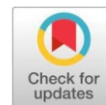


Original Research Article

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Field evaluation of in vitro derived mutants of different varieties of banana on reproductive and yield parameters

Kirankumar K. H^{*1}, Prakasha D. P², Prabhuling Guranna³, Kulapati Hipparagi⁴¹Department of Fruit Science, College of Horticulture Bagalkot, University of Horticultural Sciences, Bagalkot, -587104 Karnataka, India²Department of Fruit Science, College of Horticulture, Banavasi Road, Sirsi, -581401 University of Horticultural Sciences, Bagalkot, Karnataka, India³Department of Biotechnology and Crop improvement, College of Horticulture Bagalkot, University of Horticultural Sciences, Bagalkot, -587104 Karnataka, India⁴Department of Fruit Science, College of Horticulture Bagalkot, University of Horticultural Sciences, Bagalkot, -587104 Karnataka, India

ABSTRACT

A field experiment was conducted on field evaluation of in vitro derived mutants of different varieties of banana during 2018-19 and 2019-20 at the Department of Fruit Science, College of Horticulture, University of Horticultural Sciences, Bagalkot. The 138 in vitro derived banana mutants both physical and chemical mutagens treated plants along with a check were planted. The experiment was laid out in augmented block design with 6 blocks and 26 subplots each block having 23 in vitro mutant lines and three checks. The experiment was conducted to identify early flowering mutants, flowering to maturity and yield characters. The different parameters like Days taken to flowering, Days from flowering to maturity, Total leaf chlorophyll, bunch weight, length of bunch, number of hands per bunch were taken as reproductive and yield parameters. Among 138 in vitro derived mutants in plant crop, there was significant difference noted in days taken to flowering, total leaf chlorophyll, length of bunch. The lesser number of days taken to flowering was recorded in RAJ45Gy-14 (232 days), maximum total leaf chlorophyll was recorded in YB45Gy-09 (65.10), the maximum length of bunch recorded in YB45Gy-03 (69.48 cm). Maximum bunch weight in YB45Gy-03 (11.96 kg). In ratoon crop, significant difference seen in days taken to flowering, flowering to maturity and number of hands per bunch. The lesser number of days taken to flowering was recorded in YB40Gy-03 (216 days), days from flowering to maturity was recorded in YB35Gy-11 (86 days). Maximum total leaf chlorophyll content was recorded in RAJ40Gy-04 (62.90). Maximum bunch weight in RAJ45Gy-04 (11.09 kg). Maximum number of hands per bunch was recorded in YB40Gy-06 (9.00). Field evaluation of in vitro derived mutants reveals early flowering, flowering to maturity and yield characters among different mutants of banana.

Keywords: banana, bunch weight, days taken to flowering, In vitro, physical mutants, length of bunch, number of hands per bunch.

Introduction

Banana is a monocotyledonous herbaceous plant belonging to the section *Eumusa* under the family Musaceae. All edible bananas originate from two species namely *Musa acuminata* and *Musa balbisiana* and most of the cultivated cultivars are their hybrids. The basic chromosome number in banana varies from 7-11 (X=7, 9, 10, 11). The cultivated edible bananas are mainly triploids. As triploid varieties are highly sterile, edible plants are typically propagated by asexual methods (19).

Yelakki bale (AB) is the choicest diploid cultivar of banana, which is under commercial mono cultivation on a large scale, especially in Karnataka and Tamil Nadu. It is popularly known as Puttabale, Mitle bale in Karnataka. It is slender plant bearing bunches of 12-14 kg after 13-14 months. Fruits are small, slender having a prominent beak and are arranged around the axis in a way that they bear a wind-blown appearance (4). Fruits are very attractive due to their bright yellow color with ivory white pulp.

***Corresponding Author: Kirankumar K. H**

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Rajapuri bale (AAB) is a popular cultivar of banana grown in the northern parts of Karnataka. It is a dwarf variety growing up to 6-8 feet height with a very thick stem and stands up very well to wind. The leaves are wider than those of most bananas growing up to 3 feet wide. It is the best plant to grow in marginal areas or where a grower does not intend to put much care into the cultivation of bananas. The bunch weigh about 10-15 kg with 8-10 hands and 90-100 fingers. Fruits have attractive yellow colour with thick skin and good blend of sweet and acidity.

The Nanjangud Rasabale (*Musa* spp., AAB, silk subgroup) known for its unique taste has a huge demand across the country. But, conditions are not favorable enough for growing the banana and to match the huge demand that it generates (17). The cultivar Nanjangud Rasabale has been a geographical indication tagged and once leading cultivar of the Mysore province is under threat of extinction due to its susceptibility to panama diseases (16). Earlier, the cultivar grown in around 600 acres of land in the district of Mysore, Karnataka, now confined to only 30 acres of land in isolated area (6) due to susceptibility to wilt. Hence, the variety now which is at the danger of extinction has to strictly breed by potential methodology to save and preserve as a germplasm.

Most of the cultivated *Musa* varieties and cultivars are triploids. As triploid varieties are highly sterile, edible plants are typically propagated by asexual methods.

Genetic improvement in banana has been extremely complicated due to varied genomic constitutions, heterozygosity, polyploidy, and sterility in edible cultivars. Creating genetic variability for economically important traits in banana would not be supported application of conventional breeding programs due to the complexity in the genome of *Musa* species. In this context, induced mutation has a high potential for bringing genetic improvements of vegetatively propagated crops like banana. The main advantage of induced mutations in vegetatively propagated plants is the ability to change one or a few characters of an outstanding cultivar without altering the remaining genetic background (8).

Mutation induction using gamma rays had been applied to *Musa* spp. for improving many desirable traits, such as early flowering (14), tolerance to aluminium (13) and *Fusarium* resistance (3). A number of chemicals can induce mutations in banana plants such as sodium azide, 2,4-D (2,4-dichlorophenoxy acetic acid) and 6-Benzylaminopurine (6-BA) (2). Further, induction of mutation through chemical mutagens such as EMS and Sodium azide has generated several mutants of banana cv. Nanjangud rasabale under *in vitro* conditions (7). (1). showed that irradiated Grand Naine (clone 1 and clone 2) had longer green life than that of untreated Williams.

Mutation induction may uncover a recessive phenotype by mutating, inhibiting or deleting the corresponding dominant allele (5). Almost all the edible banana and plantain varieties originate through spontaneous mutations. The best example is the spontaneous banana mutant 'Cavendish' originating from Vietnam, which is resistant to *Fusarium* wilt (race 1) and which replaced 'Gros Michel' in the 1950s and 60s. The discovery of this banana mutant saved the banana industry from collapsing. *In vitro* mutagenesis, therefore, provides the necessary tool for the development of new clones resistant to diseases and also possessing improving characters like earliness, high yield. However, field evaluation of *in vitro* derived mutants is ultimate answer for the performance of newly mutated lines of banana under field condition for morpho-agronomic traits and also yield parameters. In this regard, the study has been planned in which the mutated (using physical and chemical mutagens)

in vitro regenerated lines of the popular cultivars of Karnataka, viz., Rajapuri bale, Yelakki bale and Nanjangud Rasabale, are field evaluated for morpho-agronomic and yield parameters.

Material and Methods

The present investigation entitled "Field evaluation of *in vitro* derived mutants of different varieties of banana (*Musa* spp.)" was carried out during two years 2018-19 and 2019-20 at the Department of Fruit Science, College of Horticulture, University of Horticultural Sciences, Bagalkot. The 138 *in vitro* derived banana mutants (both physical and chemical mutagens treated plants) along with check were planted following Augmented Block Design at the Fruit Orchard University of Horticultural Sciences, Bagalkot (Table 1). The experimental site was divided into 6 blocks and 26 sub plots. The uniform pits of 60 cm³ were dug out according to the plan of layout and recommended spacing (1.5m×1.5m). Each pit was filled with 20 kg well decomposed farmyard manure.

Planting material: The *in vitro* mutant lines of banana cultivars viz, Yelakki bale (AB), Rajapuri bale (AAB) and Nanjanagud Rasabale (AAB) of 5 months old were collected from department of Biotechnology and crop improvement, planted at Fruit Orchard, sector 70, UHS, Bagalkot on 18/10/2018. The healthy vigorous pest and disease free *in vitro* regenerated plants were used for planting.

Observations recorded: observations like days taken to flowering, flowering to maturity and total leaf chlorophyll content using SPAD-501 (spad chlorophyll meter reading portable leaf greenness meter) were taken, bunch parameters like bunch weight, length of bunch, number of hands per bunch were recorded.

Statistical analysis: statistical analysis of the data collected for different parameters was subjected to analysis of variance for augmented block design, the analysis of variance was carried out using windostat version 9.3.

Table 1. *In vitro* mutants of three cultivars of Banana

Sl. No	Origin of <i>in vitro</i> mutant line		
	a) Yelakki Bale	b) Rajapuri Bale	c) Nanjangud Rasabale
1	Control (06 plants)	Control (06 plants)	Control (06 plants)
2	25Gy (04 plants)	25Gy (02 plants)	25Gy (0 plants)
3	30Gy (11 plants)	30Gy (06 plants)	30Gy (02 plants)
4	35Gy (18 plants)	35Gy (08 plants)	35Gy (04 plants)
5	40Gy (14 plants)	40Gy (12 plants)	40Gy (05 plants)
6	45Gy (12 plants)	45Gy (10 plants)	45Gy (04 plants)
7	EMS- 0.60% (2 plants)	EMS- 0.60% (1 plants)	EMS- 0.60% (1 plants)
8	EMS -0.90% (4 plants)	EMS -0.90% (3 plants)	EMS -0.90% (1 plants)
9	SA- 0.02% (1 plants)	SA- 0.02% (1 plants)	SA- 0.02% (1 plants)
10	SA- 0.03% (1 plants)	SA- 0.03% (2 plants)	SA- 0.03% (2 plants)
11	BAP-15 mg/l (1 plants)	BAP-15 mg/l (1 plants)	BAP-15 mg/l (1 plants)
12	BAP -20 mg/ 1 (1 plants)	BAP -20 mg/ 1 (1 plants)	BAP -20 mg/ 1 (1 plants)
	75	53	28
	Total lines used		156

Note: EMS - Ethyl Methyl Sulphonate; SA - Sodium Azide; BAP - Benzyl Amino Purine Gy- Gamma irradiation



Plate 1. General view of experimental plot at shooting stage of *in vitro* mutants of different varieties of banana

Results and Discussion

In plant crop, there was significant difference with respect to days taken for flowering in plant crop among different mutant lines of banana (Table 2). The lesser number of days taken to flowering recorded in RAJ45Gy -14 (232.00 Days), RAJ45Gy- 13 (235.00 Days), YB45Gy - 07 (238.00 Days), RAJ40Gy - 03 (238.00 Days), RAJ45Gy-15 (238.00 Days), RAJ45Gy-19 (238.00 Days) and YB40Gy-13 (239.00 days) There was less number of days taken for flowering in ratoon crop in all varieties compared to checks. In ratoon crop, the lesser number of days taken to flowering was recorded in YB40Gy - 03 (216.00 days), YB40Gy - 13 (218.00 days), YB45Gy - 13 (221.00 days), RAJ45Gy - 14 (218.00 days), RAJ45Gy - 13 (220.00 days) and RAJ45Gy - 15 (224.00 days). (20) reported that treatment of 20Gy and 40Gy of gamma irradiation on gladiolus cultivars Sylvia and Eurovision decreased the number of days for heading and days for first flower opening. Similar results are reported by (18). where plant exhibit 5-6 months earliness for flowering in 30Gy and 40Gy dose of gamma rays (10). reported that nine clones derived from cv. SH3436-L9 treated with 45Gy radiation showed earliest flowering. At higher dose of gamma radiation, the early initiation of gibberellin acid pathway will help in the expression of floral meristem identifying genes which enhances earliness to flowering Similar results were obtained by (14) and (11). in Cavendish lines derived through gamma irradiation which flowered significantly early. (12). reported that the irradiated Pisang Berangan clone was earlier in flowering to maturity than the original types and 60Gy and 45Gy showed highest frequency (22.2%) and (9.2%), respectively compared to control. Similar results obtained by (18). There was no significant difference recorded with respect to flowering to maturity in plant crop among different mutant lines

of banana (Table 2). The lesser number of days taken from flowering to maturity was recorded in YB35Gy-14 (95.00 days), YB45Gy - 07 (95.00 days). Significant difference was noticed in days from flowering to maturity in ratoon crop among different mutant lines of banana (Table 2). The lesser number of days taken from flowering to maturity was found in YB35Gy - 11 (86.00 days). The data pertaining to total chlorophyll leaf content was found significant in plant crop among different mutant lines of banana (Table 2). The maximum and minimum total chlorophyll leaf content was found in YB45Gy-09 (65.10) and YB25Gy - 03 (32.70), respectively. Significant difference was noted with respect to total chlorophyll leaf content in ratoon crop among different mutant lines of banana (Table 2). The chlorophyll content was reduced in ratoon crop. The maximum total chlorophyll leaf content was found in RAJ40Gy - 25 (62.20). The minimum total chlorophyll leaf content was recorded in YB30Gy-03 (29.30). There was no significant difference recorded in weight of bunch in plant crop as well as ratoon crop among mutant lines of banana (Table 2). The maximum bunch weight was recorded in YB45Gy - 03 (11.96 kg), whereas in ratoon crop, RAJ45Gy-14 recorded highest bunch weight (11.09 kg). (10). reported that dose 45Gy of irradiated clones of SH3436-L9 showed greater bunch weight (32.80-36.20 kg) than control (32.00 kg). The yield of somaclone banana was possibly high due to increased carbohydrate accumulation, bunch and fruit weight. High yielding *in vitro* derived banana somaclones have been reported in true horn plantain (21). Bunch and fruit weights in polyploidy banana are under the control of epistatic gene interactions (15). There was a significant difference noted with respect to length of bunches in plant crop among different mutant lines of banana and data is presented in Table 3. Length of bunch is reduced in ratoon crop in few cases but it is increased in good number of lines.

The maximum length of bunches was recorded in YB45Gy - 03 (69.48 cm), which was found on par with YB45Gy-13. The minimum length of bunches was recorded in RAJ30Gy - 13 (30.00 cm) and RAJ SA 0.03% - 1 (30.00 cm).). There was no significant difference observed with respect to length of bunches in ratoon crop among different mutant lines of banana and data is presented in (Table 3). The maximum length of the bunch was recorded in RAJ40Gy-23 (64.00 cm) followed by YB 35Gy - 12 (63.40 cm). The minimum length of bunch was recorded in RAJ BAP 15-3 (33.00 cm) and RAJ SA 0.03% - 1 (33.00 cm). There was no significant difference recorded with respect to number of hands per bunch in plant crop (Table 3). The maximum number of hands per bunch was recorded in YB30Gy - 02 (9.00), YB30Gy - 07 (9.00), YB30Gy - 10 (9.00), YB35Gy - 02 (9.00) YB35Gy - 14 (9.00) YB35Gy - 15 (9.00), YB35Gy - 23 (9.00), YB35Gy - 24 (9.00), YB40Gy - 03 (9.00), YB40Gy - 06 (9.00), YB40Gy - 07 (9.00), YB40Gy - 08 (9.00), YB40Gy - 13 (9.00), YB40Gy - 14 (9.00), YB45Gy - 03 (9.00), YB45Gy - 15 (9.00), RAJ45Gy - 14 (9.00), YB EMS 0.6% -1 (9.00),

YB EMS 0.9%-1 (9.00). The minimum number of hands per bunch was recorded in RAJ30Gy - 07 (5.00). In ratoon crop, among Yelakki bale mutant lines, the maximum number of hands per bunch compared to check (5.50) was recorded in YB40Gy - 06 (9.00), YB35Gy - 14 (9.00) YB40Gy - 07 (9.00), YB45Gy - 05 (9.00) YB35Gy - 20 (9.00) and YB35Gy - 04 (9.00). In Rajapuri bale mutant lines, the maximum number of hands per bunch compared to check (5.66) was recorded in RAJ35Gy - 01 (8.00) RAJ40Gy - 03 (8.00), RAJ40Gy - 23 (8.00). In Nanjangud Rasabale mutants, the maximum number of hands per bunch compared to check (4.66) was recorded in NR35Gy-11 (6.00), NR40Gy - 05 (6.00), NR EMS 0.6%- 3 (6.00), NR SA 0.03% -1 (6.00). This might be due to physical mutagens induction at higher dose helps in generating genetic variation by inducing mutation at the gene, chromosome and genomic levels in nuclear and cytoplasmic organelle DNA (9). (18). reported that Gamma irradiated (20Gy) 'Terra Maranhao' plantain cultivar showed highest number of hands (9.75) than control (9.66).

Table 2: Shooting parameters and chlorophyll content in plant and ratoon crop of banana mutant lines

Mutant lines	Days taken to flowering		Days from Flowering to maturity		Total leaf chlorophyll (SCMR)	
	Plant crop	Ratoon crop	Plant crop	Ratoon crop	Plant crop	Ratoon crop
YB25Gy 02	281.00	266.00	115.00	108.00	46.78	42.14
YB25Gy 03	285.00	264.00	100.00	115.00	32.70	36.58
YB25Gy 04	288.00	260.00	102.00	117.00	37.58	41.50
YB25Gy 05	284.00	260.00	112.00	103.00	41.00	39.25
YB30Gy 01	310.00	272.00	104.00	100.00	39.40	38.24
YB30Gy 02	279.00	250.00	108.00	112.00	38.80	37.27
YB30Gy 03	277.00	271.00	114.00	102.00	33.90	29.30
YB30Gy 04	282.00	254.00	107.00	104.00	45.20	41.80
YB30Gy 06	274.00	245.00	125.00	106.00	38.50	43.35
YB30Gy 07	277.00	248.00	109.00	94.00	41.00	44.17
YB30Gy 08	277.00	242.00	110.00	98.00	42.10	42.55
YB30Gy 09	284.00	266.00	112.00	102.00	51.80	48.36
YB30Gy 10	281.00	262.00	116.00	100.00	48.70	53.68
YB30Gy 11	276.00	259.00	105.00	120.00	46.00	49.51
YB30Gy 15	289.00	255.00	103.00	95.00	48.00	53.20
YB35Gy 01	277.00	265.00	115.00	107.00	45.30	50.27
YB35Gy 02	274.00	248.00	124.00	107.00	44.20	40.28
YB35Gy 03	269.00	275.00	104.00	100.00	40.70	36.34
YB35Gy 04	274.00	244.00	115.00	103.00	40.20	46.35
YB35Gy 05	272.00	264.00	97.00	90.00	53.80	49.63
YB35Gy 06	281.00	267.00	114.00	100.00	47.40	53.18
YB35Gy 07	281.00	270.00	110.00	98.00	42.00	46.91
YB35Gy 09	274.00	249.00	120.00	106.00	45.10	43.00
YB35Gy 10	258.00	230.00	102.00	110.00	40.50	37.66
YB35Gy 11	254.00	226.00	106.00	86.00	47.64	49.00
YB35Gy 12	265.00	260.00	101.00	109.00	36.49	42.78
YB35Gy 14	258.00	242.00	95.00	90.00	48.00	50.32

Contd.....

Mutant lines	Days taken to flowering		Days from Flowering to maturity		Total leaf chlorophyll (SCMR)	
	Plant crop	Ratoon crop	Plant crop	Ratoon crop	Plant crop	Ratoon crop
YB35Gy 15	276.00	244.00	105.00	92.00	42.71	46.37
YB35Gy 18	277.00	244.00	106.00	102.00	43.00	45.61
YB35Gy 20	284.00	271.00	110.00	114.00	46.78	48.25
YB35Gy 23	282.00	255.00	100.00	93.00	32.70	36.27
YB35Gy 24	268.00	245.00	104.00	88.00	37.54	39.48
YB35Gy 25	254.00	240.00	97.00	104.00	44.10	41.00
YB40Gy 01	257.00	234.00	104.00	96.00	38.00	42.35
YB40Gy 02	264.00	238.00	102.00	104.00	41.30	45.40
YB40Gy 03	247.00	216.00	105.00	110.00	48.80	43.26
YB40Gy 04	245.00	221.00	108.00	108.00	45.00	41.50
YB40Gy 05	275.00	261.00	110.00	115.00	46.60	51.38
YB40Gy 06	242.00	220.00	103.00	100.00	45.00	41.00
YB40Gy 07	250.00	228.00	96.00	110.00	49.30	38.94
YB40Gy 08	254.00	233.00	115.00	107.00	52.60	47.63
YB40Gy 10	267.00	260.00	101.00	96.00	47.40	53.66
YB40Gy 11	254.00	240.00	98.00	108.00	59.30	54.00
YB40Gy 12	241.00	224.00	104.00	112.00	47.90	46.93

YB40Gy 13	239.00	218.00	96.00	102.00	53.29	45.28
YB40Gy 14	267.00	251.00	107.00	96.00	39.28	41.00
YB40Gy 15	269.00	252.00	103.00	115.00	45.27	48.00
YB45Gy 02	260.00	241.00	104.00	102.00	39.10	41.38
YB45Gy 03	244.00	225.00	98.00	100.00	48.90	51.30
YB45Gy 04	275.00	262.00	104.00	115.00	43.20	46.89
YB45Gy 05	253.00	255.00	112.00	108.00	48.90	44.00
YB45Gy 06	254.00	242.00	100.00	110.00	41.00	38.55
YB45Gy 07	238.00	230.00	95.00	103.00	44.10	46.00
YB45Gy 08	253.00	242.00	104.00	96.00	40.60	43.55
YB45Gy 09	246.00	233.00	100.00	94.00	65.10	58.12
YB45Gy 11	258.00	233.00	106.00	114.00	43.60	46.00

Contd.....

Mutant lines	Days taken to flowering		Days from Flowering to maturity		Total leaf chlorophyll (SCMR)	
	Plant crop	Ratoon crop	Plant crop	Ratoon crop	Plant crop	Ratoon crop
YB45Gy 12	253.00	245.00	104.00	102.00	38.27	36.10
YB45Gy 13	248.00	221.00	100.00	112.00	46.87	42.27
YB45Gy 15	256.00	243.00	110.00	101.00	44.00	40.36
RAJ25Gy 01	258.00	245.00	115.00	105.00	46.32	55.27
RAJ25Gy 02	285.00	260.00	110.00	102.00	56.80	50.14
RAJ30Gy 02	264.00	255.00	102.00	94.00	51.70	47.00
RAJ30Gy 03	278.00	262.00	120.00	112.00	54.20	48.00
RAJ30Gy 05	255.00	238.00	124.00	100.00	56.90	53.05
RAJ30Gy 07	253.00	236.00	112.00	110.00	41.60	43.68
RAJ30Gy 12	276.00	260.00	105.00	98.00	58.10	52.00
RAJ30Gy 13	253.00	240.00	110.00	114.00	55.40	49.00
RAJ35Gy 01	239.00	244.00	120.00	95.00	54.20	46.52
RAJ35Gy 02	241.00	234.00	125.00	96.00	58.90	53.70
RAJ35Gy 03	280.00	265.00	123.00	89.00	50.90	53.00
RAJ35Gy 06	260.00	254.00	118.00	103.00	57.00	54.25
RAJ35Gy 07	250.00	240.00	115.00	103.00	56.20	58.00
RAJ35Gy 09	275.00	260.00	126.00	98.00	55.90	51.68
RAJ35Gy 10	262.00	247.00	130.00	98.00	59.60	53.00
RAJ35Gy 12	250.00	238.00	112.00	105.00	46.40	49.62
RAJ40Gy 01	272.00	256.00	110.00	102.00	44.60	48.00
RAJ40Gy 02	243.00	219.00	104.00	110.00	57.10	59.00
RAJ40Gy 03	238.00	223.00	98.00	106.00	54.00	55.00
RAJ40Gy 04	244.00	231.00	105.00	98.00	62.90	57.00
RAJ40Gy 05	250.00	244.00	110.00	112.00	61.50	56.00
RAJ40Gy 08	244.00	228.00	114.00	105.00	60.50	53.89
RAJ40Gy 09	248.00	230.00	110.00	106.00	59.40	58.24
RAJ40Gy 11	253.00	238.00	105.00	100.00	44.00	42.31
RAJ40Gy 15	244.00	238.00	108.00	110.00	64.30	52.00
RAJ40Gy 22	260.00	244.00	112.00	106.00	53.90	46.00

Contd.....

Mutant lines	Days taken to flowering		Days from Flowering to maturity		Total leaf chlorophyll (SCMR)	
	Plant crop	Ratoon crop	Plant crop	Ratoon crop	Plant crop	Ratoon crop
RAJ40Gy 23	248.00	233.00	100.00	114.00	56.60	51.00
RAJ40Gy 25	257.00	240.00	106.00	112.00	54.50	62.20
RAJ45Gy 03	256.00	241.00	100.00	109.00	53.20	56.42
RAJ45Gy 04	244.00	231.00	105.00	100.00	51.70	54.00
RAJ45Gy 07	255.00	242.00	112.00	98.00	54.50	57.00
RAJ45Gy 08	243.00	220.00	110.00	103.00	57.30	56.69
RAJ45Gy 10	251.00	233.00	96.00	108.00	49.70	42.50
RAJ45Gy 13	235.00	220.00	95.00	104.00	52.50	49.62
RAJ45Gy 14	232.00	218.00	98.00	110.00	55.80	53.14
RAJ45Gy 15	238.00	224.00	102.00	96.00	54.50	58.00
RAJ45Gy 19	238.00	230.00	110.00	102.00	51.60	50.29
RAJ45Gy 20	242.00	228.00	102.00	106.00	58.20	56.63
NR30Gy 06	277.00	264.00	119.00	115.00	53.00	52.61
NR30Gy 10	280.00	258.00	125.00	114.00	51.18	45.89
NR35Gy 08	275.00	262.00	128.00	112.00	49.45	46.86
NR35Gy 11	277.00	286.00	120.00	106.00	47.00	44.59
NR35Gy 12	284.00	262.00	120.00	104.00	53.17	50.25
NR35Gy 19	288.00	255.00	108.00	112.00	49.73	45.43
NR40Gy 05	268.00	244.00	100.00	110.00	53.68	43.82
NR40Gy 07	265.00	248.00	97.00	104.00	49.26	40.18
NR40Gy 09	272.00	251.00	104.00	106.00	52.69	47.86
NR40Gy 12	280.00	267.00	100.00	117.00	55.63	51.03
NR40Gy 15	284.00	257.00	102.00	110.00	57.00	48.65
NR45Gy 01	284.00	260.00	102.00	115.00	50.00	47.14
NR45Gy 02	286.00	261.00	108.00	120.00	49.65	46.50

NR45Gy 04	274.00	260.00	107.00	103.00	48.45	45.86
NR45Gy 09	277.00	264.00	110.00	106.00	51.00	49.25
YB EMS 0.6% 1	269.00	252.00	112.00	96.00	48.70	50.68
YB EMS 0.6% 4	260.00	241.00	105.00	110.00	46.00	45.51

Contd.....

Mutant lines	Days taken to flowering		Days from Flowering to maturity		Total leaf chlorophyll (SCMR)	
	Plant crop	Ratoon crop	Plant crop	Ratoon crop	Plant crop	Ratoon crop
YB EMS 0.9% 1	256.00	235.00	108.00	115.00	48.00	52.20
YB EMS 0.9% 2	248.00	226.00	98.00	102.00	51.04	46.35
YB EMS 0.9% 3	255.00	252.00	110.00	108.00	48.24	46.30
YB EMS 0.9% 4	275.00	255.00	107.00	104.00	53.80	48.00
YB SA 0.02% 1	280.00	260.00	99.00	106.00	45.21	47.18
YB SA 0.03% 6	279.00	257.00	105.00	110.00	46.7	53.68
YB BAP15- 1	266.00	249.00	120.00	105.00	41.67	49.51
YB BAP 20-2	284.00	259.00	112.00	98.00	48.00	53.20
RAJ EMS 0.6% 3	258.00	236.00	115.00	110.00	57.00	54.25
RAJ EMS 0.9% 1	274.00	249.00	98.00	104.00	53.20	48.32
RAJ EMS 0.9% 2	255.00	240.00	105.00	114.00	55.90	52.14
RAJ EMS 0.9% 4	250.00	242.00	114.00	95.00	59.60	54.30
RAJ SA 0.02% 1	247.00	234.00	120.00	96.00	45.40	49.61
RAJ SA 0.03% 1	253.00	241.00	112.00	110.00	46.60	47.52
RAJ SA 0.03% 2	252.00	239.00	105.00	98.00	55.10	58.14
RAJ BAP 15- 3	247.00	242.00	120.00	106.00	52.14	55.31
RAJ BAP 20 1	256.00	239.00	112.00	127.00	62.90	57.14
NR EMS 0.6% 3	267.00	240.00	95.00	105.00	46.51	42.59
NR EMS 0.9% 5	264.00	245.00	108.00	96.00	53.17	48.60
NR SA 0.02% 1	270.00	243.00	112.00	104.00	49.73	45.43
NR SA 0.03% 1	284.00	263.00	98.00	110.00	52.68	47.82
NR SA 0.03% 2	282.00	256.00	113.00	105.00	49.26	45.18
NR BAP 15-1	280.00	265.00	105.00	115.00	50.24	46.30
NR BAP 20-3	275.00	250.00	114.00	102.00	53.62	54.16
YB	276.50	268.33	111.83	107.00	48.46	46.80
RAJ	262.17	253.83	110.17	113.17	47.71	43.42
NR	282.17	265.33	112.83	109.33	49.62	46.38
S.Em±	10.57	8.29	7.92	4.91	4.60	5.04
CD @ 5%	27.20	21.35	NS	12.65	11.83	12.97

Table 3: Yield parameters of plant and ratoon crop of banana mutant lines

Mutant lines	Weight of bunch (kg)		Length of bunch (cm)		Number of hands per bunch	
	Plant crop	Ratoon crop	Plant crop	Ratoon crop	Plant crop	Ratoon crop
YB25Gy 02	5.29	3.38	53.00	47.00	8.00	6.00
YB25Gy 03	6.12	3.91	57.00	45.00	8.00	6.00
YB25Gy 04	6.00	3.72	56.50	52.00	7.00	6.00
YB25Gy 05	4.60	5.20	46.00	40.00	7.00	7.00
YB30Gy 01	4.86	3.74	48.20	43.52	8.00	6.00
YB30Gy 02	5.61	4.18	51.34	48.21	9.00	6.00
YB30Gy 03	5.25	3.51	46.23	43.50	8.00	6.00
YB30Gy 04	5.47	4.90	53.60	47.00	8.00	6.00
YB30Gy 06	6.30	5.12	56.42	54.00	8.00	7.00
YB30Gy 07	5.95	6.14	46.00	50.28	9.00	8.00
YB30Gy 08	4.78	4.60	48.20	53.69	8.00	7.00
YB30Gy 09	5.08	3.56	44.00	46.24	8.00	6.00
YB30Gy 10	5.91	4.67	51.00	42.30	9.00	5.00
YB30Gy 11	6.20	5.68	49.50	46.00	8.00	8.00
YB30Gy 15	5.12	4.91	53.50	41.50	8.00	6.00
YB35Gy 01	4.27	3.62	44.00	46.00	8.00	5.00
YB35Gy 02	5.14	4.28	49.00	40.51	9.00	5.00
YB35Gy 03	5.43	5.02	47.00	43.60	8.00	6.00
YB35Gy 04	6.69	5.20	53.91	44.58	7.00	9.00
YB35Gy 05	5.30	5.18	56.00	54.00	8.00	8.00
YB35Gy 06	5.04	3.78	51.34	40.21	7.00	6.00
YB35Gy 07	7.06	3.57	59.00	35.50	8.00	8.00
YB35Gy 09	5.22	4.50	46.00	50.50	8.00	6.00
YB35Gy 10	4.87	4.40	57.00	45.61	8.00	5.00
YB35Gy 11	5.50	3.43	54.00	42.00	7.00	6.00
YB35Gy 12	6.65	3.86	58.50	63.40	8.00	6.00
YB35Gy 14	6.93	5.48	56.20	53.00	9.00	9.00
YB35Gy 15	5.01	4.18	61.00	44.00	9.00	5.00

Contd.....

Mutant lines	Weight of bunch (kg)		Length of bunch (cm)		Number of hands per bunch	
	Plant crop	Ratoon crop	Plant crop	Ratoon crop	Plant crop	Ratoon crop
YB35Gy 18	4.26	5.20	56.00	49.00	7.00	6.00
YB35Gy 20	6.60	5.78	62.15	53.50	8.00	9.00
YB35Gy 23	6.55	5.14	40.00	48.25	9.00	7.00
YB35Gy 24	8.62	4.37	67.24	45.67	9.00	6.00
YB35Gy 25	5.89	4.53	56.00	51.50	8.00	6.00
YB40Gy 01	5.24	6.37	48.00	55.23	7.00	7.00
YB40Gy 02	7.59	5.28	46.92	53.00	7.00	8.00
YB40Gy 03	10.17	5.45	59.00	55.34	9.00	7.00
YB40Gy 04	8.53	4.59	62.00	48.00	8.00	6.00
YB40Gy 05	5.73	4.67	42.00	38.50	7.00	5.00
YB40Gy 06	7.77	6.52	68.50	57.42	9.00	9.00
YB40Gy 07	7.95	6.24	66.00	58.00	9.00	9.00
YB40Gy 08	6.81	5.60	58.50	41.00	9.00	8.00
YB40Gy 10	5.82	5.15	51.00	54.00	7.00	8.00
YB40Gy 11	6.95	5.54	65.75	55.00	8.00	7.00
YB40Gy 12	4.93	6.28	47.00	50.81	7.00	8.00
YB40Gy 13	7.54	5.96	62.00	53.42	9.00	8.00
YB40Gy 14	5.49	4.54	56.00	43.00	9.00	6.00
YB40Gy 15	5.43	5.47	50.00	52.00	7.00	7.00
YB45Gy 02	6.73	5.21	49.00	44.00	8.00	7.00
YB45Gy 03	11.96	5.79	69.48	57.00	9.00	8.00
YB45Gy 04	6.73	4.73	52.61	41.35	6.00	6.00
YB45Gy 05	5.60	6.69	58.00	56.29	7.00	9.00
YB45Gy 06	7.01	5.47	46.00	51.00	8.00	7.00
YB45Gy 07	9.93	5.63	68.00	49.52	8.00	8.00
YB45Gy 08	6.05	5.01	56.34	47.00	6.00	6.00
YB45Gy 09	6.37	5.40	41.00	37.00	8.00	8.00
YB45Gy 11	6.63	4.62	59.00	46.62	8.00	6.00
YB45Gy 12	4.97	4.18	62.57	42.70	8.00	6.00

Contd.....

Mutant lines	Weight of bunch (kg)		Length of bunch (cm)		Number of hands per bunch	
	Plant crop	Ratoon crop	Plant crop	Ratoon crop	Plant crop	Ratoon crop
YB45Gy 13	8.20	5.82	68.54	56.50	8.00	7.00
YB45Gy 15	8.89	5.68	64.30	52.35	9.00	7.00
RAJ25Gy 01	5.24	4.36	51.24	48.31	6.00	6.00
RAJ25Gy 02	5.31	4.09	45.00	34.50	6.00	5.00
RAJ30Gy 02	4.20	5.04	47.21	37.00	5.00	6.00
RAJ30Gy 03	4.65	8.55	36.00	52.50	6.00	7.00
RAJ30Gy 05	4.43	3.38	33.74	35.00	8.00	6.00
RAJ30Gy 07	4.02	5.29	48.52	43.71	5.00	6.00
RAJ30Gy 12	5.69	7.19	54.20	50.50	6.00	6.00
RAJ30Gy 13	4.80	4.27	30.00	35.00	8.00	5.00
RAJ35Gy 01	4.55	5.10	33.58	53.00	8.00	8.00
RAJ35Gy 02	5.24	4.31	52.37	39.00	7.00	5.00
RAJ35Gy 03	4.84	4.40	50.00	41.50	7.00	5.00
RAJ35Gy 06	5.95	5.20	32.90	38.00	7.00	5.00
RAJ35Gy 07	5.72	5.64	49.28	46.00	7.00	6.00
RAJ35Gy 09	6.22	3.46	37.24	34.51	7.00	6.00
RAJ35Gy 10	5.29	3.67	42.39	40.31	5.00	5.00
RAJ35Gy 12	6.66	3.75	36.00	38.20	6.00	5.00
RAJ40Gy 01	5.89	4.62	38.00	44.00	7.00	5.00
RAJ40Gy 02	4.06	5.37	34.53	49.00	6.00	6.00
RAJ40Gy 03	5.16	6.94	32.00	51.32	7.00	8.00
RAJ40Gy 04	5.35	4.69	46.25	39.72	6.00	5.00
RAJ40Gy 05	7.52	5.45	49.50	46.00	7.00	6.00
RAJ40Gy 08	6.93	4.35	47.54	40.38	8.00	5.00
RAJ40Gy 09	6.82	4.05	41.00	35.62	6.00	6.00
RAJ40Gy 11	5.26	4.38	39.62	40.50	6.00	5.00
RAJ40Gy 15	5.57	5.12	43.56	48.00	7.00	6.00
RAJ40Gy 22	3.96	5.34	48.20	53.34	5.00	6.00
RAJ40Gy 23	5.50	5.41	54.00	64.00	7.00	8.00

Contd.....

Mutant lines	Weight of bunch (kg)		Length of bunch (cm)		Number of hands per bunch	
	Plant crop	Ratoon crop	Plant crop	Ratoon crop	Plant crop	Ratoon crop
RAJ40Gy 25	5.92	4.42	53.25	38.00	7.00	5.00
RAJ45Gy 03	6.80	5.36	41.63	44.00	8.00	6.00
RAJ45Gy 04	5.32	5.84	42.86	56.00	6.00	7.00
RAJ45Gy 07	7.94	5.28	56.25	45.50	8.00	7.00
RAJ45Gy 08	5.40	5.21	36.80	47.00	6.00	7.00
RAJ45Gy 10	6.83	5.68	51.50	35.00	7.00	9.00
RAJ45Gy 13	6.91	5.35	48.50	44.00	7.00	5.00
RAJ45Gy 14	5.60	11.09	50.00	54.51	9.00	7.00
RAJ45Gy 15	6.18	7.56	47.30	55.00	8.00	7.00
RAJ45Gy 19	6.25	5.50	37.00	42.00	7.00	6.00
RAJ45Gy 20	6.66	5.18	54.00	46.57	8.00	7.00
NR30Gy 06	5.24	4.85	46.00	42.00	5.00	5.00
NR30Gy 10	4.52	3.69	55.00	39.00	6.00	4.00
NR35Gy 08	4.65	4.22	52.00	46.00	6.00	5.00
NR35Gy 11	4.80	5.10	48.37	45.00	6.00	6.00
NR35Gy 12	5.18	4.55	47.00	38.00	5.00	5.00
NR35Gy 19	4.74	4.00	56.00	47.00	5.00	5.00
NR40Gy 05	6.46	5.41	42.38	45.00	6.00	6.00
NR40Gy 07	7.45	5.29	42.00	46.50	5.00	5.00
NR40Gy 09	6.32	4.28	47.00	36.00	5.00	5.00
NR40Gy 12	5.91	3.56	49.50	38.00	6.00	4.00
NR40Gy 15	4.70	4.25	53.00	41.00	5.00	5.00
NR45Gy 01	5.26	4.38	56.00	39.00	7.00	5.00
NR45Gy 02	4.62	4.20	49.00	44.00	5.00	5.00
NR45Gy 04	5.48	3.61	51.20	40.00	5.00	5.00
NR45Gy 09	6.66	5.18	48.00	43.00	5.00	5.00
YB EMS 0.6% 1	7.67	6.52	57.00	54.00	9.00	8.00
YB EMS 0.6% 4	5.85	4.89	50.00	47.00	7.00	7.00
YB EMS 0.9% 1	7.82	6.61	53.62	56.00	9.00	7.00

Contd.....

Mutant lines	Weight of bunch (kg)		Length of bunch (cm)		Number of hands per bunch	
	Plant crop	Ratoon crop	Plant crop	Ratoon crop	Plant crop	Ratoon crop
YB EMS 0.9% 2	10.84	5.42	63.00	56.00	8.00	6.00
YB EMS 0.9% 3	5.28	3.71	45.20	42.31	8.00	6.00
YB EMS 0.9% 4	7.56	4.50	50.50	49.20	7.00	6.00
YB SA 0.02% 1	6.58	5.07	57.00	48.00	8.00	7.00
YB SA 0.03% 6	7.91	5.64	58.20	46.00	7.00	7.00
YB BAP15- 1	5.61	4.26	56.50	52.00	8.00	5.00
YB BAP 20-2	8.75	4.42	64.00	45.20	8.00	5.00
RAJ EMS 0.6 3	8.01	8.37	48.00	62.50	7.00	6.00
RAJ EMS 0.9% 1	5.84	4.65	56.00	42.00	7.00	7.00
RAJ EMS 0.9% 2	7.68	5.62	44.00	39.42	7.00	6.00
RAJ EMS 0.9% 4	6.50	4.09	34.00	37.00	6.00	6.00
RAJ SA 0.02% 1	5.22	8.73	32.00	61.20	6.00	7.00
RAJ SA 0.03% 1	4.56	3.94	30.00	38.00	8.00	5.00
RAJ SA 0.03% 2	5.28	4.08	46.00	35.52	7.00	5.00
RAJ BAP 15- 3	5.64	4.20	38.00	33.00	6.00	5.00
RAJ BAP 20 1	4.34	3.82	36.00	38.62	5.00	5.00
NR EMS 0.6% 3	7.15	4.25	59.50	47.00	6.00	6.00
NR EMS 0.9% 5	5.64	5.30	54.00	49.00	5.00	5.00
NR SA 0.02% 1	4.69	3.89	44.00	47.00	5.00	5.00
NR SA 0.03% 1	5.36	4.28	48.00	53.00	5.00	6.00
NR SA 0.03% 2	4.32	3.96	41.00	45.00	5.00	4.00
NR BAP 15-1	5.66	4.13	48.00	55.00	6.00	5.00
NR BAP20-3	5.83	4.20	60.00	54.02	5.00	5.00
YB	6.01	4.75	50.24	43.26	8.33	5.50
RAJ	5.26	4.94	43.36	45.82	5.83	5.66
NR	4.84	4.06	47.60	41.99	5.33	4.66
S.Em±	1.24	1.48	4.88	8.05	1.43	0.95
CD @ 5%	NS	NS	12.56	NS	NS	2.45

NS- indicates Non significant YB – Yelakki bale RAJ- Rajapuri bale, NR- Nanjangud rasabale

Conclusion: Mutation induction can lead to enhance heritable variation this might be useful for functional genomics or breeding applications. At higher dose of gamma radiation, the early initiation of gibberlic acid pathway will help in the expression of floral meristem identifying genes which enhances earliness to flowering. The yield of banana was possibly high due to increased carbohydrate accumulation, bunch and fruit weight. The application of gamma radiation and chemical mutagen is a promising technique to obtain earliness and good yield in banana.

Future line of work: further it is also worthwhile to study continuation of evaluation of identified mutant lines for consistency in performance. generation of some more mutant lines *in vitro* using physical mutagens at 40Gy and 45Gy. Evaluation of lines for disease resistance by challenging with artificial inoculation of isolated culture or in the sick plot.

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