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RESEARCH ARTICLE

Effect of gamma rays on yield attributing characters of Okra [*Abelmoschus esculentus* (L.) Moench]

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Abstract

Okra [*Abelmoschus esculentus* (L.) Moench] is the most common vegetable crop of tropical and subtropical regions of the world. It is used to cure goiter, leucorrhea, catarrhal jaundice, functional impotency etc. The effect of gamma irradiation on various yield attributing characters such as plant height, internode length, number of leaves/plant, pollen sterility, number of fruits/plant and fruit characters such as length, girth, weight, number of seeds/ fruits and weight of 100 seeds were studied. Seed germination and survival of plants were also recorded.

Introduction

Mutation breeding is one of the conventional breeding methods in plant breeding. The radiations are the best tools to induce genetic variability within a very short span of time. Induced mutation is highly effective in enhancing natural genetic resources and has been used in developing improved cultivars of cereals, fruits and other crops (Lee et al., 2002). The genus Abelmoschus ,belongs to family Malvaceae is represented by 12 species (Bentham and Hooker,1867)in which the most common vegetable crop, okra [Abelmoschus esculentus (L.) Moench] is included. A. esculentus is a multipurpose crop valued for its tender and delicious fruits. Okra is the sixth important popular vegetable crop widely grown under varying climatic conditions in almost all parts of India throughout the year except in the mountainous region. It is estimated that world okra production is about 5 to 6 million tonnes per year. India is the largest producer of okra covering an area of 3.8 lakh hectares with an annual production of 36.84 lakh tones (Gangashetty et. al., 2010). Immature green fruits are cooked in curry and soups. High iodine content of fruits helps to control goiter. However, the widespread incidence of yellow vein mosaic disease in this crop has affected its successful cultivation. It is a virus disease transmitted by the white fly (Bemisia tabaci). In okra, mutation breeding has been done by Norfadzrin et al. (2007) Manju and Gopimony (2009) ,Phadvibulya et al. (2009) ,Hegazi and Hamideldin (2010) and Muralidharan and Rajendran (2013) by using different doses of gamma rays. With the objective of producing disease resistant variety gamma irradiation was done in A. esculentus. The effect of gamma irradiation on the various yield attributing characters were reported in this study.

Materials and Methods

In the previous study, out of the 25 accessions collected from different localities of Kerala a superior variety namely Anakomban was selected based on the comparative studies on yield attributing characters. This variety was used for irradiation for further improvement of characters in the present study. The seeds were irradiated at six different dose levels such as 100Gy, 150Gy, 200Gy, 300Gy, 400Gy and 500Gy. These doses were delivered from a 3500 curie CO^{60} gamma cell installed at Kerala Agriculture University, Vellanikkara. The gamma source was stationery and its irradiations were done at a dose rate of 3200 Rads/min by moving down a cylindrical gasket carrying the seeds.

The experiment was laid out in Randomised Block Design, with seven treatments and four replications. The 140 seeds of each of the seven treatments were sown on the third day of treatment at the rate of 20 progeny rows/ treatment with proper randomization. The seeds were soaked overnight to facilitate uniform pre- soaking. Data on

qualitative and quantitative characters of M_1 generation were gathered from 25 plants/treatment. The seeds of M_1 generation were collected and M_2 generation is being raised for further selection.

For scoring of Yellow Vein Mosaic disease intensity in the irradiated populations (M1 generation), the rating scale suggested by Arumugam et al. (1975) was used. For noting germinability of the seeds, the seeds were sowed in moist soil. The number of seeds germinated was counted everyday for 15 days. The percentage of germination of each treatment was then calculated. The survival of seedling was recorded on the 10^{th} day onwards after sowing. Pollen sterility was studied by mounting the pollen in 1glycerine: 1 acetocarmine stain.

Results and Discussion

During this study the effects of gamma radiation on various characters such as seed germination, survival of seedlings , height of plants, number of leaves/ plant, pollen sterility, number of fruits/plant and fruit characteristics such as length, girth, weight, number of locules/fruit, number of seeds/fruit and 100 seed weight of M_1 generation were recorded (Table 1). The direct effect of the mutagen is seen in the first generation of mutagenesis. The details of various characters are presented separately.

1. Seed germination

The data on germination of seeds sown after treatment are presented in table 1. The germination per cent ranged from 80.0 per cent in control to 44.0 per cent in 500 Gy exposure. Treated seeds showed a tendency for decrease in percentage of germination with an increase in doses such as 100Gy (72.0%), 150Gy (68.0%), 200Gy (66.0%) and 300Gy (64.0%). The plants developed from 400Gy exposure showed 76.0 per cent of seed germination. Hegazi and Hamideldin (2010) also reported that among the three doses of gamma rays such as 300, 400 and 500Gy exposures, maximum percentage of seeds germinated in 400Gy exposure compared to the control. In cow pea, percentage of germination and seedling survival were higher at lower doses and lower at higher dose (Gnanamurthy et al.,2013).

2. Survival of plants

Percentage of survival of plants reaching to maturity ranged from 90.0 per cent in control to 25.0 per cent in 500Gy exposure. With an increased dose of gamma rays, the percentage of survival decreased gradually upto 300Gy exposure. In 400Gy exposure percentage of survival was 62.0 per cent. According to Manju and Gopimony (2009) the influence of mutagen on plant growth regulators caused a delay in the initiation of germination. The reduction in the survival of plants is an index of post-germination mortality as a result of cytological and physiological disturbances due to the radiation effect. Norfadzrin et al. (2007) and Muralidharan and Rajendran (2013) have also reported that increased dose of gamma rays decreased the percentage of germination and survival of seedlings in okra.

3. Height of plants

Height of the plants at harvest ranged from 102.17±2.15 cm in control to 63.54 ± 1.83 in higher exposure of 500Gy except in 400Gy exposure which showed 115.16±2.94cm. This showed the effect of mutagen on the height of the plant where plant height decreased from lower to higher dose except 400Gy exposure. The same trend of decrease in plant height was also noticed in 30, 60and 90 days after planting. Height of the plant, derived from 400Gy treated seeds exceeded to that of control also. Hegazi and Hamideldin (2010) also obtained plants with maximum height for 400Gy exposure while using 300, 400 and 500Gy gamma ray exposures.

4. Length of internode

Length of internode ranged from 5.21±0.49cm in control to 3.31 ± 0.39cm in 500Gy exposure except in 400Gy which showed 6.17±0.34cm. Internode length of plants which developed from 400Gy exposure exceeded to that of control. Based on the observations on internode length and plant height Manju and Gopimony (2009) reported that the growth rate was reduced by the mutagen. This reduction could be due to auxin destruction and it may also be attributed to the influence of ionizing radiation leading to the genetic loss due to chromosomal aberrations(Evans et al., 1961). Norfadzrin et al. (2007) have also reported that height of the plants was decreased while increasing the dose of gamma rays in okra.

5. Number of leaves

Highest number of leaves (32.26 ± 0.75) were seen in plants of 400 Gy exposure and lower in 500Gy exposure (19.47 ± 0.53). Other irradiations showed a decline with a range of 29.23 ± 0.21 (100Gy) to 22.72 ± 0.61(300Gy). The same trend of decrease in number of leaves was also noticed in 30, 60 and 90 days after planting.

6. Number of fruits (Yield)

Maximum number of fruits was developed from 400Gy exposure (14.34 ± 0.86) while lowest number was observed in 500Gy exposure (2.67 ± 0.31). A regular declinity in fruit number due to increasing levels of gamma ray exposure could be seen in the plants with exposures of 100Gy (12.16±1.80),150Gy (6.60±1.62) ,200Gy (5.21±0.95) and 300Gy (5.19±1.15).

7. Length of fruit

Maximum fruit length was observed in 400Gy exposure (38.65 ± 2.27 cm) and lowest fruit length (20.59 ± 1.13) was seen in 500 Gy exposure. Progressive decline in fruit length as a result of direct effect of increasing levels of gamma ray exposure could be seen in the plants of 100Gy exposure (34.084 ± 2.14 cm), 150Gy exposure (30.53 ± 1.85 cm), 200Gy exposure (30.27 ± 2.01 cm) and 300Gy exposure (30.04 ± 1.96 cm).

8. Girth of fruit

Girth of fruits ranged from 10.17 ± 0.34cm in 400Gy exposure to 5.58±0.26cm in 500Gy exposure. Girth of fruits in 400Gy exposure exceeded to that of control also. Regular declinity in fruit girth was also seen with increase in irradiation dose of gamma rays except that of 400Gy exposure.

9. Weight of fruit

Fruit weight ranged from 51.14±1.67gm in 400Gy exposure to 18.48±0.83gm in 500Gy exposure. Regular reduction in fruit weight was observed with increase in irradiation doses such as 100Gy (42.61±2.52gm), 150Gy (33.78±0.97 gm), 200Gy (34.11±1.57 gm) and 300Gy (32.67±0.99 gm). Weight of the fruit developed from 400Gy exposure exceeded to that of control also.

10. Number of seeds/fruit

Number of seeds/fruit ranged from 87.02 ± 6.31 in 400Gy exposure to 21.46 ± 4.82 in 500Gy exposure. Reduction in seed number with increase in dose from 100Gy (66.45±4.04) to 300Gy (51.03±4.83) was also observed.

11. Weight of 100 seeds

100 seeds each from every treatment were collected at random and weighed. Maximum seed weight (7.780gm) was seen in 400Gy exposure and lowest (6.150gm) in 500Gy exposure. Regular declinity in weight of 100 seeds was observed with increase in doses such as 100Gy (7.364gm), 150Gy (7.268gm), 200Gy (6.856gm) and 300Gy (6.680gm).

12. Number of locules/fruit

There was much variations in the number of locules/fruit. The plants derived from 150Gy irradiation showed 5,7 and 8 locules and 400Gy showed 6,7 and 8 locules. Others showed 6, 6 and 7, 7 and 8 or 7 and 9 locules.

It is clear that in majority of the above characters, regular declinity in their values were observed with increase in irradiation dose with the exception of 400Gy exposure where the values are maximum.

13. Pollen sterility

Control plants showed 1.21 percentage of pollen sterility. The irradiated plants showed pollen sterility ranged from 8.40 per cent in 100Gy exposure to 16.89 per cent in 500Gy exposure. A progressive increase in the percentage of sterility with increase in radiation doses was also observed. High pollen sterility together with higher percentage of fruit set, observed in 400Gy exposure might be the result of normal chromosome pairing which was dependent on dose of gamma irradiation and indicates the possibility of obtaining high fertile segregants in the succeeding generations of the irradiated population. The mutagenic effectiveness was found to increase with increase in dose of gamma rays and 400Gy treatment showed the highest efficiency.

The intensity of Yellow Vein Mosaic disease was determined by examining the characteristic symptoms of the disease in all the irradiated population (M_1 generation). In the M_1 generation, those irradiated with a dose of 400Gy were found to be resistant compared to others.

In the present study, among the six doses of irradiations applied to the seeds, those treated with 400Gy has the highest values for mean height, number of leaves, number of fruits/plant, fruit characteristics such as length, girth, weight, number of seeds/fruit and weight of 100 seeds. Hence it was identified as superior one based on their yield, yield attributing characters and disease rating of Yellow Vein Mosaic disease. It is also interesting to note that in majority of the characters, the values of 400Gy irradiated plants exceeded to that of control plants. A regular

decrease in the values of above traits was also seen as doses were increased from 100Gy to 300Gy exposure. LD_{50} value was set at 500Gy exposure. In M_2 generation plants were smaller than M_1 generation but their fruits were strickingly larger (upto 46cm long). Moreover, the plants showed abnormalities like flowers with 6 and 7 petals and 6, 7 or 8 stigmata, node with two flowers, unequal leaves with irregular shape etc. Detailed studies on these characters are being carried out.

Table 1. Effect of gamma rays on various traits of M_1 generation of Abelmoschus esculentus

Dose of gamma irradiation	Germination (%)	Survival (%)	Plant height (cm)	Internode length (cm)	Total number of leaves	Pollen sterility (%)	No.of fruit/plant	Fruit length (cm)	Fruit girth (cm)	Fruit Weight (gm)	No.of locules in the fruit	No.of seeds/fruit	100 Seed weight (gm)	Mean disease rating of YVM
0 (Control)	80.00	90.00	102.17±2.15	5.21 ±0.49	30.01±0.43	1.21	13.21±0.81	35.26 ± 2.83	9.51 ±0.26	44.72 ±1.98	6,7	74.81 ±9.63	7.582	3.40
100 Gy	72.00	88.00	98.68 ±2.90	5.16 ±0.38	29.23 ± 0.21	8.40	12.16±1.80	34.08 ± 2.14	9.24 ±0.51	42.61 ±2.52	6,7	66.45 ±4.04	7.364	3.40
150 Gy	68.00	73.00	83.44 ±1.98	4.85 ±0.41	27.65 ± 0.68	9.64	6.60 ± 1.62	30.53 ± 1.85	9.05 ±0.55	33.78 ±0.97	5,7,8	58.66 ±7.67	7.268	3.36
200 Gy	66.00	60.00	80.47 ±2.64	4.52 ±0.34	25.13 ± 0.59	12.57	5.21± 0.95	30.27 ± 2.01	9.13 ±0.48	34.11 ±1.57	7,8	47.64 ±6.18	6.856	3.32
300 Gy	64.00	54.00	90.91 ±2.67	5.25 ±0.40	22.72± 0.61	12.89	5.19±1.15	30.04 ± 1.96	9.52 ±0.29	32.67 ±0.99	7,9	51.03 ±4.83	6.680	2.87
400 Gy	76.00	62.00	115.16 ±2.94	6.17 ±0.34	32.26± 0.75	13.62	14.34±0.86	38.65 ± 2.27	10.17 ± 0.34	51.14 ±1.67	6,7,8	87.02 ±6.31	7.780	2.01
500 Gy	44.00	25.00	63.54 ±1.83	3.31 ±0.39	19.47± 0.53	16.89	2.67±0.31	20.59± 1.13	5.58 ± 0.26	18.48 ±0.83	6	21.46 ±4.82	6.150	2.83

Conclusions

Among the six doses of gamma irradiations, 400Gy exposure was found to increase plant height, internode length, number of leaves/plant, pollen sterility, number of fruits/plant and fruit characters such as length, girth, weight, number of seeds/fruit and weight of 100 seeds. The resulted plants were identified as superior one based on their yield, yield attributing characters and disease rating of Yellow Vein Mosaic disease. In majority of cases the values of 400Gy irradiated plants exceeded to that of control plants also.

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