Short communication

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

.

ABSTRACT

Harvesting hairy fruits of currentcocona (*Solanumsessiliflorum*) is a painful task because the hair is itching. Therefore, growerswould be interested in hairless fruit type planting materials. Breeding for this character depends on the amount of genetic variety present within the species. In the case of limited genetic variabilityoccurring naturally, one can be created using mutagenic agents.Gamma rays were used in the course of the present study**Aims:** The present work aims to assess the gamma rays effects on cocona (*Solanum sessiliflorum*).

Study design:onCcocona seeds of genotype CUB-08 genotype were exposed to gamma rays (at 0, 100, 150, 200, 300 and 400 Gy. Irradiated seeds were) andsowedsowninstyrofoam seedling trays, then . Seedlings were thentransplanted, in the open field, three months later, followinga randomized block design with four blocks and seven plants per plot,

Place and Duration of Study: The present study was developed inthe Agricultural experimental station of theInstitutoNacional 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,The 100 and 150 Gyradiations doses did not affect germinating vigor, but justcreated led togerminating vigor andfruit pilosity variability whereas 200Gy decreased the germination rate, and 300 and 400 Gy were totally deleterious. Therefore,

Conclusion: The gamma ray 100-150 could dosemay be used to enhancethis species'genetic diversityfor fruit pilosityand for fruit number as well.

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

1. INTRODUCTION

Cocona (*Solanumsessiliflorum*Dunal) is a traditional Amazonian fruit.,itsIts 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 foundlimited 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[1, 2].

Radiation dose and number of genetic mutations have shown to be directly related, yet higher doses induce chromossomical mutations[5][3], preventing the seeds from germinating and, thus leading to the embryo to diedeath. Conversely, lower doses have shown to be unable to induce significant mutations [2][1]. Therefore, it is essential to be able to calculate determinethe 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 applied to its seedsincreases increasedthe fruit size and mass, when it is applied to its seeds[64]. In another similar work in eggplant, 160 Gy displayed to be appropriate dose for induce favorable mutations [21].

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 Itproduces ions inside the cells causing irreparable damage to cellular nucleus or . It is considered the genome mutations to gene mutationsmutations main inductorsfor creatingof 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 pPlant breeding programs have been usedwhole plants or different plant tissues for irradiation, such as whole plants, seeds, tubers, stems, buds, bulbs, pollen, *in vitro* plants, embryos, microspores and callus [85]. 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 100to 400 Gy for determining the optimal dose to bring about theirthat creates variability.

2. MATERIAL AND METHODS

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

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Cocona seeds of genotype"CUB-08" genotype were gamma-irradiated with different doses i.e. 100, 150, 200, 250, 300 and 400 Gyfrom a 5010 Gy/hcobalt-60 sourceat the Centro de Energia Nuclear Aplicada à Agricultura(CENA/USP, Piracicaba, SP). The control was not irradiated 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.

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These seeds were then sent to Manaus-AM and sown in 128-cell styrofoam trays filled with Plantmax® mineral-organic substrate. Following Afterthree weeks, the seedlings were transplanted to into plastic cups filled with this thesame Plantmax®substrate.,tThen, three months later; they were transplanted to the open field in a randomized complete block design, with four blocks replicationsand 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 ripenessing~~ing~~ 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~~ usingSAS 9.1.3, procedure PROC GLM (SAS Institute, Cary NC). Moreover, ~~using JMP 10 software was done~~ an biplot graphic was done based on correlations and principal components analysisusing JMP 10 software(..).

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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)~~[5]. Physical radiations that include gamma 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~~inspired by 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 100 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 indicated~~s~~ the seeds ~~to~~ have likely been submitted to temperature stress during their transport (Manaus-São Paulo-Manaus). In fact, ~~S~~studies have shown that cocona seeds arethermosensible [~~10, 11~~7], where variations of temperature from 20 to 30 °C increase the germination percentage. This reduced plot size is close to ~~that~~ the 10 plants per plot~~being~~ used for ~~other Solanaceae family species:~~ *Capsicum annuum*~~(10 plants)~~[~~12,13~~8]. Therefore, the 7 plants per plot ~~plant number~~ used in this study ~~is~~wasacceptable.

~~Dose of~~ The ANOVA reveal radiation effect on the fruit pilosity and on the number of fruits per plant. It did not detect any radiation effect of the rest of the characters such as, stem, fruit's pilosity,number, yield, mass, length, diameter, C/D ratio and ripening time.

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The150 Gyradiation 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, fruit mass, fruit length ~~(L)~~, fruit diameter (D), fruit length to diameter ratio (L/D)~~ratio~~ and fruit ripenessing~~ing~~. This ~~conclusion~~ resultis also shown on biplot graphic (Figure 1), which explains 89% of total variation. ~~, where~~The 150 Gy~~is~~ was found in the fruit pilosity vector's opposite direction, i.e. this dose decreased~~s~~ the character expression. Moreover, fruit yield and number vectors orthogonal projections point toward 150 Gy, suggesting this dose tended 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 traits~~means~~ of cocona (*Solanumsessiliflorum*Dunal)~~. Manaus 2016.~~

Radiation dosages	Plant number per plot	Stem pilosity	Fruit pilosity[1] (cm?)	Fruit Yield (t ha^{-1})	Mean fruit mass (g or kg?)	Fruit length ~~(L)~~(cm?)	Fruit diameter ~~(D)~~(cm)	L/D ratio	Ripenessin~~g~~ (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

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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)~~C:V- Coefficient of variation, mean values followed by the same letter were not significantly different

The 150 Gy radiation was very close to the 160 Gy that created genetic diversity ~~se findings shown to be similar to found~~ for plant dry and fresh weights in a eggplant genotype ~~(160 Gy)~~ [~~2~~1]. 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~~ wouldneed different doses.

~~Given these four treatments,~~ Our findings have shown 100 and 150 Gy~~to~~ contributed 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~~9].Another study on *in vitro*culantro (*Eryngiumfoetidum* L.) 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 and pyridoxine[~~15~~10].These facts suggest that combination of some metabolites may break downseed dormancy and consequentlyincreasethe germinating vigor. On the other hand, pilosity~~decreasing~~ decreasecan be explained by genetic factor such as in nectarine/peach case[~~16~~11]; however, the present work ~~suggests~~ suggestedthat coconapilosity~~to be~~was not controlled by asingle gene.

In contrast, 200 Gydecreasedgerminati~~on~~ rateng ~~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, non-irradiation (0 Gy) is near the vector origin, indicating natural environment's~~its~~ lower effect ~~for~~ on creating variability of~~modifying the~~morphoagronomiccharacteristics. Hence, gamma rays have shown to be able to inducing ~~modify~~ agronomical characters' variation in cocona. On the other hand and in absolute terms, 150 Gy was related with high fruit yield and fruit number per plant. Whereas 100 Gywas related with high values of fruit mass and diameter in absolute terms also. These findings indicate 100 to 150 Gy~~being~~ could bethe optimal ~~range of~~ doses ~~that~~ tocreate~~s~~ variability for fruit yield and its components in cocona genotype CUB-08. The graphic showed

~~This biplot has also shown~~ 200 Gy~~being~~ in opposite direction of the characteristics' vectors indicating this radiation dose~~. This indicates that their~~ effect ~~is~~ was deleterious for coconafor both plant developmenting and fruit yield.~~ing.~~

Dose recommendation of gamma ray to induce non-deleterious mutations depends on species and vegetative material. For example, in tomato seeds it was~~recommended~~ 50 to

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150 Gy [~~17~~12]~~, 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~~13]. Therefore, each species and material needs a specific recommendation.

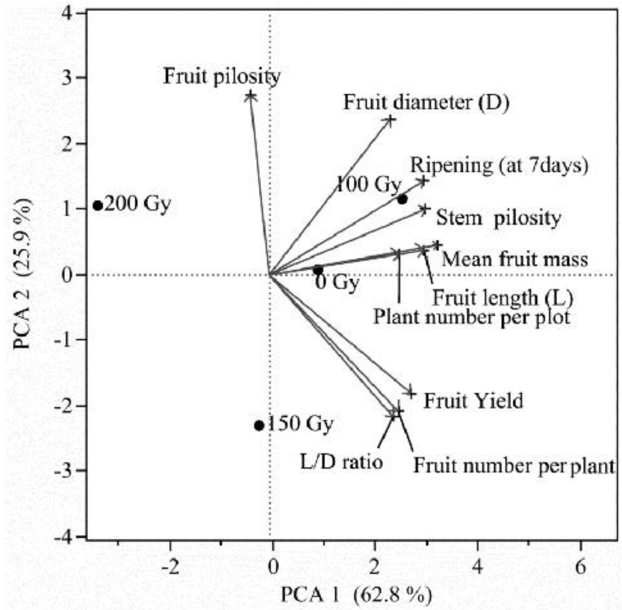

Fig. 1.Biplot graphic of gamma radiation doses over cocona (*Solanumsessiliflorum*) seeds and some morphoagronomic characters ~~(~~vectors~~)~~

Doses from 250 to 400 Gy were highly deleterious leading to~~as shown by their seeds'germinating vigor loss~~non-germination of their irradiated seeds.~~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~~

In 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~~ in cocona have shown to range from 100 to 150 Gy, ~~yet, if the objective is to induce high variability,~~although 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.Gamma radiation doses above 200Gy showed to be highly deleterious on account of hampering the seed germination.

COMPETING INTERESTS

Authors have declared there not to be any competing interests.

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