Short communication

Effects of gamma rays on cocona (*Solanum sessiliflorum*Dunal)

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ABSTRACT

Aims: The present work aims to assess the gamma rays effects on cocona (*Solanum sessiliflorum*).
Study design: Cocona seeds of CUB-08 genotype were exposed to gamma rays (0, 100, 150, 200, 300 and 400 Gy) and sowed in styrofoam seedling trays. Seedlings were then planted, in the open field, three months later, following randomized block design with four blocks and seven plants per plot,
Place and Duration of Study: The present study was developed in Instituto Nacional de Pesquisas da Amazônia at the Agricultural experimental station, which is located on Km 14AM-10 roadway,fromApril 2016 to December 2016
Methodology: Fruits wereharvested from November to December 2016. Fruit characteristics such as yield, pilosity (1=No pilosity and 3=Excessive pilosity), weight, diameter, number per plant, and ripening after seven days (1=firm; 3=rotten) were assessed. Furthermore, stem pilosity was assessed, as well.
Results: Results showed 200 Gy dose to decrease the germinating vigor, whereas300 and 400 Gy were highly deleterious and prevented seeds from germinating. In contrast, 100 and 150 Gy doses did not affect germinating vigor, but justcreated germinating vigor andfruit pilosity variability.
Conclusion: The gamma ray-150 dosemay be used to enhance this species'genetic diversity.

Keywords: cubiu;peach tomato;irradiation; mutation; plant breeding

1. INTRODUCTION

Cocona (*Solanum sessiliflorum*Dunal) is a traditional Amazonian fruit, its flavor is like an unknown citrus mixture. This fruit displays pilosity, which is a typical characteristic of this species, making it harder to be harvested on account of the itching it inflicts onto the pickers' exposed skin parts. This phenotype would have to keep on exhibiting its natural genetic variability so as to overcome this drawback, which will enable it to be improved through manual crossings or backcrossings. However, cocona's fruit pilosity variability must be induced since it is hard to be found naturally. The use of gamma radiation, to come up with desirable mutants, has shown to be the successful way of increasing any crop's genetic diversity [1,2,3,4].

Radiation dose and number of genetic mutations have shown to be directly related, yet higher doses induce cromossomical mutations [5], preventing the seeds from germinating and, thus leading the embryo to die. Conversely, lower doses have shown to be unable to induce significant mutations [2]. Therefore, it is essential to be able to calculate the accurate dose to be used. In the case of cocona, there seems to be no published information concerning the optimal dose to be used, therefore, one must seek for it on kin species.

Eggplant, a species phylogenetically related to cocona, has enabled to determine that 300 Gy of gamma radiation increases the fruit size and mass, when it is applied to its seeds [6]. In another similar work in eggplant, 160 Gy displayed to be appropriate dose for induce favorable mutations [2].

Gamma radiation that is used in plants, is generally produced by radioactive elements such as cobalt-60 and cesium-137 [7]. Its short waves, at picometer level, have high penetration power, which produce ions inside the cells causing irreparable damage to cellular nucleus. It is considered the mutations main inductor for creating new varieties from 1971 to 2008 [7],its genetic effects on cellular nucleus go from genome mutations to gene mutations [8]. The gene mutations for plant breeding are more useful because they don't damage most of the genetic material.

In plant breeding programs have been used different plant tissue for irradiation, such as whole plants, seeds, tubers, stems, buds, bulbs, pollen, *in vitro* plants, embryos, microspores and callus [8]. Yet, seeds have been preferred for their easy to transport, handle and store, i.e. can be irradiated, stored and germinated at any time.

The present study has irradiated cocona seeds with different doses ranging from 0 to 400 Gy for determining the optimal dose to bring about their variability.

2. MATERIAL AND METHODS

The experiment was carry out atInstituto Nacional de Pesquisas da Amazônia (Manaus, AM) in the Agronomical Experimental Station (Manaus, AM), which is located on Km 14AM-10 roadway(2.9964S and 60.0236 W).

Cocona seeds of "CUB-08" genotype were gamma-irradiated at Centro de Energia Nuclear Aplicada à Agricultura (CENA/USP, Piracicaba, SP) with different doses i.e. 0, 100, 150, 200, 250, 300 and 400 Gy with a cobalt-60 source, which itself emitted 5010 Gy/h.

These seeds were sent to Manaus-AM and sown in 128-cell styrofoam trays filled with Plantmax® mineral-organic substrate. Following three weeks, the seedlings were transplanted to plastic cups filled with this same substrate, then, three months later; they were transplanted to the open field in randomized complete block design, with four blocks and seven plants per plot. Plants were grown for five months and their fruits harvested every week for two months

The assessed fruit characteristics were yield, pilosity (1=No pilosity and 3=Excessive pilosity), weight, diameter, number per plant, and ripening after seven days (1=firm; 3=rotten). Furthermore, stem pilosity was assessed, as well.

Data were submitted to analyses of variance (ANOVA) and means were compared by the Duncan Test (P<0.05). These analyses were performed in SAS 9.1.3, procedure PROC GLM (SAS Institute, Cary NC). Moreover, using JMP 10 software was done an biplot graphic based on correlations and principal components analysis.

3. RESULTS AND DISCUSSION

Mutagenic agentswhich are grouped into chemical, physical and biological ones may be recommended for inducing genetic variability in plants (Bado et al. 2015). Physical radiations have been a very popular, plant breeding mutagenic agent, and gamma radiation has shown to be the most utilized one [7]. However, there are no former studies addressing radiation dosages in cocona. On account of both cocona and eggplant being phylogenetically related [9], this research was oriented through a previous work on eggplant [6], which demonstrated that 300 Gy of gamma radiation would induce non deleterious variability, thus the tested dosages for cocona were determined from 0 to 400 Gy.

The experiment was initially planned to be conducted with 20 plants per plot, yet only seven plants per plot were used due to their seeds' general germinating vigor loss, which was evident in the control treatment (0 Gy). This indicates the seeds to have likely been submitted to temperature stress during their transport (Manaus-São Paulo-Manaus). Studies have shown that cocona seeds are thermosensible [10, 11], where variations of temperature from 20 to 30 °C increase the germination percentage. This reduced plot size is close to that being used for other Solanaceae family species: *Capsicum annuum* (10 plants) [12,13]. Therefore, the plot plant number used in this study is acceptable.

Dose of 150 Gy significantly decreased fruit pilosity (Table 1). Furthermore, it induced no effect on the other traits, such as the number of plants per plot, the stem's pilosity, fruit yield, mass, length (L), diameter (D), L/D ratio and ripening. This conclusion is also shown on biplot graphic (Figure 1), which explains 89% of total variation, where 150 Gy is found in the fruit pilosity vector opposite direction, i.e. this dose decreases the character expression. Moreover, fruit yield and number vectors orthogonal projections point toward 150 Gy, suggesting this dose tend to increase these characteristics. Therefore, this dose shows to be more adequate for inducing the fruit pilosity's genetic variability and increasing fruit yield.

Table 1. Effect of different gamma radiations on the morphoagronomical trait means of cocona (*Solanum sessiliflorum*Dunal). Manaus 2016.

Radiation dosages	Plant number per plot	Stem pilosity	Fruit pilosity[1]	Fruit Yield ($t\ ha^{-1}$)	Mean fruit mass	Fruit length (L)	Fruit diameter (D)	L/D ratio	Ripening (at 7 days)[2]
0 Gy	3.00 b[4]	2.08 a	2.28 a	7.19 a	152.66 a	8.60 a	6.40 a	1.34 a	1.46 a
100 Gy	5.75 a	2.20 a	2.18 ab	6.65 a	167.44 a	8.48 a	6.62 a	1.31 a	1.62 a
150 Gy	4.00 ab	2.05 a	2.00 b	7.42 a	146.90 a	7.98 a	6.08 a	1.35 a	1.18 a
200 Gy	2.75 b	2.00 a	2.25 a	2.07 a	132.85 a	7.62 a	6.22 a	1.22 a	1.13 a
Mean	3.87	2.08	2.16	5.83	149.96	8.17	6.33	1.29	1.34
CV[3] (%)	30.10	9.31	5.80	59.95	13.93	9.19	5.40	6.93	25.01

[1] 1=No pilosity e 3=Excessive pilosity. [2] 1=firm; 3=rotten. [3] Coeffient of variation

[4]Equal letters indicate there not to have been significant radiation differences, by the Duncan test (P=.05)

These findings shown to be similar to found for plant dry and fresh weights in a eggplant genotype (160 Gy) [2]. But these researchers observed low effect of the same radiation dose in another eggplant genotype, displaying the presence of genotype x radiation interaction. Thus, our results would be valid mainly for CUB-08 cocona genotype. Other genotypes can need different doses.

Given these four treatments, our findings have shown 100 and 150 Gy to contribute to significantly increase the germinating vigor and decrease fruit pilosity as compared with 0 Gy (Table 1). This positive effect can be explained by gamma rays ability to modify both cell physiology and morphology. For instance, irradiation can increase polygalacturonase and pectin-methyl-esterase activityresulting in pectin degradation [14].Another study showed in *in vitro* culantro (*Eryngium foetidum* L.) that 40 Gy-gamma rays increased flavonoids, flavonone, anthocyanin, vitamin C and folic acid content, and decrease flavonols andpyridoxine[15].These facts suggest that combination of some metabolites may break downseed dormancy and consequentlyincreasethe germinating vigor. On the other hand, pilosity decreasing can be explained by genetic factor such as in nectarine/peach case[16]; however, the present work suggests cocona pilosity to be not controlled by asingle gene.

In contrast, 200 Gy decreasedgerminating vigor. The rest of characters such as, stem, fruit's pilosity,number, yield, mass, length, diameter, C/D ratio and ripening time have shown no significant radiation dose-induced differences. They suggest 100 to 200 Gy doses not to be deleterious for these characters. However, 200 Gy tends to reduce fruits number per plant and yield (Table 1).

Biplot graphic (Figure 1) explained about 89% of total variation. In consequence, this graphic represents most part of data and their interactions. It showed three equidistant radiation doses (100, 150 and 200 Gy), suggesting their different and contrasting effects. Yet, 0 Gy is near the vector origin, indicating its lower effect for modifying the morphoagronomic characteristics. Hence, gamma rays have shown to be able to modify agronomical characters in cocona. On the other hand, 150 Gy was related with high fruit yield and fruit number per plant. Whereas 100 Gy was related with high values of fruit mass and diameter. These findings indicate 100 to 150 Gy being the optimal range of doses that creates variability for fruit yield and its components.

This biplot has also shown 200 Gy being in opposite direction of characteristics vectors. This indicates that their effect is deleterious for cocona both plant developing and fruit yielding.

Dose recommendation of gamma ray to induce non-deleterious mutations depends on species and vegetative material. For example, in tomato seeds was recommended 50 to 150 Gy [17], in grasspea seeds 100 Gy [18]. Yet, in banana plants and shoots was recommended 20 to 30 kGy [19], in fig plantlets 30 kGy [20] and in potato meristems 2.5 Gy [21]. Therefore, each species and material needs a specific recommendation.

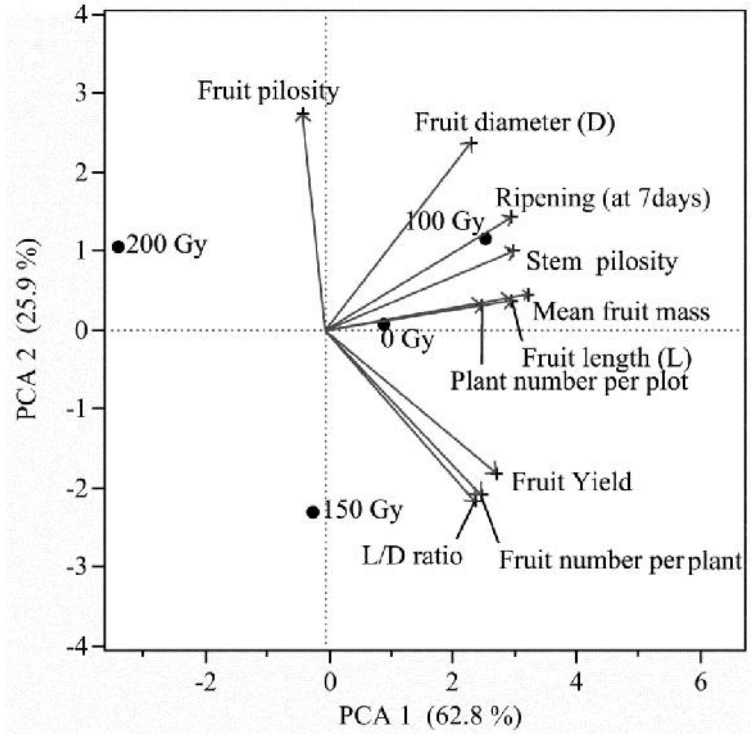

Fig. 1. Biplot graphic of gamma radiation doses over cocona (*Solanum sessiliflorum*) seeds and some morphoagronomic characters (vectors)

Doses from 250 to 400 Gy were highly deleterious as shown by their seeds'germinating vigor loss and, experimental treatments number reduction to four (0, 100, 150 and 200 Gy). These findings suggest genetic variability in cocona to be able to be induced by using doses of less than 250 Gy.

4. CONCLUSION

Gamma radiation doses applied on cocona seedsabove 200 Gy showed to be highly deleterious on account of hampering the seed germination. The optimal dosages for inducing mutations on cocona have shown to range from 100 to 150 Gy, yet, if the objective is to induce high variability, 150 Gy has shown to be more effective, in addition to not modifying any of the fruit's agronomical traits such as, yield, mass, length and diameter.

COMPETING INTERESTS

Authors have declared there not to be any competing interests.

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