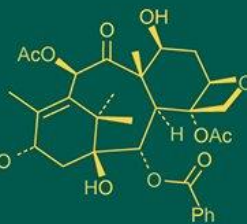
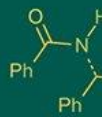


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Characterization of qualitative trait variability in gamma-irradiated Chinese potato tubers (*Plectranthus rotundifolius*)

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Abstract

The present study was conducted to evaluate qualitative trait variability in gamma-irradiated populations of Chinese potato (*Plectranthus rotundifolius* var. Sreedhara). A total of 21 irradiation treatments ranging from 0 to 100 Gy were initially applied, of which treatments up to 65 Gy were considered for analysis due to poor survival at higher doses. Morphological characterization was carried out using standard descriptors, focusing on traits such as plant vigour, pigmentation, tuber morphology, aroma, and stress response. The results revealed considerable variation among the treated populations, particularly in plant vigour, stem pigmentation, tuber shape, and stress response, indicating the effectiveness of gamma irradiation in inducing phenotypic variability. Most treatments exhibited good plant vigour (78.57%), while only a small proportion showed very good growth (14.29%). Stem pigmentation was predominantly green (85.71%), with minor variations observed at higher doses. Tuber traits showed notable diversity, with globose shape being dominant (78.57%), while oblong forms appeared in higher dose treatments. Tuber skin colour ranged from dark brown (57.14%) to light brown (42.86%), whereas tuber flesh colour remained relatively stable, with white (71.43%) as the predominant class. Variation in aroma intensity and biotic stress response further highlighted the influence of irradiation treatments. Overall, the study demonstrates that gamma irradiation is an effective approach for generating useful qualitative variability, providing valuable scope for selection and genetic improvement in Chinese potato.

Keywords: Chinese potato, gamma irradiation, mutation breeding, qualitative traits, genetic variability, tuber morphology

Introduction

Tuber crops constitute a major component of global food systems, ranking next to cereals and legumes as important sources of dietary carbohydrates [7, 5]. These crops produce underground storage organs rich in starch that develop from modified stems or roots. Although their energy yield is comparatively lower than that of cereals due to high moisture content, tuber crops play a crucial role in food and nutritional security, particularly in developing countries [12]. In addition to their nutritional importance, many tuber crops possess medicinal properties and are traditionally used in the preparation of stimulants, tonics, carminatives, and expectorants [6, 16].

Chinese potato (*Plectranthus rotundifolius* (Poir.)), synonymously known as *Solenostemon rotundifolius* (Poir.) J.K. Morton is an underutilized tuber crop belonging to the family Lamiaceae [2, 11]. It is widely cultivated in parts of Africa and Asia and is well adapted to marginal environments and low-input agricultural systems [17, 3]. The crop produces small, potato-like tubers that are rich in carbohydrates, minerals, and essential nutrients required for normal physiological functions [10, 15]. Despite its nutritional and agronomic potential, Chinese potato remains underexploited, and its genetic improvement has been limited due to a narrow genetic base and lack of systematic breeding efforts. The assessment of genetic variability is fundamental to crop improvement, and morphological characterization is a primary tool for evaluating diversity, especially in less-studied crops [19].

Among morphological descriptors, qualitative traits are particularly valuable as they are usually governed by simple genetic mechanisms, exhibit minimal environmental influence, and show stable and distinct expression across generations [8, 14]. These traits are therefore

widely used for varietal identification, classification, and the detection of phenotypic variations in breeding populations. Several studies have reported the importance of morpho-agronomic characterization in Chinese potato. Evaluations of germplasm collections have utilized a combination of qualitative and quantitative descriptors to assess variability in foliage, growth habit, and tuber characteristics^[15, 18]. The results indicated that qualitative traits serve as reliable markers for distinguishing cultivars due to their consistent expression^[14]. Additionally, significant associations between growth traits and tuber yield have been reported, emphasizing their usefulness as selection criteria in crop improvement programs^[13].

However, the limited genetic variability in Chinese potato necessitates the use of alternative approaches to broaden its genetic base. Mutation breeding, particularly through gamma irradiation, has proven to be an effective method for inducing heritable variations and generating novel phenotypes in vegetatively propagated crops^[4, 9]. Therefore, the present investigation aims to characterize qualitative trait variability in mutagenized populations of Chinese potato, with a focus on identifying stable and distinguishable traits for future breeding and selection programs.

Materials and Methods

The Chinese potato cv. *Sree Dhara* was used as the experimental material. Breeder seed tubers were subjected to gamma irradiation at ICAR-National Research Centre for Banana (NRCB), Tiruchirappalli. A total of 21 treatment doses ranging from 0 Gy (control) to 100 Gy were applied to induce variability. It was observed that tubers treated beyond 65 Gy did not survive and were excluded from further evaluation. Morphological observations were recorded following standard descriptors of the National Bureau of Plant Genetic Resources (NBPGR Descriptors)^[1].

Qualitative Trait Characterization

Qualitative morphological traits were recorded to assess the extent of induced variability in the mutagenized plants. Observations were taken at 60 and 120 days after planting (DAP), as well as at harvest for tuber-related traits. The characterization was carried out using the minimum descriptor guidelines developed by the National Bureau of Plant Genetic Resources (2006). These descriptors are based on visually observable, discrete traits that are largely governed by simple genetic factors and are minimally influenced by environmental conditions.

The following qualitative traits were recorded

The observed qualitative traits included plant vigour (PV), pigmentation of stem (PS), pigmentation of leaves (PL), tuber shape (TS), tuber skin colour (TSC), tuber flesh colour (TFC), largest tuber shape (LTS), medium tuber shape (MTS), smallest tuber shape (STS), presence of aroma (PA), and biotic/abiotic stress response (BSR). These descriptors

were used to assess the morphological and physiological variation among the evaluated samples.

Results and Discussion

The qualitative characterization of gamma-irradiated populations of Chinese potato showed noticeable variation across treatments, as defined by the descriptor classes (Table 1) and their corresponding scoring patterns (Table 2). The expression of these traits based on standard descriptors is given in Table 3 and their frequency distribution in Table 4 (Fig. 1). Plant vigour was predominantly classified as good (78.57%), followed by very good (14.29%) and poor (7.14%), with reduced performance observed at 65 Gy indicating the adverse effect of higher irradiation doses, which may be attributed to radiation-induced physiological and cellular damage as reported in mutation breeding studies^[4, 9]. Stem pigmentation was largely green (85.71%), with occasional expression of purple and purple at the base in specific treatments, suggesting induced variation in pigment expression. Leaf pigmentation remained uniform (green) across all treatments, indicating stability under mutagenic conditions, as has also been reported for strongly inherited qualitative traits^[19, 8]. Tuber shape was mainly globose (78.57%), while oblong types (21.43%) appeared in certain treatments, particularly at higher doses, reflecting induced morphological variability similar to earlier findings in Chinese potato and related crops^[15, 18]. Similarly, the largest tubers were predominantly globose (85.71%) with limited occurrence of oblong forms, whereas medium tubers showed comparatively higher variation with both globose and oblong shapes. A greater degree of variability was observed in the smallest tubers, which exhibited globose, oblong, and long shapes, indicating that mutagenic effects were more evident in secondary tuber development, a pattern commonly reported in mutation breeding experiments^[4]. Tuber skin colour varied between dark brown (57.14%) and light brown (42.86%), with a shift towards lighter shades in higher dose treatments, possibly due to alterations in pigment-related biochemical pathways^[5], while tuber flesh colour remained relatively stable with white (71.43%) as the dominant class and only slight variation towards light yellow (28.57%), indicating strong genetic control^[10]. Aroma intensity was generally low to medium, with no high aroma types recorded, and a slight reduction was observed at higher irradiation levels, which may be due to disruption of metabolic pathways involved in volatile compound synthesis^[9]. The response to biotic stress showed variation from very low to intermediate levels, with some treatments exhibiting nematode incidence while others remained unaffected, highlighting the dual effect of mutagenesis in inducing both susceptibility and tolerance^[14]. Overall, the results indicate that gamma irradiation was effective in inducing variability in several qualitative traits, particularly at moderate doses, thereby providing useful scope for selection and genetic improvement in Chinese potato^[4, 9].

Table 1: Morphological descriptors and their descriptor state

S. No	Descriptor	Descriptor state
1.	Plant Vigour (PV)	1. Very good 2. Good 3. Poor
2.	Pigmentation of the stem (PS)	1. Green 2. Purple 3. Purple base 4. Others
3.	Pigmentation of leaves (PL)	1. Green 2. Greenish purple 3. Others
4.	Tuber Shape (TS)	1. Globose 2. Oblong 3. Long 4. Others
5.	Tuber Skin colour (TSC)	1. Light brown 2. Brown 3. Dark Brown 4. Others
6.	Tuber flesh colour (TFC)	1. White 2. Light Yellow 3. Yellow 4. Others
7.	Largest tuber shape (LTS)	1. Globose 2. Oblong 3. Long 4. Others
8.	Medium Tuber shape (MTS)	1. Globose 2. Oblong 3. Long 4. Others
9.	Smallest Tuber shape (STS)	1. Globose 2. Oblong 3. Long 4. Others
10.	Presence of aroma (PA)	0-Absent 1-Low 2-Medium 3-High
11.	Biotic/Abiotic stress response (BS/AS)	1-Very low 3-Low 5-Intermediate 7-High 9-Very High

Table 2: Scoring of Gamma-irradiated tubers based on NPBGR descriptors (2006)

TRT	PV	PS	PL	TS	TSC	FC	LTS	MTS	STS	PA	BSS
C	1	1	1	1	3	1	1	1	1	2	1
5 Gy	2	1	1	1	3	1	1	2	1	2	1
10 Gy	2	1	1	1	3	1	1	2	1	2	1
15 Gy	2	1	1	1	3	1	1	1	1	1	3
20 Gy	2	1	1	1	3	1	1	1	2	1	1
25 Gy	2	2	1	1	3	2	1	2	2	2	5
30 Gy	2	1	1	1	3	2	1	1	2	2	5
35 Gy	2	1	1	1	3	1	2	1	3	1	5
40 Gy	2	3	1	1	1	1	1	2	2	1	5
45 Gy	2	1	1	2	1	1	1	1	1	2	3
50 Gy	2	1	1	2	1	1	1	1	2	1	3
55 Gy	1	1	1	2	1	2	1	1	1	2	3
60 Gy	2	1	1	1	1	2	2	2	2	1	1
65 Gy	3	1	1	1	1	2	1	2	1	1	1

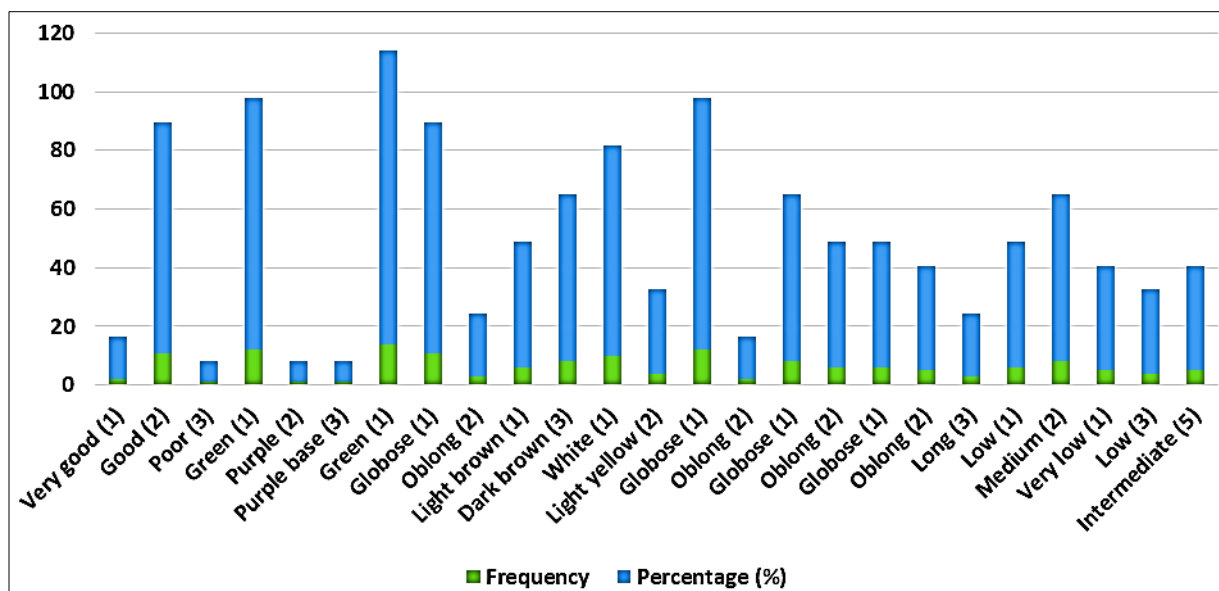


Fig 1: Frequency and percentage of each qualitative descriptor

Table 3: Evaluation of Morphological Traits of Tubers Based on Standard Descriptors

TRT	PV	PS	PL	TS	TSC	FC	LTS	MTS	STS	PA	BSS
C	Very good	Green	Green	globose	Dark Brown	White	Globose	Globose	Globose	Medium	no
5 GY	Good	Green	Green	globose	Dark Brown	White	Globose	oblong	Globose	Medium	no
10 GY	Good	Green	Green	globose	Dark Brown	White	Globose	oblong	Globose	Medium	no
15 GY	Good	Green	Green	globose	Dark Brown	White	Globose	Globose	Globose	Low	Nematodes
20 GY	Good	Green	Green	globose	Dark Brown	White	Globose	Globose	Oblong	Low	no
25 GY	Good	Purple	Green	globose	Dark Brown	White	Globose	oblong	Oblong	Medium	nematode
30 GY	Good	Green	Green	globose	Dark Brown	White	Globose	Globose	Oblong	Medium	nematode
35 GY	Good	Green	Green	globose	Dark Brown	White	oblong	Globose	Long	Low	nematode
40 GY	Good	Purple at base	Green	Globose	Light Brown	White	globose	oblong	Oblong	Low	nematode
45 GY	Good	Green	Green	oblong	Light Brown	White	globose	Globose	Globose	Medium	nematode
50 GY	Good	Green	Green	oblong	Light Brown	White	globose	Globose	Oblong	Medium	nematode
55 GY	Very Good	Green	Green	oblong	Light Brown	White	globose	Globose	Globose	Medium	nematode
60 GY	Good	Green	Green	Globose	Light Brown	White	Oblong	oblong	Oblong	Low	no
65 GY	poor	Green	Green	Globose	Light Brown	White	Globose	oblong	Globose	Low	no

Table 4: Frequency and percentage of each qualitative trait

Trait	Descriptor State	Frequency	Percentage (%)
Plant vigour (PV)	Very good (1)	2	14.29
Plant vigour (PV)	Good (2)	11	78.57
Plant vigour (PV)	Poor (3)	1	7.14
Stem pigmentation (PS)	Green (1)	12	85.71
Stem pigmentation (PS)	Purple (2)	1	7.14
Stem pigmentation (PS)	Purple base (3)	1	7.14
Leaf pigmentation (PL)	Green (1)	14	100
Tuber shape (TS)	Globose (1)	11	78.57
Tuber shape (TS)	Oblong (2)	3	21.43
Tuber skin colour (TSC)	Light brown (1)	6	42.86
Tuber skin colour (TSC)	Dark brown (3)	8	57.14
Tuber flesh colour (FC)	White (1)	10	71.43
Tuber flesh colour (FC)	Light yellow (2)	4	28.57
Largest tuber shape (LTS)	Globose (1)	12	85.71
Largest tuber shape (LTS)	Oblong (2)	2	14.29
Medium tuber shape (MTS)	Globose (1)	8	57.14
Medium tuber shape (MTS)	Oblong (2)	6	42.86
Smallest tuber shape (STS)	Globose (1)	6	42.86
Smallest tuber shape (STS)	Oblong (2)	5	35.71
Smallest tuber shape (STS)	Long (3)	3	21.43
Presence of aroma (PA)	Low (1)	6	42.86
Presence of aroma (PA)	Medium (2)	8	57.14
Biotic stress susceptibility (BSS)	Very low (1)	5	35.71
Biotic stress susceptibility (BSS)	Low (3)	4	28.57
Biotic stress susceptibility (BSS)	Intermediate (5)	5	35.71

Conclusion

The present study demonstrated that gamma irradiation is an effective tool for inducing qualitative variability in Chinese potato. Noticeable variation was observed in key traits such as plant vigour, stem pigmentation, tuber shape, skin colour, and stress response, while traits like leaf pigmentation and tuber flesh colour remained relatively stable. Moderate irradiation doses (25-55 Gy) were found to be most effective in generating useful variability without severely affecting plant growth. The variability observed, particularly in tuber morphology and stress response, offers valuable opportunities for selection and future crop improvement. Overall, mutation breeding can serve as a promising approach for broadening the genetic base and enhancing desirable traits in Chinese potato.

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