coefficient indicates that as the mean values of the independent variable increased, the mean of the dependent variable also tends to increase. A negative coefficient suggests that as the independent variable increased, the dependent variable tends to decrease. Regression coefficients having t -values $\geq \pm 2$ and p -values ≤ 0.005 are statistically significant. The results from Table 3 indicated that dosage had the greatest effect on NXs 001(4.31) while storage had the greatest effect on NCe 001 (1.301). The effect of dosage and storage had no significant difference (0.131) at $p \leq 0.05$. The results in Table 3 indicated that the two-way interaction of dosage and storage was significant ($p \leq 0.05$). The study noted that dosage had a negative effect on NCe 001, while storage had a negative effect on NCe 011 and NXs 001. Overall, dosage had an inverse relationship with sprouting, as its effect on the sprouting of cocoyam corms was negative. The effect of dosage and length of storage had little or no effect on the decay of NXs 002; hence it was removed from the result.

Table 3: Regression Coefficients for Sprouting

Term	Effect	Coef	SE Coef	t-Value	p-Value
Constant		1.25	1.07	1.17	0.257**
D	8.321	4.161	0.649	6.41	0.000*
ST	2.545	1.272	0.575	2.21	0.040*
V					
NCe 011	-1.010	-0.505	0.677	-0.75	0.465**
NCe 001	4.896	2.448	0.657	3.73	0.002*
NXs 001	-2.626	-1.313	0.677	-1.94	0.068**
D*D	7.67	3.83	1.33	2.88	0.010*
ST*ST	-1.86	-0.93	1.16	-0.80	0.432**
D*ST	-3.83	-1.91	1.21	-1.58	0.131**
D*V					
NCe 011	2.00	1.00	1.08	0.92	0.367**
NCe 001	-8.30	-4.15	1.08	-3.84	0.001*
NXs 001	4.31	2.16	1.08	2.00	0.061**
ST*V					
NCe 011	-0.080	-0.040	0.941	-0.04	0.966**
NCe 001	1.301	0.651	0.885	0.74	0.472**
NXs 001	-0.651	-0.326	0.941	-0.35	0.734**

D = Dose (Gy); ST = Storage (weeks); V= Variety; *significant difference ($p < 0.05$); **no significant difference ($p < 0.05$).

Prior to sprouting, the endogenous metabolic rate of corms is at their minimum with a constant respiration rate. The corms at this stage are classified as being in a dormant phase (Aniokwe, 2015). As the cocoyam corms start to sprout during storage, they utilise stored food to support their activities. Sprouting thus results in increase of metabolic activity and respiration leading to loss of quality (Alabi *et al.*, 2019). The rate of metabolism during sprouting is controlled by sprout regulators such as nucleic acid, nucleotide, hormonal synthesising system (Kalu *et al.* 2019). Postharvest processes that inhibit sprouting target the disruption of these sprout regulator. Feng *et al.* (2016) reported that the energy of agitation associated with gamma irradiation leads to disruption of the activities of nucleotides which is one of the sprout regulators. The results obtained in this study are thus the consequence of disruption in the activities of sprout-regulators. The results in the study obtained agreed with the findings of Adeyanju *et al.* (2019) for *Colocasia species* and Alabi *et al.* (2019) for *Xanthosoma species* on the sprouting behaviours of non-irradiated corms.

Conclusion

Irradiation treatment is among the few available technologies to replace chemicals due to their carcinogenic and mutagenic properties. The result of the study shows that the dose of gamma irradiation had significant and negative effect on the number of sprouted cocoyam which implied that increased in irradiation dose resulted in decreased number of sprouted cocoyam. Gamma irradiation therefore can with its positive advantage of not contributing to global warming serves as a means to reduce sprouting thus ensuring food security.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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