EFFECTS OF GAMMA RADIATION ON SOME MORPHOLOGICAL CHARACTERS OF SWEET POTATO

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ABSTRACT

Inherent variations were observed in the leaf shape of sweet potato cultivars Kinabakab and UPLB Acc. 624 and in the root skin pigmentation of BNAS-51 cultivar. Doses of 2000 and 3000 rads produced wrinkled and deformed leaves in vM_1 plants of all three cultivars with the latter dose giving the higher percentage of aberrant leaves and plants with such leaves. Among the cultivars, Kinabakab apparently has the most radiosensitive leaf shape and leaf rugosity. Only Kinabakab had some vM_2 plants which retained the wrinkled leaves observed in vM_1 plants. The same cultivar exhibited the highest mortality of cuttings obtained from vM_1 plants which showed wrinkled and deformed leaves. One Kinabakab vM_2 plant treated with 3000 rads produced a secondary branch that was an apparent genetic variant. Vine length at maturity and internode length of vM_2 plants of the three cultivars were not significantly affected by various doses of gamma radiation.

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KEY WORDS: Sweet potato. Gamma radiation. Varietal characteristics. Inherent variation. Induced variation. Aberrant leaves. Mortality.

INTRODUCTION

Many studies have shown that ionizing radiations are more effective than mutagenic chemicals in inducing mutation in vegetatively propagated plants *(vpp)*. Nybom (1970) postulated that this may be because chemical mutagens do not easily penetrate target meristems and because chromosomal rearrangements which account for a large fraction of observed mutations in *vpp* are produced in higher proportions by means of ionizing radiations. In mutation induction studies in sweet potato [*Ipomoea batatas* (L.) Lam.], gamma radiation is a commonly used type of ionizing radiation. Among the morphological variants reported to have been induced by gamma radiation in sweet potato plants are mutations in root skin and flesh color (Hernandez et al., 1964; Kukimura and Kouyama, 1982 as cited by CAB, 1983), aberrations in leaf shape (Soriano, 1972) and darker color of leaves (Miu et al., 1973 as cited by Broertjes and van Harten, 1978). The present study was conducted to determine other mutations in morphological characters that may be induced by gamma radiation.

MATERIALS AND METHODS

Thirty 30-cm shoot tip cuttings each of Kinabakab, BNAS-51 and UPLB Acc. 624 sweet potato cultivars were divided into three groups of 10 cuttings each. The three groups of each cultivar were correspondingly irradiated with 1000, 2000, and 3000 rads Co^{60} gamma rays at the gamma research facility of the Philippine Atomic Energy Commission using a dose rate of 10,000 rads/hour. Another set of 10 cuttings each of the three cultivars were left unirradiated and set aside to serve as control. All cuttings were designated as vM_1 planting materials, planted in pots on the day of irradiation, and maintained for 2 months. Observations on cutting survival, plant growth and foliage traits were made on the unreplicated plots during the 2-month period. After 2 months, two randomly selected shoot tips were cut from the lateral branches of each vM_1 plant. These cuttings were designated as vM_2 planting materials to distinguish them from the vM_1 cuttings which were directly subjected to radiation. The vM_2 cuttings were used in a 3 x 4 factorial field experiment arranged following the completely randomized design with two replications. Each plot consisted of 10 vM_2 cuttings/plot spaced 1.0 m x 0.25 m apart. Cutting survival, plant growth as well as qualitative and quantitative foliage traits were observed regularly during the entire duration of the experiment. Plant pigmentation was determined using the color nomenclature book of Ridgway (1912) as reference.

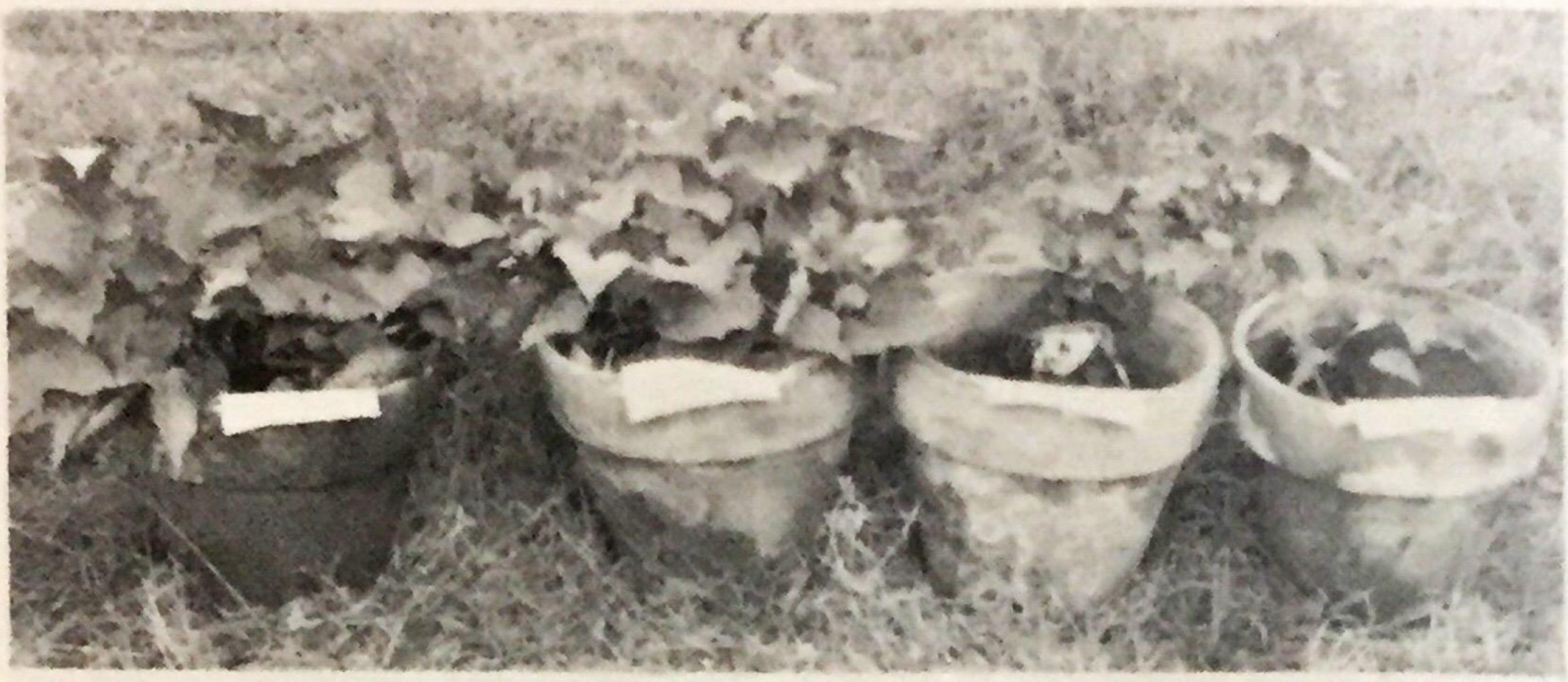
RESULTS AND DISCUSSION

Observations on vM_1 Plants

Gamma radiation to vM_1 plants resulted in reduced plant growth, and in wrinkled and deformed leaves. None of the vM_1 plants died as a result of irradiation.

All three cultivars generally exhibited greater growth reduction with increasing dose of gamma radiation as indicated by visually detectable differences in plant height (Fig. 1). This is a commonly observed phenomenon in plant irradiation experiments and is said to be due to plant damage which results from the inhibition of cell division and disruption of protein synthesis and hormone production (Sparrow, 1961).

Wrinkled and deformed leaves were observed only in plants treated with 2000 and 3000 rads with the



A

B

C

Figure 1. Effect of various doses of gamma radiation on plant height of three sweet potato cultivars. From top to bottom; A - Kinabakab, B - BNAS-51, and C - UPLB Acc. 624. From left to right pot; 0 rad, 1000 rads, 2000 rads and 3000 rads.

latter dose producing higher percentage of such damaged plants (Table 1). During the first 3 weeks of growth, most damaged plants produced wrinkled and deformed leaves but they started to produce normal-looking leaves during the fourth week. Leaf counts on the damaged plants during the eighth week showed that plants treated with 3000 rads generally had more wrinkled and deformed leaves per plant than those treated with 2000 rads (Table 1). Of the three cultivars, Kinabakab had the most wrinkled and deformed leaves, the greatest proportion of aberrant leaves per plant as well as the highest percentage of plants with such leaves. This indicates that the leaf shape and leaf rugosity of this cultivar are more radiosensitive than those of BNAS-51 and UPLB Acc. 624. Moreover, these results suggest that more meristematic cells in Kinabakab are damaged by radiation particularly in terms of leaf shape and leaf rugosity because recovery rate to normal leaf (apparently through diplontic selection) in this cultivar was slower than that in BNAS-51 and UPLB Acc. 624. Differences in response to gamma radiation among sweet potato culti-

Table 1. Percentage of vM_1 plants of three sweet potato cultivars that exhibited wrinkled and deformed leaves, and percentage of wrinkled and deformed leaves per damaged plant at 8 weeks after planting as affected by varying doses of gamma radiation.[1]

Cultivar	**Dose (rads)**			
	0	**1000**	**2000**	**3000**
	Percentage of Plants With Wrinkled and Deformed Leaves			
Kinabakab	0	0	40	90
BNAS-51	0	0	10	80
UPLB Acc. 624	0	0	10	90
	Percentage of Wrinkled and Deformed Leaves/Damaged Plant[2]			
Kinabakab	—	—	73	91
BNAS-51	—	—	69	73
UPLB Acc. 624	—	—	59	44

[1] Based on 10-plant unreplicated plots.
[2] Values are means of all plants that exhibited wrinkled and deformed leaves.

vars were also observed by Hernandez et al. (1964) and Cuevas-Ruiz and Koo (1973).

The foregoing observations fall under the physiological damage type of radiation effect. In mutation breeding, the term physiological damage as explained by Gaul (1970) is descriptive but does not point to the origin of the induced biological change, and may have both extra-chromosomal and chromosomal bases. Assuming that the observed wrinkled and deformed leaves were partly due to induced genetic changes, the plants that exhibited such leaves would be chimeras. Chimerism automatically results when several initial cells are present during mutagenic treatment, as in the case of the shoot tip cuttings irradiated in this experiment.

Observations on vM$_2$ Plants

Control Plants. Kinabakab and UPLB Acc. 624 exhibited two and several leaf shapes, respectively, while BNAS-51 exhibited uniform leaf shape. On the other hand, two types of root skin pigmentation were observed in BNAS-51 while the root skin of Kinabakab and UPLB Acc. 624 had uniform pigmentation (dull magenta purple - light buff for Kinabakab and light buff for UPLB Acc. 624). Apparently, these are inherent characteristics of the cultivars studied.

Variations in leaf shape of Kinabakab and UPLB Acc. 624 were due to angling of leaf margins or to indention or serration of lobes. In Kinabakab, the observed leaf types were both entire but differed in the form of the central margins. In one type, the central margins were smoothly curved while in the other type, each of the opposite central margins were angled (Fig. 2). Leaf shape and plant type (classified according to leaf shape exhibited) counts done at 4 months after planting are tabulated in Table 2. The type with angled central margins was fewer than the type with smooth margins. Moreover, most plants exhibited both types of leaves. All plants of UPLB Acc. 624 produced leaves of various shapes (Fig. 3). However, the leaves of this cultivar seemed essentially three-lobed with the basal lobes being variously indented or serrated, thus giving rise to various leaf shapes.

The storage root skin of BNAS-51 was either entirely light buff or light buff with Congo pink streaks. Root skin type (classified according to pigmentation) count showed that there were fewer roots with Congo pink streaks.

The foregoing morphological variations indicate that the cultivars used may have inherent somatic genetic variation at least with respect to leaf shape and root skin pigmentation. They may be mistaken as mutagenic effect in sweet potato mutation induction work hence, it is necessary to watch out for such inherent variations.

Irradiated Plants. The morphological variations observed in control plants were also observed in irradiated plants (Tables 2 and 3). Wrinkled leaves were also observed

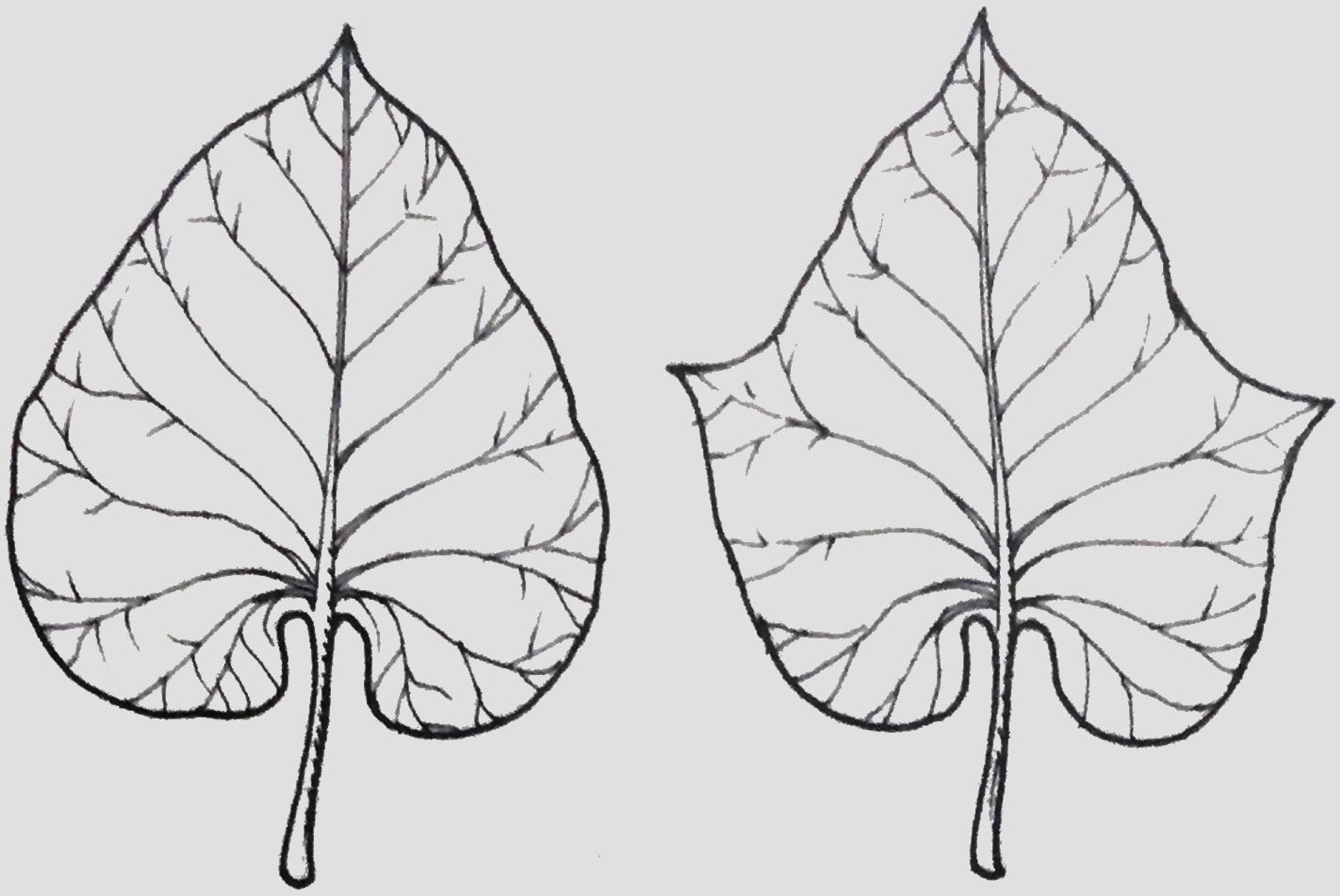


Figure 2. Two leaf shapes exhibited by Kinabakab sweet potato cultivar.

Table 2. Leaf shape count per vM_2 plant and plant type (classified according to leaf shape exhibited) count in Kinabakab sweet potato cultivar at varying doses of gamma radiation.[1]

		Dose (rads)			
		0	**1000**	**2000**	**3000**
		Number of Leaves/Shape/vM_2 Plant[2]			
Leaf Shape	Entire	169	142	162	128
	3-lobed	66	61	48	46
Mean Number of Leaves/Plant		235	203	210	174
		Number/Plant Type[3]			
Plant Type	Entire only	1	1	1	1
	Entire and 3-lobed	15	15	15	12
	3-lobed only	1	0	1	0
Total Number of Plants		17	16	17	13

[1] Counts were made on vM_2 plants at 4 months after planting.

[2] Averaged across total number of surviving plants in each dose.

[3] Counts included all surviving plants in each dose.

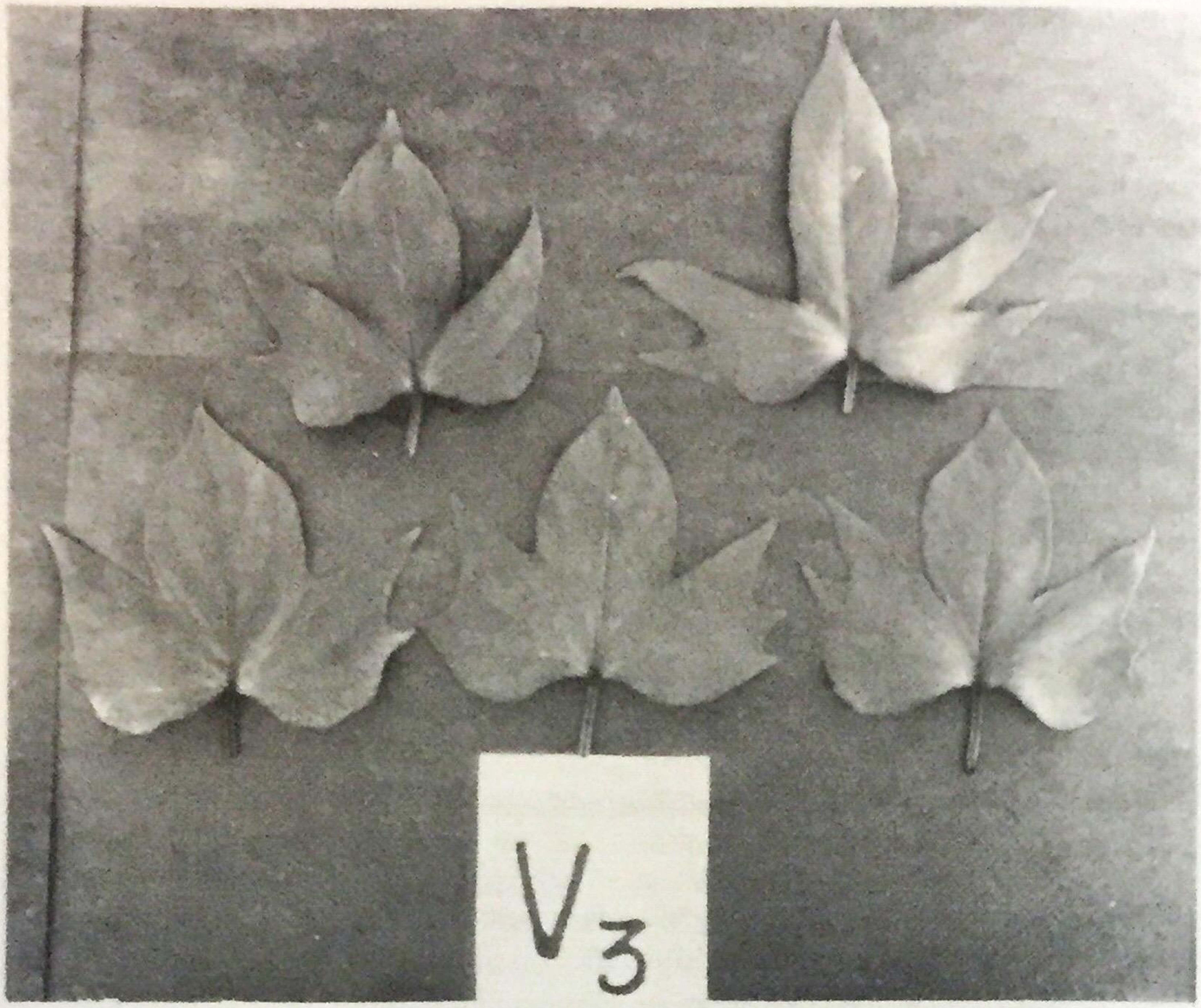


Figure 3. Various leaf shapes exhibited by UPLB Acc. 624 sweet potato cultivar.

Table 3. Root skin color type count in BNAS-51 sweet potato cultivar at varying doses of gamma radiation.[1]

Root Skin Color	Number of Roots/Root Skin Color Type			
	Dose (rads)			
	0	1000	2000	3000
Light buff	15	14	17	10
Light buff with Congo pink streaks	3	8	8	5
Total Number of Roots	18	22	25	15

[1]Roots were harvested about 7 months after planting and counts included all roots of all surviving plants in both replications.

but deformed leaves previously observed in vM_1 plants were absent. Of the three cultivars, only Kinabakab showed wrinkled leaves in vM_2 plants but at a lower percentage than in vM_1 plants (Table 4). This cultivar also had the highest mortality of cuttings obtained from vM_1 plants that exhibited wrinkled and deformed leaves. In BNAS-51, some of the cuttings obtained from damaged vM_1 plants also died but none died in UPLB Acc. 624. These results suggest that Kinabakab generally had the worst radiation damage while UPLB Acc. 624 had the least. Moreover, the results imply that the cultivars differ in their ability to recover from radiation damage. However, recovery would obviously be affected by the severity of the damage on meristematic cells.

Table 4. Mortality and percentage of vM_2 plants of three sweet potato cultivars that exhibited wrinkled leaves, and percentage of wrinkled leaves per damaged plant at 2 months after planting as affected by varying doses of gamma radiation.

	Dose (rads)			
Cultivar	**0**	**1000**	**2000**	**3000**
		Mortality (%)[1]		
Kinabakab	—	—	12	39
BNAS-51	—	—	0	31
UPLB Acc. 624	—	—	0	0
	Percentage of Plants with Wrinkled Leaves			
Kinabakab	0	0	6	31
BNAS-51	0	0	0	0
UPLB Acc. 624	0	0	0	0
	Percentage of Wrinkled Leaves/ Damaged Plant[2]			
Kinabakab	—	—	72	89
BNAS-51	—	—	—	—
UPLB Acc. 624	—	—	—	—

[1]Refers to the mortality of shoot tip cuttings obtained from vM_1 plants that exhibited wrinkled and deformed leaves.

[2]Values are means of all plants that exhibited wrinkled leaves.

Among the radiation doses, 3000 rads caused the greatest damage to Kinabakab and BNAS-51 plants. This effect was not observed in UPLB Acc. 624.

The reduction in percentage of plants that exhibited wrinkled/deformed leaves from vM_1 to vM_2 strongly indicates that some plants partially recovered from the radiation damage. According to Broertjes and van Harten (1978), recovery from morphological damage may be brought about by the taking over of axillary buds or adventitious buds. Pratt (1963) mentioned that recovery can also occur within a shoot apex and described various ways by which this can take place. No matter how recovery is brought about, diplontic selection always acts as the somatic sieve that usually gives the selective advantage to normal and often fittest cells.

Only one apparent genetic variant was observed in the entire experiment. The variant which was observed in Kinabakab at 3000 rads, exhibited a chimerical secondary branch with leaf and stem pigmentations that were markedly different from the normal (Fig. 4 and Table 5). The variant branch was observed at 27 weeks after planting and arose from a plant that exhibited some wrinkled leaves. The pigmentation

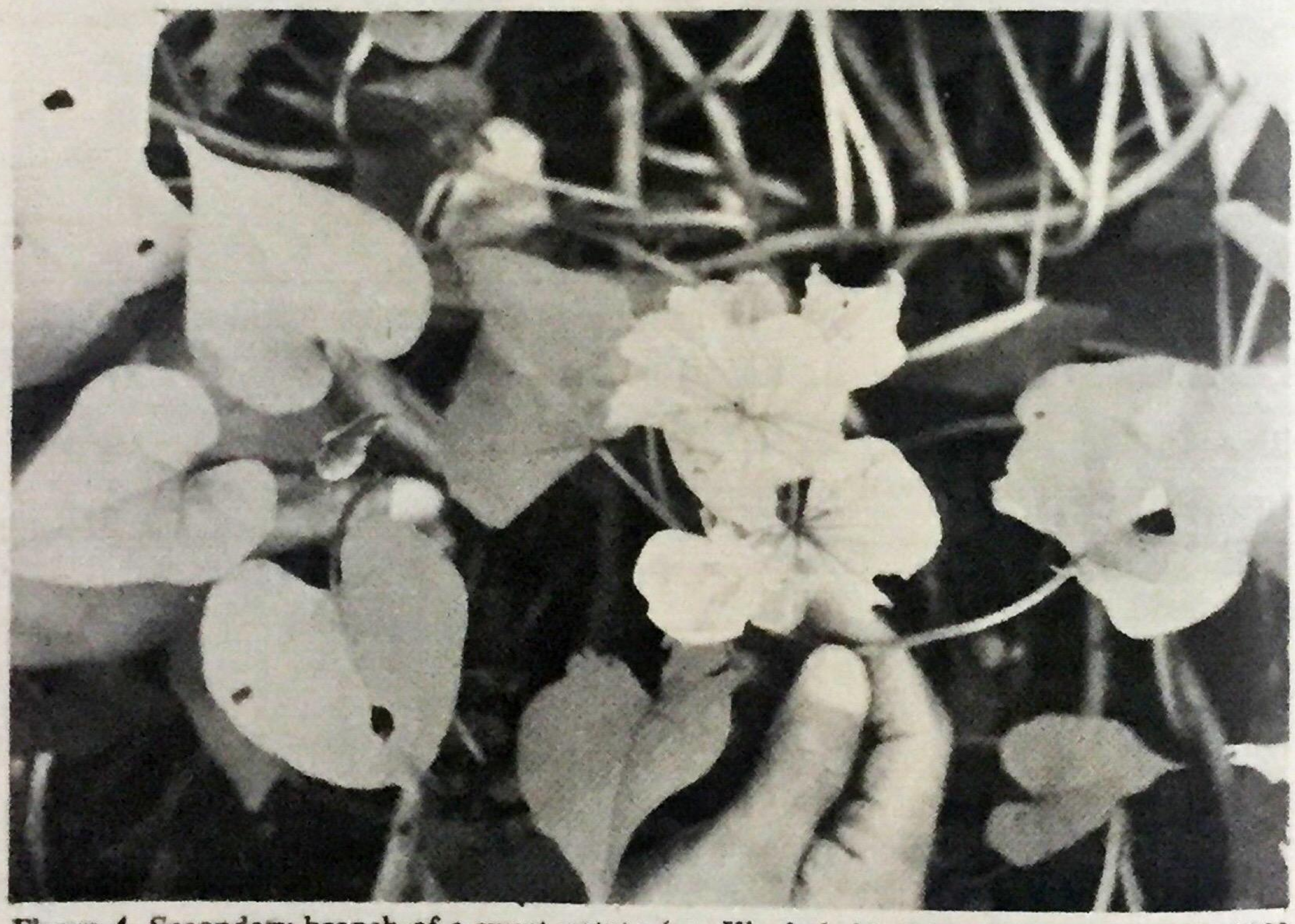


Figure 4. Secondary branch of a sweet potato (cv. Kinabakab) vM_2 plant treated with 3000 rads showing variant foliage pigmentation.

Table 5. Comparison of the pigmentations of a normal and a variant branch in one Kinabakab vM_2 plant treated with 3000 rads of gamma radiation.

Branch	Stem	Leaf			
		Petiole	Vein	Margin	Blade
Normal	Rivage green	Pale yellow	Pansy purple	Pansy purple	Tiber green
Variant	Rhodamine purple	Rhodamine purple	Rhodamine purple	Rhodamine purple	White or amaranth pink with lumiere green spots

shift in the variant branch started at the fourth internode with the third node serving as the pigmentation boundary. The shift in pigmentation was sharp and the pigmentation boundary made a smooth circle around the third node. Apparently, the variant phenotype of this branch was uncovered through apical tissue rearrangements. It cannot be ascertained, however, whether the variant characteristics were induced by radiation or were merely manifestations of an inherent genetic heterogeneity of the material uncovered by radiation.

Mean vine and mean internode lengths of plants at harvest were not significantly affected by various radiation doses in the three cultivars (Table 6). As it is difficult to detect variants in these quantitative characters unless quantitative changes are radical, appropriate experimental procedures such as those employed by Poole (1959) in detecting clonal yield differences in sweet potato have to be carried out.

Table 6. Mean vine and internode lengths of three sweet potato cultivars at 4 months after planting as affected by various doses of gamma radiation.

Cultivar	Dose (rads) 0	1000	2000	3000
		Vine Length (cm)[1]		
Kinabakab	236 ± 13.56	276 ± 6.70	212 ± 19.10	219 ± 14.22
BNAS-51	294 ± 5.52	324 ± 4.53	278 ± 8.83	315 ± 16.69
UPLB Acc. 624	206 ± 13.51	209 ± 14.19	184 ± 7.84	210 ± 13.92
		Internode Length (cm)[1]		
Kinabakab	4.12 ± 0.32	4.34 ± 0.19	3.95 ± 0.14	3.70 ± 0.30
BNAS-51	7.11 ± 0.31	7.08 ± 0.40	6.63 ± 0.35	5.52 ± 0.30
UPLB Acc. 624	3.32 ± 0.16	3.78 ± 0.26	3.66 ± 0.22	3.66 ± 0.12

[1] Values are followed by standard error and are not significant at 5% level, DMRT.

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