EFFECT OF GAMMA IRRADIATION ON GROWTH PARAMETERS OF VEGETABLE COWPEA (*Vigna unguiculata L.Walp*)

Original Research Article

ABSTRACT

Aim: The present investigation was carried out to study the effect of gamma irradiation on the growth parameters of cowpea variety Paiyur-1.Seeds were irradiated with physical mutagen viz., gamma irridation. The doses of radiation used were control, 50 $_{Gy}$, 100 $_{Gy}$, 150 $_{Gy}$, 200 $_{Gy}$, 250 $_{Gy}$, 300 $_{Gy}$, 350 $_{Gy}$, and 400 $_{Gy}$.Finding the LD_{50} and GR_{50} value for the physical mutagen dosages is the study's major goal. Cs137 is exposed to gamma radiation, and the observation were recorded in the M1 generation.

Study Design: The regression method by applying Probit analysis based on rates of fatalities was utilised to estimate the Lethal Dose (LD_{50}). Simple Linear Regression on the dose-response curve was adopted to evaluate the GR_{50} incorporating all of the vegetative parameters using R software.
Place and Duration of Research: The study was carried out at Horticulture orchard, Department of Vegetable Science, Horticulture College and research Institute, Tamil Nadu Agricultural University, Coimbatore during 2022-2023.
Methodology: In this study, the paiyur-1 variety of cowpea was sown with two replications, those mutagenized seeds were planted individually in germination paper using the roll towel method and dry seeds that weren't irradiated served as the control. To find the lethal dose 50 and to observe the shoot length, root length, germination percentage, mortality rate and seed vigour.
Results: Among the 9 gamma irradiated treatments, 50_{Gy} and 100_{Gy} exhibited superior germination percentages, despite the fact 50 Gy treated seeds were having appealing shoot length, root length, and plant height. The linear relationship have given that shoot length and root length are the two parameter that are highly susceptible to gamma irradiation than plant height and seed vigour.

Keywords: Mutation, Vegetable cowpea, Gamma irradiation, Lethal dose (LD_{50}), Growth reduction (GR_{50}), germination percentage and mortality rate.

1. INTRODUCTION

Cowpea ***(Vigna unguiculata* (L.)Walp*)*** is also known as southern pea, black eye pea, black-eyed bean, asparagus bean, body bean, snake bean *lobia, niebe* or *coup'e*, originated from Africa. It is a diploid plant with chromosome number 2n=22 belongs to the family Fabaceae (Papilionoideae as the subfamily), genus *Vigna*, and section *Catiang*, and species *unguiculata.* It is a nutritious vegetable legume crop with the potential to reduce protein-calorie deficiency. It is an annual legume and an essential component of cropping systems in the dry and marginal areas of the tropics. In tropical and sub-tropical regions of the world, its ability to endure climatic change makes it a crucial legume crop for food and nutritional security.

Most of the cowpea varieties are high in biological yield although their economic yield is low. India accounts for about 0.5 million tonnes production from 1.5 million ha. Average productivity in India is 600 to 750 kg/ha (Indiastat). It is cultivated in the semi-arid regions of Rajasthan, Gujarat, Karnataka, Tamil Nadu and Maharashtra mostly as grain legume. In Tamilnadu, vegetable cowpea cultivated under the area of 2946.40 ha with the production of 68787.17 tonnes, which accounts productivity 23.35. (Anon, 2021-22).

It provides numerous economic, environmental, and agronomic benefits that improve food and nutritional security. Due to its biological capacity to fix nitrogen and its favourable impacts on the soil, which include promoting microbial diversity and enhancing soil's ability to withstand present climate changes and helps to sustainably improve the environment. Cowpea is a crop that has the potential to help India meet its need for plant-based protein because of the high protein content in its leaves, immature pods, and grain. It improve India's food, nutrition, and health security. In India, cowpea is eaten in a variety of ways. Young leaves, growing points, green pods, and green seeds are all utilized as vegetables. Vegetable cowpea provides vitamins and minerals, if used properly it can enhance the nutritional status of human being. A crop with strong nutritional and nutraceutical qualities, the cowpea has great potential as a smart food crop. The cowpea is a truly multipurpose, climate-resilient crop that can advance global food security.

Cowpeas are a versatile legume crop. It is abundant in macro- and micronutrients for human consumption and contains high-quality protein. Hence, new varieties with desirable characters has to be developed.The productivity of cowpea is much less, when compared to other pulse. The main reason for most of the present day varieties were developed through selection by exploiting the variability. It is self - pollinated and crop pollination process is complete before flower opens. Therefore, the inherent variability in this crop is very much limited. On the other hand, there is high rate of flower bud abortion in cowpea. About 70-88% of flower buds shed prior to anthesis. Under certain environmental conditions, about half may abort prematurely, leaving only 6 to 16% of the total flower buds produce mature fruits.

Cowpea is self-pollinated crop, variety development by mass selection, pureline selection, hybridisatiion and pedigree breeding are challenging. Due to their autogamous nature, they also lack genetic diversity. The inherent variations in cowpea is also low.The natural variations in cow pea were used in traditional breeding, and as a result, there is no enough favourable variation to continue improving cowpea.

Mutation breeding is one of the best way to create variability in cowpea. Mutation breeding is a quick and efficient strategy for crop improvement that works well for generating genetic variants in self-pollinated plants. In order to get the desired genotype, mutations obtained through mutation breeding can also be included as traditional alleles in crossing programs.

High mutagenic doses could decrease the growth promoters, induce growth inhibitors and cause distinctive abnormalities in the chromosomes. Hence, high dose of the mutagens will lead to maximum lethality of the plants, except few plants. On the other hand, low radiation dose is associated with early emergence, a greater probability of germination, and field being able to survive with sturdy and resilient seedlings. However, this is correlated with the low mutation frequency and a good response of selection to target mutations.

Maluszynski *et al*., (2000) and Reddy and Dhanashekar (2007) reported that seven mutant varieties of cowpea were released in India by using physical mutagen (gamma rays) and chemical mutagen (EMS). The aim of the present investigation was to assess the efficiency and effectiveness of physical as well as chemical mutagens in cow pea variety. Since, vegetable cowpea varieties with high yield and better pod quality has not been released in Tamil Nadu till now and no proper research thrust has been given for the improvement of this legume vegetable.

In conventional breeding genetic variability couldn't be created. Hence, mutation breeding is one of the best method for creating variability in Cowpea. Among the physical mutagens, gamma mutagen took advantage to generate genetic diversity. The success of the mutation breeding depends on the genetic makeup of test varieties, dosage and duration are the main factors that determines the effectiveness and efficiency. It stimulates genetic changes in crop varieties. Gamma irradiation has created number of useful mutants in vegetative plants for improving their economic traits (Predieri, 2001). In this context, gamma irradiation was used to mutate cowpea variety Paiyur1.Keeping the above points in view, the experiment was carried out with the objectives of studying the effect of gamma irridation on vegetataive parameters of cow pea variety. Paiyur1.

MATERIALS AND METHOD:

EXPERIMENTAL MATERIAL:

The experiment was carried out at the

Department of Vegetable Science, Tamilnadu Agricultural University, Coimbatore, Tamil Nadu during 2023. The details of variety chosen and characters of the variety is mentioned in **Table 1.**

Table 1.Characters of the Cowpea variety Paiyur 1

VARIETY	PARENTLINE
Paiyur-1	Selection from VM 16
Particulars	Details
Organisation of release	Paiyur Research Station, TNAU
Year of release	1985
Habit	Bushy erect plant
Plant height (cm)	60-70
Leaf shape	Dark green leaflets possessing triangular white spots
Inflorescence	Axillary raceme
Flower colour	purple
Days to 50% flowering	70-75^{th} day
Maturity (days)	100-120 days
Number of seeds per pod	10-12
Seed colour	Brick red
Pod yield /plant (g)	120g
Grain yield (t/ha)	0.9
100 seed weight (g)	9.9
Special features	Suitable for rainfed

The physical mutagen, gamma rays was used to irradiate the seeds of vegetable cowpea variety Paiyur-1. The treatment was done in the gamma chamber- Low dose irradiator 2000 in ICAR-National Research Centre for Banana,Trichy,Tamil Nadu. Cs^{137} served as source of gamma rays .For irradiation, the dry, evenly sized, well-filled, genetically pure, uniform seeds were taken in the brown colour envelope and placed in the gamma chamber and subjected to gamma radiation for the proper amount of time for each dose. Dry, non-irradiated seeds were served as control. The seeds were irradiated with series of doses *viz.,*50 Gy,100Gy, 150Gy, 200Gy, 250Gy, 300Gy, 350Gy and 400 Gy and treatment dose is furnished in T

EXPERIMENT IN LAB

Both treated and untreated seeds were sown in roll towel method for the purpose of laboratory analysi. After sowing the seeds, observations were made on a variety of vegetative characteristics, including the survival %, plant height (cm), shoot length (cm), root length (cm), and vigour index. Nine gamma irradiation doses, including a control with two replications were adopted in the study. The experimental design, followed in the study was randomised complete block design.

GERMINATION PERCENTAGE

Seed germination was counted on 5^{th} and 8^{th} day after sowing. It was expressed in percentage of germinated seedling by total number of seeds sown.

SEED VIGOUR

Table 2: Gamma irradiation dosage

Treatments	**Selected dose**	**Irradiation time**
T1	CONTROL	-
T2	50	00:04:10
T3	100	00:08:20
T4	150	00:12:31
T5	200	00:16:41
T6	250	00:20:52
T7	300	00:25:02
T8	350	00:29:12
T9	400	00.33.23

The formula used to determine the vigour of the seedlings is mean root length + mean shoot length X percentage of seed germination.

STATISTICAL EVALUATION:

The regression method by applying Probit analysis based on rates of fatalities was utilised to estimate the Lethal Dose (LD_{50}). Simple Linear Regression on the dose-response curve was adopted to evaluate the GR_{50} incorporating all of the vegetative parameters. The R programming language served as the tool for the analysis

RESULT

Lethal dose (LD_{50}) Determination

The survival percentage demonstrated a negative linear connection in response to dose, indicating that an increased dose of mutagen could trigger the survival rate to decline. Based on the mortality rate for plants that were subjected to gamma radiation, the LD_{50} values derived from the Probit approach were **250.316**Gy.

Growth reduction (GR_{50}) Determination

From the present investigation, gamma irradiation treatment resulted in the survival rate of t 752.0833 Gy. All vegetative parameters *viz*., survival rate, shoot length, root length, plant height, and seed vigour, exhibited GR_{50} values that were 752.0833 Gy, 1429.9Gy, 661.7 Gy, 920.6307 Gy, and 427.004Gy, respectively.
In Gamma Irridation treatment, the R2 value of 0.5621167 was obtained for the root length indicating that the doses might not influence more on it. The R_2 value for the survival rate, shoot length, root length, plant height, and seed vigour were 0.8857, 0.3840, 0.7812, 0.6766473 and 0.9801respectively. Out of which seed vigour showed maximum 2 value. The values are furnished in the Table 3.

Growth parameters	GR 50	R_2	Linear regression equation
Survival rate	752.083	0.8857	Y= -0.13866 x + 104.2889
Shoot length	1429.9	0.3840	Y= -0.01279 x + 18.2982
Root length	661.7	0.7812	Y= -0.002617 x + 17.322
Plant height	920.6307	0.6766473	Y= -0.1000667 x + 92.12444
Seed vigour	427.004	0.9801	Y= -7.1418 x + 3049

TABLE 3: **Relationship Between Growth Parameters and Gr 50 With Linear Regression Equation**

DISCUSSION

According to the study, it was found that the there is negative correlation between the dose and survival rate of the plants.. This indicates that the survival rate of the plants decreased as the radiation exposure increased. According to the probit analysis, the dosage at which 50% of the plants should be anticipated to die was determined to be **250.316Gy.**, or the LD50 value. The strong negative linear correlation between radiation dosage and survival rate is further supported by the linear regression equation with an R2 value of 0.9453, y = 2.3588x - 0.452.

The strong and extremely dependable negative linear association may be inferred from the high correlation coefficient (R2 = 0.9453). According to this, cowpea plants are susceptible to gamma radiation and even little doses can have a big impact on whether or not they survive. The biological reactions and DNA damage brought on by ionising radiation exposure are to blame for this sensitivity. The likelihood of harmful mutations and cellular damage grows along with the gamma radiation dose, which lowers survival rates.

The choice of acceptable radiation doses that strike a compromise between the necessity of causing desirable genetic alterations and the preservation of plant viability is made possible by an understanding of this threshold. While avoiding extremely high dosages that could result in increased plant mortality, doses below the LD_{50} value can be used to promote advantageous characteristics.

According to the studies, the amount of gamma radiation (mutagen) and the proportion of vegetable cowpea plants that survived have a negative linear connection. This indicates that the survival rate of the plants goes down as the gamma radiation being exposed increased. In other words, the viability and survival of the cowpea plants are negatively impacted by higher doses of mutagenic gamma radiation.

In general, the GR_{50} values offer important data for enhancing gamma irradiation procedures in vegetable cowpea. Radiation doses must be precisely calibrated to produce the desired mutagenesis effects without significantly impairing growth or survival. The results of this study help us better grasp the dose-response relationship between gamma irradiation and cowpea growth metrics, which will help us create fresh strategies for crop mutagenesis

The dose-dependent effects of gamma irradiation on many growth parameters in vegetable cowpea are widely recognised through the GR_{50} values. The study explored into the manner in which cowpea growth parameters were affected by gamma radiation. The survival rate, shoot length, root length, plant height, and seed vigour all showed substantial dose-dependent impacts, according to the findings. The doses at which a 50% reduction in each relevant parameter was observed are represented by the GR_{50} values. The R2 values obtained from the linear regression studies also shed light on the degree to which gamma radiation has an impact on each growth parameter.

Shoot Length

The shoot length was reduced by 50% compared to the control group at this dosage of gamma irradiation, according to the GR_{50} value of 1429.9Gy. This suggests that the lengthening and growth of the plant shoots were adversely affected by the mutagenesis effects of gamma irradiation.

Plant height

The GR_{50} value of plant height was 920.6307 Gy indicates that the plant height of cowpea was decreased by 50% as compared to the control. This showed that the plants overall vertical growth was negatively correlated with gamma irradiation. Light absorption and crop productivity could be affected by decreased plant height.

Seed vigour

The GR_{50} value of seed vigour was 427.004Gy showed that when cowpea seeds were exposed to this level of gamma irradiation, their vigour was significantly reduced. The high GR_{50} graph suggested that exposure to gamma radiation had a severe negative impact on the viability and general vigour of the seeds, which is a critical component of seed quality and germination potential. It has great impact on germination of seeds and establishment after sowing.

With respect to GR_{50} values of shoot length and root length was 1429.9Gy and 661.7 Gy, respectively. Shoot length and root length were the most sensitive characters. These findings indicates that even relatively small amounts of gamma radiation can significantly affect cowpea shoot and root growth. This sensitivity might make it possible to use targeted mutagenesis to introduce particular growth-related features.

A higher GR_{50} value of 920.6307 Gy for the plant height indicated a considerable sensitivity to gamma radiation. This suggested that greater doses may dramatically alter some characters of plant development and elongation, smaller amounts may have little effect on others.

Lower GR_{50} values, such as those observed for root length (661.7Gy) and shoot length (1429.9Gy), suggested that these growth traits are more susceptible to radiation-induced changes. On the other hand, higher GR_{50} values, like plant height (920.63076Gy) and seed vigour (427.004Gy), indicated that these traits are less affected by gamma irradiation.

Dose-Response Relationship

The linear regression equations and corresponding R^2 values provide valuable information about the dose-response relationship for each growth parameters. The negative coefficients in the regression equations indicates that increasing radiation dosage leads to decreased growth in all parameters. The R^2 values represents the goodness of fit for the linear regression models. Higher R^2 values, such as those observed for shoot length, plant height, and seed vigour, suggests that the variations in these traits are better explained by the radiation doses. Conversely, the R^2 value of 0.7812for root length indicates that the dose may not have strong influence on this particular parameter, as the model explains only about 57.99% of the variation.

CONCLUSION

The present study emphasised a significant negative linear association between gamma radiation exposure and cowpea plant survival percentage. The dose at which 50% of the plants are anticipated to survive is indicated by the LD_{50} value of 250.31 Gy. These results indicates the possibility of mutation induction in this crop and highlight the susceptibility of cowpea to gamma radiation. To establish a balance between causing desired mutations and minimising negative effects on plant life, optimal radiation dosages must be carefully taken into account. Mutation breeding in cowpea has the potential to improve desired features and contribute to increased agricultural output and sustainability by using radiation doses below the LD50 threshold. It shows how gamma radiation has dose-dependent effects on various cowpea growth indices. The optimisation of gamma irradiation dosages in mutation breeding efforts can be accomplished by using the GR_{50} values and linear regression analyses. The development of more resilient and high-yielding cowpea varieties can be facilitated by focused crop improvement tactics, which are made possible by an understanding of the sensitivity of various growth parameters to radiation-induced mutations.

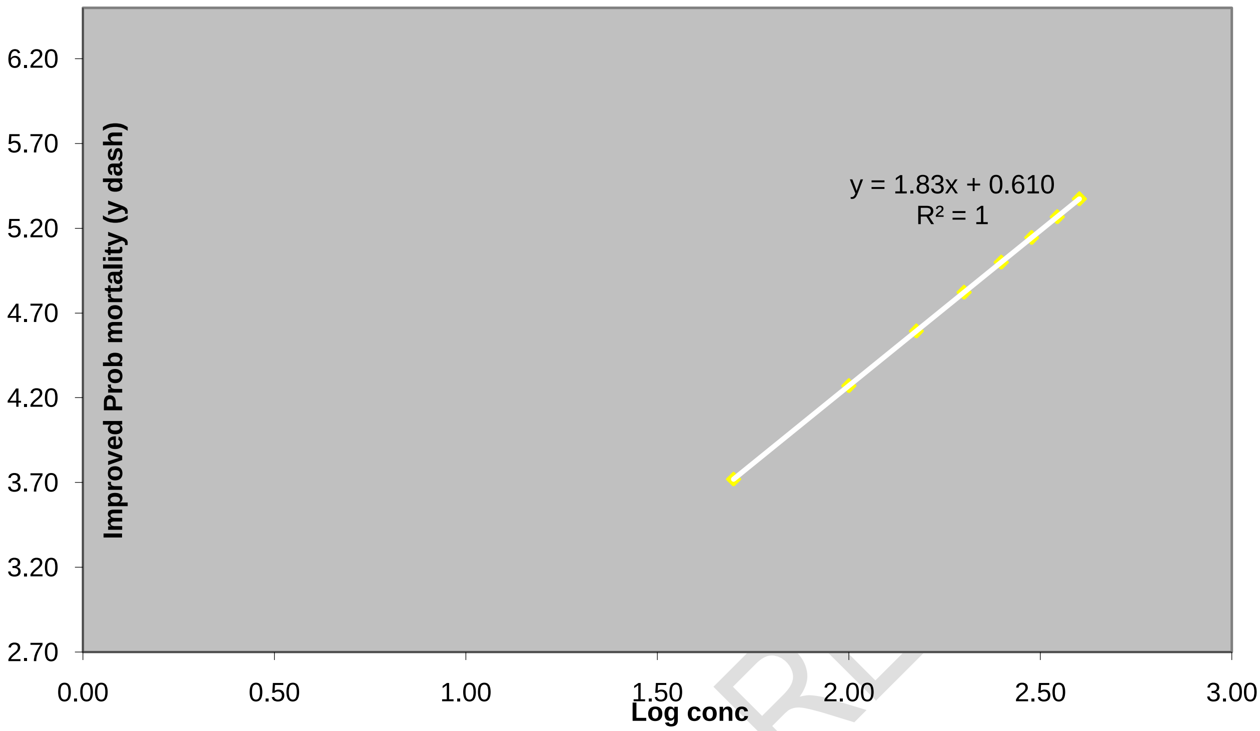

Fig 1 : Probit Analysis

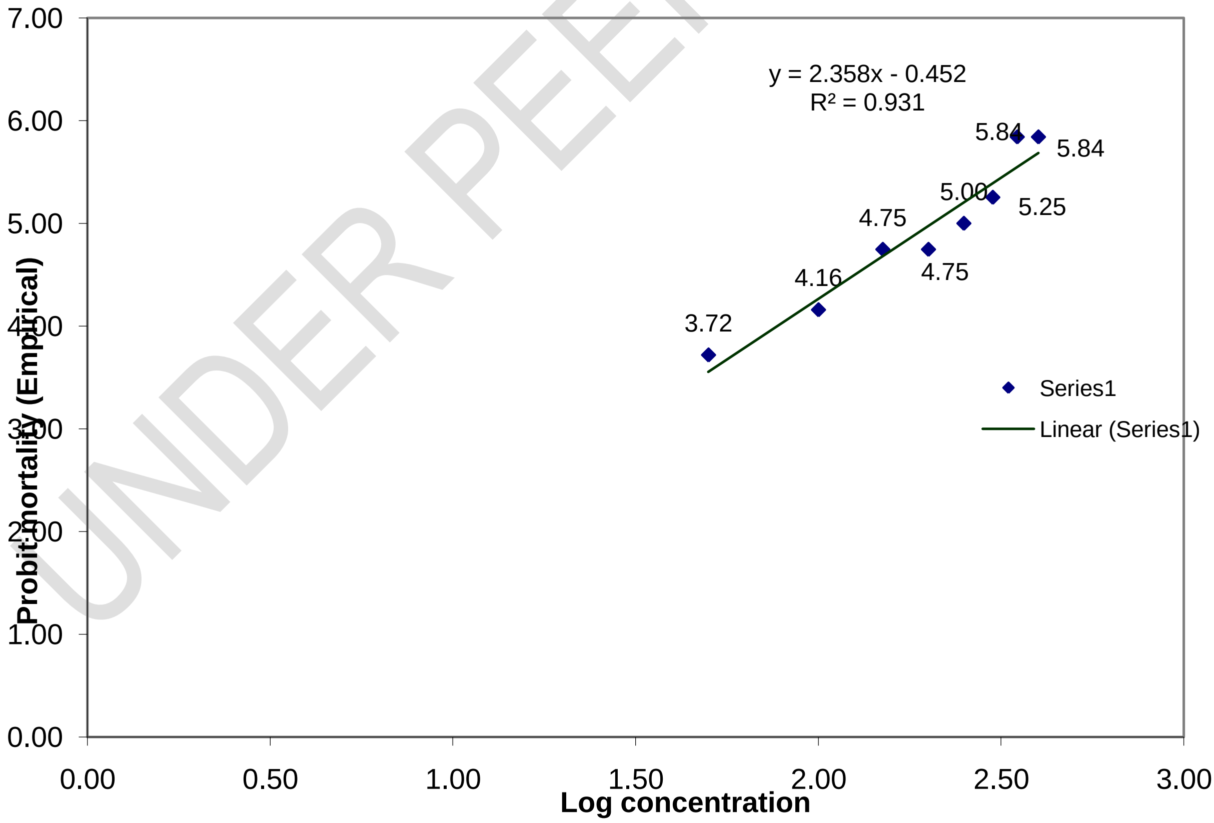

Fig 2: Probit Analysis for fixing LD_{50} for Cowpea var Paiyur-1

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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