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PHENOTYPIC VARIABILITY IN M1 POPULATIONS OF SESAME (*Sesamum indicum* L.) IRRADIATED WITH GAMMA RAYS

Variabilidad fenotípica en poblaciones M_1 de sésamo (*Sesamum indicum* L.) irradiado con rayos gamma

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ABSTRACT. Mutation induction has been used in breeding programs to produce genetic variability. The objective of the research was to evaluate the phenotypic variation induced by gamma radiation in sesame seeds. The experiment was carried out in the experimental field of the Agricultural Sciences Faculty in the National University of Asunción, between October 2013 and February 2014. Seeds used corresponded to the M_1 generation, from Escoba cultivar. Completely randomized design was used, with three treatments 0, 300 and 400 Gy, respectively, and twenty five repetitions, randomly selected within the field crop, with eight plants each one. The variables evaluated were: color, pubescence and position of leaves, stem color at maturity, pubescence and type of branching, density of pubescence and dehiscence of capsules, color and texture seed, morphological traits used as varietal descriptors. International Sesame descriptor was used for the characterization of each variable. The data for all variables were subjected to analysis of variance and Tukey test at 5 % probability of error. Variables that showed statistically significant differences for all treatments were: color, position and leaf pubescence, color at maturity, pubescence branching type and capsules pubescence. For dehiscence of capsules, color and texture of the seeds coat were not observed statistical differences. It was concluded that for the morphological traits gamma radiation treatments at doses of 300 and 400 Gy, is effective as a method of mutation induction and generation of phenotypic variability in sesame seeds.

Key words: phenotype, mutation, gamma radiation

RESUMEN. La inducción de mutaciones ha sido utilizada para crear variabilidad genética en programas de mejoramiento. El objetivo de la investigación fue evaluar la variación fenotípica inducida por radiación gamma en semillas de sésamo. El experimento se realizó en la Facultad de Ciencias Agrarias de la Universidad Nacional de Asunción, de Octubre del 2013 a Febrero del 2014. Se utilizaron semillas de la variedad Escoba, correspondientes a la generación M_1. El diseño fue completamente al azar, con tres tratamientos 0, 300 y 400 Gy y veinticinco repeticiones, seleccionadas al azar dentro de la parcela, con ocho plantas por repetición. Las variables evaluadas fueron: color, pubescencia y posición de las hojas, color en la madurez, pubescencia y tipo de ramificación, densidad de la pubescencia y dehiscencia de cápsulas, color y textura de la semilla, características morfológicas consideradas descriptores varietales, que fueron caracterizadas con el descriptor de Sésamo internacional. Los datos obtenidos fueron sometidos a análisis de varianza y las medias a la prueba de Tukey al 5 % de probabilidad de error. Las variables que presentaron diferencias estadísticas significativas para todos los tratamientos fueron: color, posición y pubescencia de hojas, color del tallo en la madurez, pubescencia y tipo de ramificación y pubescencia de cápsulas. Para dehiscencia de cápsula, color y textura de la cubierta de semillas no se observaron diferencias estadísticas. Se concluye que, los tratamientos con radiación gamma en dosis de 300 y 400 Gy, resultan efectivos como método de inducción de mutación y generación de variabilidad fenotípica en semillas de sésamo.

Palabras clave: fenotipo, mutación, radiación gamma

INTRODUCTION

Sesame (*Sesamum indicum*) is a crop that in most countries where it is sown, it is in the hands of small producers, very few technicians, who use varieties with

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low productivity. Better yields, tolerance or resistance to pests or diseases, grain quality are characteristics that should be improved. Using from conventional methods to techniques associated with biotechnology. The gamma-induced mutation on seeds of cultivated plant species has proven to be a valid tool in breeding programs for the creation of genetic variability in order to obtain genotypes to satisfy the needs and demands of producers of different cultivated species. Until 2007, approximately 2,300 cultivars were developed from mutagenesis, which were released and officially registered in the database of mutant varieties. The main strategy in mutation-based breeding has been the use of well-adapted varieties in which one or two major traits have been altered, limiting their productivity or increasing their qualitative value (1, 2).

Ionizing radiations are currently an important route that the breeder can use to create genetic variability that does not exist in nature (3). Because of the high energies they possess, gamma rays constitute a type of ionizing radiation capable of penetrating matter more deeply than alpha and beta radiation. They can cause severe damage or modifications to the nuclei of cells (4, 5). Thus, numerous studies have been carried out using gamma rays, in order to obtain crops of high yield, varieties resistant to diseases, tolerant to lack of water and high salinity of soils. Likewise, works has been reported on obtaining genotypes resistant to broad spectrum herbicides (6, 7).

The use of irradiation with gamma rays in sesame produced mutants, with characteristics as indehiscent or semi-indehiscent capsules and habit of indeterminate growth that facilitates and avoids losses in the harvest. Mutations have also been reported for wilt tolerance, chlorophyll deficiency, very pubescent and multicarpelate capsules, increased size and number of capsules per axilla, changes in branching, plant height and cycle, fatty acid content and other characteristics that result Useful according to the zones and production techniques of this species (8, 9). The objective of the work was to evaluate the phenotypic variability induced by gamma radiation in sesame seeds through the evaluation of the variability observed in the morphological descriptors normally used to characterize the cultivars.

MATERIALS AND METHODS

The work was carried out in the experimental field of the Faculty of Agrarian Sciences of the National University of Asunción, in San Lorenzo city. Seeds of the sesame, Escoba variety were used, which is characterized by being long-cycle, plant erection, stem branched and hairless, white flowers, white grains and sweet taste, characteristic for which, it is the most sown in areas of production and preferred in export markets (10). The seeds used corresponded to the M1 generation. The material was supplied by the Multidisciplinary Center for Technological Research of the National University of Asunción. A completely randomized design was established for three treatments 0, 300 and 400 Gy. Three plant populations corresponding to each of the treatments were planted. Twenty-five samples were taken at random, within each population, each with eight plants on which the evaluations were performed. The variables evaluated were color, pubescence and leaf position, stem color at maturity, pubescence and type of branching, pubescence density and capsule dehiscence, color and texture of seed. For the statistical analysis, the codings corresponding to each variable evaluated according to the Sesame descriptor of the International Plant Genetic Resources Institute (IPGRI) of 2004 were used (11). The data obtained were subjected to analysis of variance and the comparison of means of each treatment was performed using the Tukey test at 5 % probability of error.

RESULTS AND DISCUSSION

Color, position and pubescence of leaves

The analysis of variance revealed highly significant differences among the treatments for the characteristic leaf color ($p \leq 0.0116$). In the unirradiated control 97 % of the plants had yellowish green leaves according to the descriptor used. In contrast, only 78 % of the plants from seeds irradiated with 400 Gy had leaves with this characteristic, statistically different from the control, but not from the treatment with 300 Gy con 82 %. The statistical differences in the observed percentages for the characteristic color of the leaf are due to the presence of green leaves in the populations submitted to 300 and 400 Gy. Thus, in the plants that came from irradiated seeds, between 18 and 22 % of plants with green leaves were observed, whereas in the control treatment with 0 Gy the green leaves did not exceed 3 %. (Figure 1). The irradiated treatment plants had 97 % yellowish - green leaves, characteristic of the Escoba variety according to the descriptions made, which establishes the yellowish - green color of the leaves as one of Escoba's varietal descriptors (10, 12, 13).

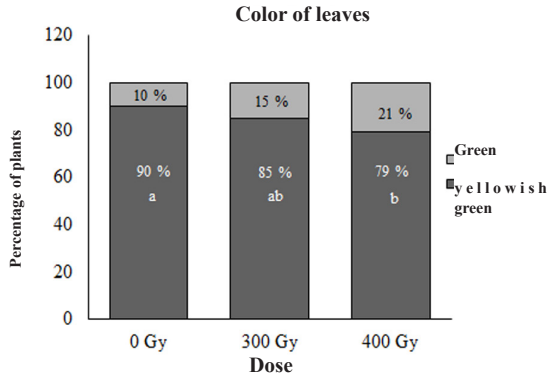
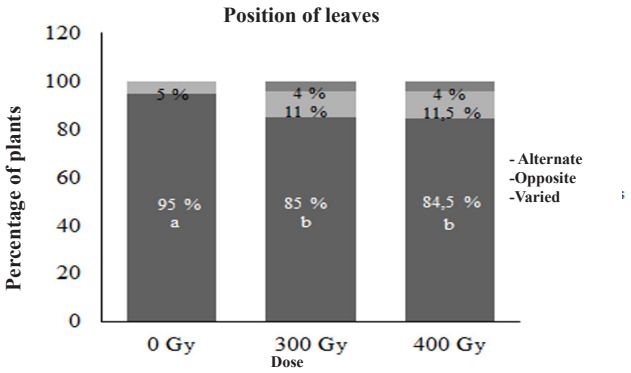


Figure 1. Percentage of phenotypic variants observed for the characteristic color of leaves in sesame, Escoba variety, from irradiated and unirradiated seeds

Regarding the characteristic position of the leaf, we also observed highly significant differences (p≤0,002). In the unirradiated control, 95 % of the plants with leaves of varied position were observed according to the descriptor used, statistically different to the percentages corresponding to the plants coming from seeds irradiated with 300 and 400 Gy with 85 and 84,5 % respectively. The statistical differences observed are due to the presence of other types of arrangement, different from the varied position, which is opposite at the bottom and alternates at the top of the same plant (11). For the doses of 300 and 400 Gy in addition to the leaves with varied position were observed 4 % of plants with alternate position and in the remaining 11% leaves in opposite positions (Figure 2). In the Escoba variety, a varied leaf position predominates as reported by other researchers. However, since it is a variety that does not derive from a pure line, some phenotypic variability is still observed for certain characteristics (12, 13).



Likewise, the differences for the characteristic leaf pubescence were also highly significant (p≤0,001). The comparison between the observed percentages indicated differences between the unirradiated control and the treatments with 300 and 400 Gy. The observed differences are due to the presence of phenotypic variants other than the characteristic hairless that was observed in almost all the plants coming from unirradiated seeds, while in the plants coming from 300 Gy, 10 % was observed and in the treatment of 400 Gy, 22 % of plants with scarce pubescence respectively (Figure 3). In the published morphological descriptions of the Escoba variety one of its most distinctive features is the absence of leaf and stem pilosity as reported by the different descriptors (10, 12, 13).

Color of stem at maturity, pubescence and type of branch

The analysis of variance indicated highly significant differences among treatments for stem color characteristics at maturity (p≤0,0044). Differences were observed between the control and the treatments with 300 and 400 Gy but not between the latter. In the unirradiated control 94 % of the plants had the yellow stem at the time of maturation, while in the treatments with 300 and 400 Gy, 86 and 83 % respectively of plants with this characteristic were observed. The differences observed are due to the presence of plants with stems of green color in a proportion of 14 and 17 % in the treatments with 300 and 400 Gy (Figure 4). The yellow color of the stem at the ripening time has been reported as a distinctive feature of the Escoba variety, becoming one of the varietal descriptors (10, 12).

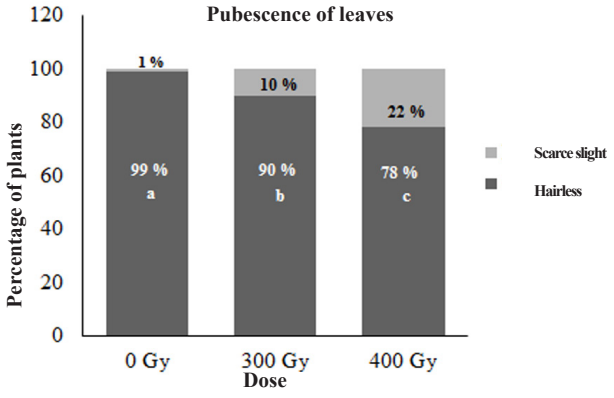


Figure 3. Percentage of phenotypic variants observed for the characteristic pubescence of leaves in sesame, Escoba variety, from irradiated and unirradiated seeds

In relation to the pubescence of the stem were also verified highly significant differences among the treatments evaluated (p≤0.0001). The unirradiated control had mostly (99 %) stalks with hairless characteristics, statistically different from treatments with 300 and 400 Gy with 90 and 75 % respectively, with plants with hairless stems. The statistical differences observed for the characteristic pubescence of the stem are due to the presence of stems with low pubescence or scaling in proportions of 10 and 20 % in the treatments with 300 and 400 Gy respectively (Figure 5). The hairless stem is a characteristic in which the descriptions of the Escoba variety coincide that distinguish it fundamentally from other similar varieties in terms of branching, size and cycle, color of flower and grain, although it is possible to observe stems with some type of pilosity in low proportions (10, 12, 13, 14).

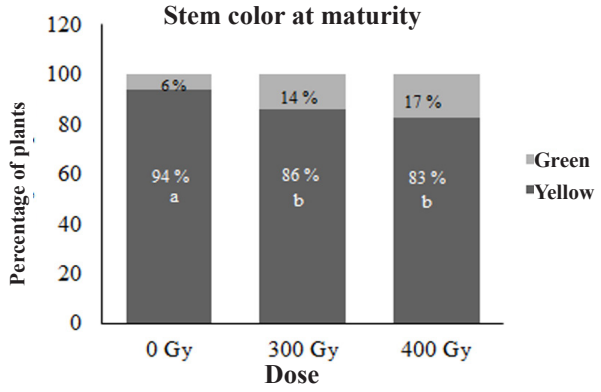


Figura 4. Percentage of phenotypic variants observed for the characteristic stem color at maturity in sesame, Escoba variety, from irradiated and unirradiated seeds

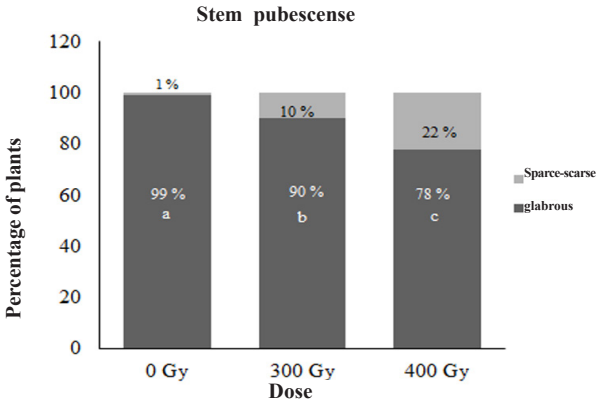


Figura 5. Porcentaje de variantes fenotípicas observadas para la característica pubescencia del tallo en sésamo, variedad Escoba, provenientes de semillas irradiadas y sin irradiar

Regarding the type of branching, it also observed highly significant differences (p≤0.0157) among treatments with doses of 300 and 400 Gy, but not between the control and the same. In the unirradiated control all the plants had branching and 87 % of them had a higher branching statistically equal to the 92 and 82 % observed in the treatments with 300 and 400 Gy respectively. In the treatment with 400 Gy, 18 % of plants with basal branching and also single stem plants were identified (Figure 6). In the treatment with 400 Gy were also observed some plants without branching in percentages inferior to 1 %. The branching type of the Escoba variety is described as upper branching (10, 12, 13). On the other hand, non-branched mutants are frequently observed in gamma irradiated sesame (8).

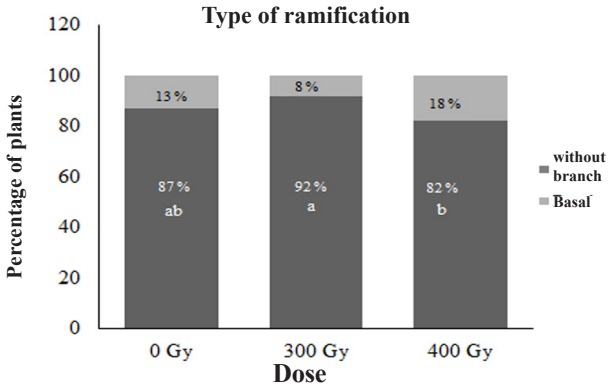


Figure 6. Percentage of phenotypic variants observed for the characteristic type of branching in sesame, Escoba variety, from irradiated and unirradiated seeds

WITHOUT PUBESCENCE AND CAPSULE DEHISCENCE

For the density of pubescence were observed highly significant differences (p≤0,0001). At 97 % of plants with hairless capsules, statistically different to 82 and 72 % of plants with hairless capsules observed in treatments with 300 and 400 Gy, respectively, were observed. Statistical differences between irradiated treatments were also observed (Figure 7). The characteristic of pubescence of the capsules in the Escoba variety has been reported in some cases as hairless (10) and in other works with scarce pubescence (13). Research carried out using a dose of irradiation with 300 Gy in a Turkish variety, report the production of plants with capsules very pubescent (6).

For the characteristic, dehiscence of the capsules, it was not possible to perform the analysis of variance, because when they reached the maturation stage in all treatments evaluated, the plants presented dehiscence capsules (Figure 8). The reported work agrees that the dehiscence of capsules in the field is characteristic of the Escoba variety, a characteristic that in this trial was not modified by irradiation treatments of 300 and 300 Gy (10, 12, 13). Using 600 Gy, out of a total of 85 plants, two plants were observed that showed indehiscent and 13 of them resulted in semi- indehiscent of capsules (8).

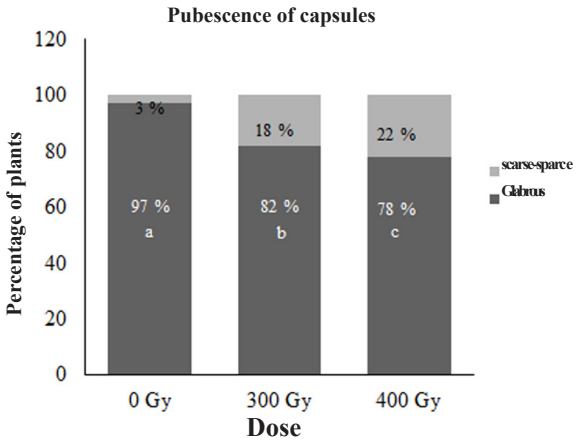


Figure 7. pubescence of capsules

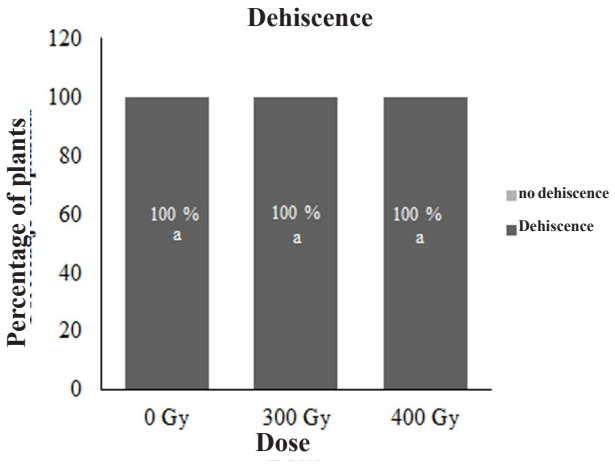


Figura 8. Percentage of phenotypic variants observed for the characteristic dehiscence in sesame, Broom variety, from irradiated and unirradiated seeds

Color and texture of the seed cover

No significant statistical differences were observed for the color variables (p≤0.2389) and texture (p≤0,2904) of the seed cover. In all treatments cream seeds were observed, in proportions of 87, 86 and 81 % for treatments without irradiation and irradiated with 300 and 400 Gy (Figure 9). In general, seed of the Escoba variety has been described as a light-colored seed with reports indicating that it is white (10), while in other works it is mentioned as white-beige or beige according to the varietal descriptors (11, 13). In relation to the texture of the seed coat, the rough texture was observed in 97 % of the plants of the unirradiated control and 88,5 and 89,1 % of the plants from seeds irradiated with 300 and 400 Gy respectively, There being no significant differences among treatments (Figure 10). The seeds of the Escoba variety have been characterized with covers of smooth texture in some works (10) and, with rough texture in others according to the varietal descriptors used (11, 13). On the other hand, the roughness pattern is modified according to the time of harvest. So, in the same batch of seeds it is possible to observe different patterns of texture of the cover. Although the color of the seed is governed by other genes, the texture of the integument has influence on it; seeds with rough texture have darker shades than the seeds of smooth texture (15).

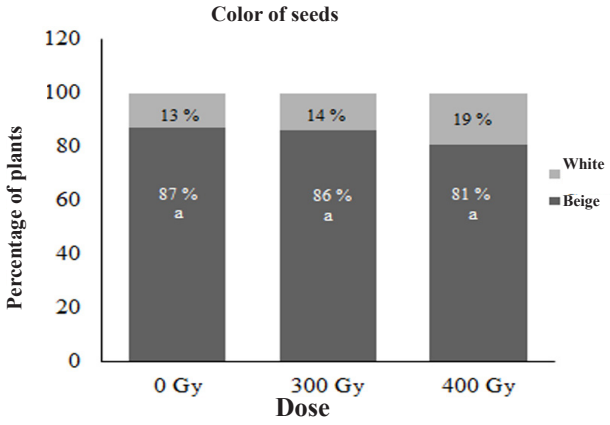
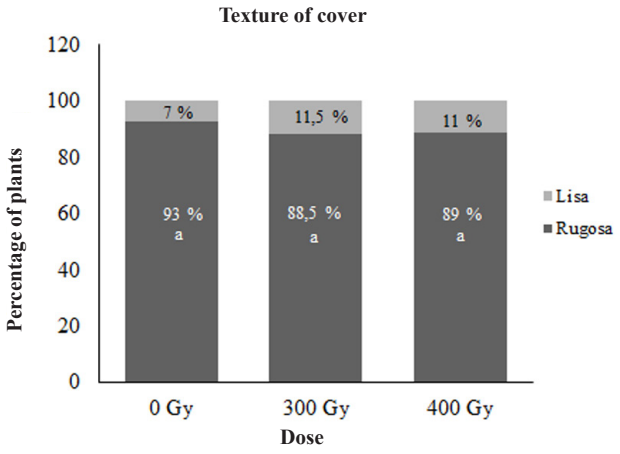


Figure 9. Percentage of phenotypic variants observed for the characteristic color of seeds in sesame, Ecsoba variety, from irradiated and unirradiated seeds



The increase in the pubescence of leaves, stems and fruits are characteristics that can contribute to a better resistance of the Escoba variety to the sucking insects and consequently to the virus diseases transmitted by them, to which the variety is highly susceptible (10, 16, 17). The absence of significant changes in the color and texture of the seeds, is favorable because it is sought to maintain these characteristics, typical of the Escoba variety and important at the commercialization time.

CONCLUSIONS

- The treatments with gamma radiation in doses of 300 and 400 Gy are effective as a method of mutation induction and phenotypic variability generation in sesame seeds.
- The characteristics that presented variation with irradiated treatments were: color, position and pubescence of leave; color of stem at maturity, pubescence and type of branching and pubescence of capsules. No variation was observed in the characteristics, dehiscence, color and texture of the seed cover.
- The most useful phenotypic changes generated by irradiation treatments are increases in leaf, stems and fruit pubescence, which may contribute to the improvement of resistance of the variety to viral diseases.
- There were no changes in the color and texture of the seeds, which is favorable because it is sought to maintain these characteristics in the Escoba variety.

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SPECIAL NUMBER

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Note:

During the editing process it was not possible to access the work of retouching and improvement of images, so they have been inserted with the same quality as the ones sent by their authors.

The editorial

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