EFFECTS OF GAMMA IRRADIATION ON THE AGRO-MORPHOLOGICAL TRAIT OF SELECTED NIGERIAN SPINACH (*Amaranthus hybridus* L.) ACCESSION

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ABSTRACT

The mutagenic effects of gamma irradiation on the agro-morphological traits of spinach accessions were investigated to induce useful genetic variability for further breeding programme. Seeds of two spinach (*Amaranthus hybridus* L) accessions (GWM-002 and GWM-003) were collected from the Plant Biology Departmental Seed gene bank, Federal University of Technology Minna, Niger State. The seeds were exposed to five different gamma irradiation doses (0 Gy, 50 Gy, 100 Gy, 150 Gy, 200 Gy) at Centre for Energy and Research Training (CERT), Ahmadu Bello University, Zaria, Nigeria. The irradiated and the control seeds were planted at Department of Plant Biology Garden in a randomized complete block design with three replicates each. The results obtained showed significant differences ($p \leq 0.05$) on the agro-morphological traits with the highest number of leaves per plant (35.00), plant height (41.48), length of spike (33.16) and leave surface area (48.40) in GWM-002 and highest number of leaves per plant (38.60), plant height (52.50), length of spike (37.50) and surface area (80.40) in GWM-003. Therefore, 150 Gy and 200 Gy doses of gamma irradiation were obtained to be appropriate in creating beneficial traits in Spinach (*Amaranthus hybridus* L.) accessions.

Keywords: accession, agro-morphological, spinach, gamma irradiation

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INTRODUCTION

Amaranthus hybridus L. (2n =32) is popularly (called smooth Amaranthus or amaranth or pig weed) is cultivated in several areas of the world including south America, Africa, India, China and the United States (He and Corke, 2010). It is among the first generation of food crops in the world (Gigliola and Vera, 2012), and one of the most promising plant genera, and it consists of approximately 70 species of which 40 originated from the Americans, 17 are mainly vegetable species, three are grain while others are weedy (Andreas *et al.,* 2011). In Nigeria especially Yoruba community all species are referred to as "tete" even though they may add a second name to indicate a particular variety or species. The Hausas refers to them as "alaiyaho" while Igbos call them "imne". Spinach is a multipurpose crop whose leaves and grains are tasty and of high nutritional value, additionally, it can be cultivated as an ornamental plant (Venskutonis and Kraujalis, 2013). Amaranth is considered one of the most commonly produced and consumed indigenous vegetables on the African continent (Grubben, 2004). Spinach is mostly annual fast growing herbs that are mostly cultivated on lowlands especially the leafy species. Cultivation is not restricted to distant farms, Riverside, and home gardens as some families maintain some plants in small pots inside the house. Generally, spinach is fast growing and can be ready for harvest within weeks.

Mutation breeding by gamma rays is one of the most powerful methods for introducing a wide genetic variability in crops, as well as developing new varieties (Animasaun *et al.,* 2014). They are effective in improving growth and quality of plants, through their high mutation frequency; and can interact with atoms and molecules, thus producing free radicals in cells that affect the morphology, anatomy, biochemistry and physiology of the plants (El-Khateeb *et al.,* 2016). Large number of plant mutant varieties with desirable agro-morphological traits has been developed in closely related species by various authors using irradiation (Chopra, 2005 and Falusi *et al.,* 2012). This can also be of great value and benefit for the improvement of spinach (*Amaranthus hybridus* L.) which is an important food crop in Nigeria. The improvement of the crop through creation of variability would give room for selection of high yielding variety with improved agro-morphological characters and increase its agricultural productivity. Therefore, this study was carried out to determine the effects of the gamma irradiation doses on the agro-morphological parameters of selected Nigerian spinach (*Amaranthus hybridus* L.) accessions

MATERIAL AND METHODS

Seeds of two accessions of *Amaranthus hybridus* viz; GWM-002 and GWM-003 were collected from the Plant Biology Departmental Seed gene bank, Federal University of Technology Minna, Niger State. The viability of the seeds was tested before and after gamma irradiation according to the method described by (Maity *et al.*, 2009). Viable seeds of the accessions were irradiated at Centre for Energy and Research Training (CERT), Ahmadu Bello University, Zaria, Nigeria. The doses include; 50 Gy, 100 Gy, 150 Gy and 200 Gy, with un-irradiated seeds (0 Gy) as the control. The irradiated seeds with the control were planted in experimental pots, filled with sandy-loamy soil. Each treatment was replicated three times and arranged in a randomized complete block design, at the botanical garden of the Department of Plant Biology, Federal University of Technology Minna, Nigeria. All agronomic practices were carried out when necessary and the plants were monitored for morphological parameters.

Statistical analyses

The agro-morphological parameters collected for the experiment plant height, number of leaves per plant, length of spike, number of spikelets per plant, leaves surface area, and seed weight (100 seed). The data generated were subjected to statistical analysis using Analysis of variance (ANOVA) to test for significant differences and Duncan's multiple range test (DMRT) was used to separate the means.

RESULTS AND DISCUSSION

The effects of gamma irradiation on morphological parameters are presented in table 1 below. The result showed that gamma irradiation significantly ($p \leq 0.05$) influenced the highest plant height of 10.58 cm obtained in 50 Gy at week 2 while 30.22 cm and 41.46 cm were obtained in 150 Gy at week 4 and harvest respectively in accession GWM-002 were not significantly different from the height of other doses and lowest plant height of 6.48 cm, 23.68 cm and 34.92 cm were obtained in control and 50 Gy at week 4 and harvest respectively in accession GWM-002. Similarly, in accession GWM-003 highest plant height of 34.42 cm and 52.50 cm were obtained in 200 Gy at week 4 and harvest respectively. The highest plant height (34.42) obtained in 200 Gy at week 4 in accession GWM-003 were not significantly different ($p > 0.05$) from the height of other doses (Table 1).

A pronounced variation was observed in the number of leaves of mutant spinach at the different doses of gamma irradiation. In accession GWM-002 (35.00), the highest number of leaves (35.00) was recorded in 200 Gy which was not significantly different from other doses. Similarly, no significant ($p > 0.05$) highest number of leaves per plant (38.60) were obtained in plants exposed to 200 Gy gamma ray in accession GWM-003. The result reveals that gamma irradiation at high doses (200 Gy) increase the number of leaves in spinach. This result is however contrary to the findings of (Tshilenge *et al.*, 2013) who observed variations in the number of leaves of gamma irradiated groundnut (*Arachis hypogaea* L.) with 100 Gy having the highest number of leaves per plant. These differences could be attributed to difference in the biochemical and physiological constituents of the plants. As reported by Lockhart *et al.*, (1996), the increased in leaf number and area provides an increase in the surface area for gaseous ex-change which considerable affect the process of photosynthesis. Therefore, higher number of leaves will definitely give room for more photosynthetic processes, hence increase the plant production (Table 1).

Similarly, a significant variation was observed in most of the yield parameters such as number of spikelets per spike, length of spike, weight of 100 seeds and surface area in all the doses. The highest weight of 100 seeds (0.18 g), length of spike (33.16), number of spikelets per spike (106.4) and surface area (48.40) was obtained in plants exposed to 200 Gy gamma ray in accession GWM-002. In accession GWM-003, the highest weight of 100 seeds (0.20 g) was obtained in 200 Gy while the highest number of spikelets per spike (153.8), length of spike (37.50) and surface area (80.40) was also obtained in plants exposed to 200 Gy gamma ray (Table 2).

This could be attributed to the increase in the number of leaf and leaf area obtained in the doses which increase the photosynthetic rate of the plants and result in high yield. Khan and Wani, (2005) reported a decrease of pod number at 0.4 kGy (400Gy) treatments and an increase at 50 kGy (500 Gy) without a change in the number of seed per pod of chickpea. These differences could be due to the fact that gamma rays produce radicals that can damage and affect differentially plant morphology, anatomy, biochemistry, and physiology depending on the irradiation level and species of plants.

Conclusion

This study has demonstrated that 150 Gy and 200 Gy significantly influenced the agro-morphological traits such as plant height, number of leaves per plant, length of spike, number of spikelet per spike and surface area. Therefore, for effective induction of useful genetic variability in spinach (*Amaranthus hybridus* L.) accessions, moderate doses of gamma irradiation of 150Gy and 200 Gy should be employed for its improvement and selection of desirable mutants for breeding purpose.

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Table 1. Effects of gamma irradiation on the agro-morphology of spinach (*Amaranthus hybridus* L.) accessions

Irradiation Dose (Gy)	Plant height @ 2 WAG	Plant height @ 4 WAG	Plant height @ harvest	No. of leaves
GWM-002				
0	8.90±0.62ab	23.68±1.93a	40.20±3.16a	27.60±5.39a
50	10.58±1.11b	27.22±2.00a	34.92±1.79a	26.40±1.44a
100	8.58±1.59ab	26.60±2.23a	38.74±2.17a	29.80±3.02a
150	9.90±0.99ab	30.22±3.26a	41.46±3.36a	32.20±3.79a
200	6.48±0.97a	24.98±1.97a	37.62±1.43a	35.00±5.27a
GWM-003				
0	11.10±1.37a	30.44±2.14a	42.26±3.35a	35.40±2.52a
50	12.96±0.72a	33.14±2.72a	44.40±3.27a	30.80±2.50a
100	14.12±1.35a	30.74±2.64a	42.08±1.83a	29.00±1.48a
150	14.08±0.73a	33.28±0.28a	43.90±0.61a	28.40±1.29a
200	10.18±1.71a	34.42±3.12a	52.50±3.05b	38.60±6.49a

Values are Means ± Standard Error, followed by the same superscript(s) along the column are not significantly different at $p > 0.05$ as tested by DMRT., weeks after germination (WAG)

Table 2. Effects of gamma irradiation on the yield of spinach (*Amaranthus hybridus* L.) accessions

Irradiation Dose (Gy)	Length of spike	No. of spikelet per spike	100-seed weight	Surface area
GWM-002				
0	19.98±3.45s	46.20±10.24a	0.14±0.01ab	30.00±0.55a
50	27.84±3.76ab	69.00±5.25a	0.14±0.01ab	33.00±1.14a
100	31.40±1.03b	68.20±5.71a	0.18±0.02b	31.20±0.80a
150	30.54±2.90b	63.20±11.89a	0.13±0.01a	47.80±1.24b
200	33.16±1.41b	106.4±53.71a	0.15±0.01ab	48.40±1.21b
GWM-003				
0	32.80±3.10ab	93.40±21.17	0.16±0.02a	33.20±1.28b
50	32.86±3.71ab	113.0±18.26a	0.20±0.01a	30.20±1.28b
100	27.92±2.15a	74.80±12.54a	0.16±0.01a	39.40±1.78c
150	31.80±2.26ab	73.20±14.01a	0.19±0.03a	23.60±1.17a
200	37.50±2.99s	153.8±58.42a	0.19±0.03a	80.40±1.91d

Values are Means ± Standard Error, followed by the same superscript(s) along the column are not significantly different at $p > 0.05$ as tested by DMRT