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Response of ems and colchicine on genetic variability, heritability and genetic advance in bhendi (*Abelmoschus esculentus* (L) moench) varieties of MDU 1 and Arka Anamika

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Abstract

Bhendi (*Abelmoschus esculentus* L.) is major vegetable crop in tropical and subtropical regions of the world. Mutation induction has been accepted as a useful tool in plant breeding programme to provide more variability. The seeds of bhendi varieties MDU 1 and Arka Anamika were subjected to the chemical mutagens. The investigation using ethyl methane sulphonate (EMS) and colchicine in various concentrations which were fixed based on LD₅₀ value. The yield and its component traits were recorded in M₂ generation. The PCV and GCV were more for number of branches per plant, number of nodes per plant, fruit girth, fruit weight, and fruit yield per plant indicating the release of micro mutation for these characters. High heritability coupled with genetic advance for fruit yield per plant was observed in 0.8 percent EMS treatment in MDU 1 variety. This indicated that variability induced by these treatments in these variety is highly heritable and additive in nature and hence selection will be effective.

Keywords: Mutation, EMS, Colchicine, Bhendi

Introduction

Bhendi (*Abelmoschus esculentus* (L.) Moench), commonly known as okra or ladies finger has a prominent position among vegetables due to its wide adaptability, year round cultivation, export potential and high nutritive value.

The medicinal values of bhendi are associated with genito-urinary disorders, spermatorrhoea and chronic dysentery. It is a potential export earner, accounting for 60 per cent of export of fresh vegetables (Sharma and Arora, 1993) [16]. This significant achievement in bhendi production is possible by development of high yielding varieties, hybrids, breeding for resistance to biotic and abiotic stresses and mutation breeding (Ajay Verma, 2000) [1].

Variability is a prerequisite for any breeding programme to evolve high yielding varieties with other desirable attributes. Mutagenesis is an important method of plant breeding employed to create variability and to widen the genetic base.

Though mutation breeding has been adopted in many crop plants and considerable improvement has been achieved, bhendi which is an important vegetable crop of Afro-Asian countries, has not been subjected to systematic mutation breeding so far. The introduction of genetic variability through interspecific hybridization has been relatively difficult because it is possible only through ovule and / or embryo culture method. Consequently improvement in this crop was mainly brought about through selection.

Physical and chemical mutagens are the potential mutagenic agents for induction of mutations. Various classes of chemical and physical mutagens differ in their efficiency in inducing mutations and in the spectrum of mutations induced. However, chemical mutagens are most widely used and compared to ionizing radiations, they induce more viable mutants (Heslot *et al.*, 1961) [7].

Materials and Methods

The present investigation was carried out at the Plant Breeding Farm, Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalai Nagar during 2013 to 2014. The materials used and the methods followed are described below.

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Materials

Biological material

Table 1: Source and special characters of the parents

S.No	Parents	Source	Special Character
1.	MDU-1	AC&RI, Madurai, TNAU	Tall plants. Normal green and broad leaves. Light green with long beaked fruits
2.	Arka Anamika	IIHR, Bangalore	Medium tall plants. Medium green and medium long fruits. Resistant to Yellow Vein Mosaic (YVM)

Mutagens employed

Chemical mutagens like ethyl methane sulphonate (EMS) and colchicine were used at various concentrations to induce mutagenesis.

Ethyl methane sulphonate (EMS) ($\text{CH}_2\text{SO}_2\text{OC}_2\text{H}_5$)

The chemical was obtained from Koch-light Laboratory, Colnbrook -Bucks -England, having a dosimetry 1 half-life period of 30 hours with a molecular weight of 124.16 and density of 1.20.

Colchicine ($\text{C}_{22}\text{H}_{25}\text{NO}_6$)

The chemical was purchased from HI-MEDIA Laboratories, Mumbai, having a molecular weight of 399.45 with a melting point of $147^\circ - 150^\circ\text{C}$.

Determination of LD_{50} value

Ethyl methane sulphonate

Two sets containing 200 well filled healthy seeds were selected for treatment to determine the LD_{50} value. Seeds were presoaked in water for 12 hours followed by EMS at 0.20, 0.40, 0.60, 0.80, 1.00, 1.20, 1.40, 1.60, 1.80 and 2.00 per cent concentrations. The seeds after soaking in EMS were thoroughly washed under tap water for 8 to 10 times. The treated seeds were then subjected to germination test. Based on reduction of germination to 50 per cent. LD_{50} value was determined. Three concentrations of EMS around LD_{50} were used for further studies.

Colchicine

Two sets containing 200 well filled healthy seeds were selected for treatments. The seeds were presoaked in water 12 hour followed by soaking in colchicine at 0.20, 0.40, 0.60, 0.80, 1.00, 1.20, 1.40, 1.60, 1.80 and 2.00 per cent concentrations. The seeds after soaking in colchicine were thoroughly washed under tap water for 8 to 10 times. The treated seeds were then subjected to germination test. Based on reduction of germination to 50 per cent LD_{50} value was determined. Three concentrations of colchicine around LD_{50} were used for further studies.

Mutagen treatment

Ethyl methane sulphonate

The required concentrations of EMS were prepared in distilled water. The volume of solution is about three times the volume of seeds. The seeds were presoaked in distilled water for 12 hours. The excess moisture in the seeds was removed by pressing it in folds of filter paper. Then the seeds were soaked in for 12 hours at room temperature ($26 \pm 2^\circ\text{C}$) with intermittent shaking. After the treatment, the seeds were thoroughly washed with tap water for 8 to 10 times before sowing in the main field.

Colchicine

The seeds were soaked in distilled water for 12 hours. Then the excess moisture in seeds was removed by pressing in folds of filter paper. The seeds were then soaked in colchicine prepared in distilled water for 12 hours at room temperature ($26 \pm 2^\circ\text{C}$) with intermittent shaking. After the treatment, the seeds were thoroughly washed in tap water for 8 to 10 times before sowing in the main field.

Control

Seeds soaked in distilled water for 24 hours were used as control.

Generation Studies

Study of M_2 generation

The seeds harvested from M_1 generation were bulked from individual treatments and were used for raising M_2 generation (Panda and Subudhi, 1994). But few treatments such as 0.8 per cent, 1.0 per cent and 1.2 per cent EMS in Arka Anamika variety. The M_2 generation was grown with three replications in randomized block design and 25 plants were maintained for each treatment per replication. Biometric observations were recorded and individual plant data and mean values were used for statistical analysis. Observations recorded for Plant height, Number of branches per plant, Number of nodes per plant, Fruit length, Fruit girth, Number of fruits per plant, Number of seeds per fruit, Fruit weight and Fruit yield per plant.

Result and Discussion

Plant height: In MDU-1 variety, maximum PCV value was recorded in 0.4 per cent colchicine treatment (4.57) and GCV value in 0.6 per cent colchicine treatment (2.70) while minimum values were recorded in 1.0 per cent EMS (0.85) and 0.8 per cent colchicine (0.34) respectively. High heritability was noted in 0.6 per cent colchicine (73.68) while low heritability in 0.8 per cent colchicine (2.89). High genetic advance was noticed in 0.6 per cent colchicine treatment (4.98) and high genetic advance as per cent of mean value in 0.6 per cent colchicine treatment (4.78) while low genetic advance and genetic advance as per cent of mean value was noticed in 0.8 per cent colchicine (0.16).

In Arka Anamika variety, maximum PCV and GCV values were recorded in 0.4 per cent colchicine (1.95 and 1.48, respectively) while minimum PCV and GCV values were recorded in 0.8 per cent colchicine as (1.56 and 1.08, respectively). High heritability was noticed in 0.8 per cent colchicine (65.46) while low heritability was noticed in 0.4 per cent colchicine (53.96). Higher genetic advance and genetic advance as per cent of mean values were noticed in 0.8 per cent colchicine (2.58 and 2.35, respectively) while lower genetic advance and genetic advance as per cent of mean values was noticed in 0.6 per cent colchicine (1.95 and 1.81, respectively).

Number of branches per plant: In MDU-1 variety, maximum PCV and GCV values were recorded in 0.4 per cent colchicine and 1.0 per cent EMS (39.90 and 14.35, respectively) while minimum PCV and GCV values were recorded in 0.6 per cent colchicine (28.17 and 5.42, respectively). High heritability value was noticed in 1.0 per cent EMS (17.95) while low heritability values was noticed in 0.6 per cent colchicine (3.70). Higher genetic advance and genetic advance as per cent of mean values were recorded in 1.0 per cent EMS (0.24 and 12.52, respectively) while lower

genetic advance and genetic advance as per cent of mean values were noticed in 0.6 per cent colchicine (0.04 and 2.14, respectively).

In Arka Anamika variety, maximum PCV and GCV values were recorded in 0.8 per cent colchicine (74.33 and 57.70, respectively) while minimum PCV and GCV values were recorded in 0.6 per cent colchicine (37.03 and 12.34, respectively). High heritability value was noticed in 0.8 per cent colchicine (60.26). Higher genetic advance and genetic advance as per cent of mean values were noticed in 0.8 per cent colchicine (0.84 and 92.27, respectively) while lower genetic advance and genetic advance as per cent of mean values were noticed in 0.6 per cent colchicine (0.10 and 8.47, respectively).

Number of Nodes per plant: In MDU-1 variety, maximum PCV and GCV values were recorded in 1.0 per cent EMS (27.27 and 11.05, respectively) while minimum PCV and GCV values were recorded in 0.6 per cent colchicine (6.03 and 4.05, respectively). High heritability value was noted in 0.8 per cent colchicine (67.87) while low heritability value was noted in 1.0 per cent EMS (16.44). Higher genetic advance and genetic advance as per cent of mean values were noticed in 0.8 per cent colchicine (2.19 and 15.58, respectively) while lower genetic advance and genetic advance as per cent of mean values were noticed in 0.6 per cent colchicine (0.71 and 5.63, respectively).

In Arka Anamika variety, maximum PCV and GCV values were recorded in 0.4 per cent colchicine (7.11 and 3.98, respectively). High heritability value was noted in 0.6 per cent colchicine (48.86 per cent) while low heritability value was noted in 0.4 per cent colchicine (31.41 per cent). Higher genetic advance and genetic advance per cent of mean values were noticed in 0.8 per cent colchicine and 0.4 per cent colchicine (0.65 and 4.60, respectively). While lower genetic advance and genetic advance as per cent values were noticed in 0.4 per cent colchicine and 0.8 per cent colchicine (0.55 and 4.34, respectively)

Fruit Length: In MDU-1 variety, maximum PCV and GCV values were recorded in 0.4 per cent colchicine (5.20 and 3.86, respectively) while minimum PCV and GCV values were recorded in 1.0 per cent EMS (1.30 and 0.52, respectively). High heritability value (65.38) was noted in 0.8 per cent colchicine while low heritability value (14.99) was noted in 1.2 per cent EMS. Higher genetic advance and genetic advance as per cent of mean value were recorded in 0.4 per cent colchicine (0.83 and 5.83, respectively) while low genetic advance and genetic advance as per cent of mean value were recorded in 1.0 per cent EMS (0.07 and 0.54, respectively).

In Arka Anamika variety, the maximum PCV and GCV values were recorded in 0.8 per cent colchicine (4.75 and 1.80, respectively) while the minimum PCV and GCV values were recorded in 0.6 per cent colchicine and 0.4 per cent colchicine (1.78 and 0.54, respectively). High heritability value was noted in 0.6 per cent colchicine (22.72) while low heritability value was noted in 0.4 per cent colchicine (2.92). Higher genetic advance and genetic advance as per cent of mean values were noticed in 0.8 per cent colchicine (0.22 and 1.41, respectively) while lower genetic advance and genetic advance as per cent of mean values were noticed in 0.4 per cent colchicine (0.03 and 0.19, respectively).

Fruit Girth: In MDU-1 variety, maximum PCV and GCV

values were recorded in 0.4 per cent colchicine and 0.6 per cent colchicine (19.60 and 3.70, respectively) while minimum PCV and GCV values were recorded in 1.2 per cent EMS and 0.8 per cent EMS (1.07 and 0.28, respectively). High heritability value was noted in 0.6 per cent colchicine (83.40) while low heritability value was noted in 0.8 per cent EMS (4.00). Higher genetic advance and genetic advance as per cent of mean value were noticed in 0.6 per cent colchicine (0.37 and 6.96, respectively) while lower genetic advance and genetic advance as per cent of mean value were noticed in 0.8 per cent EMS (0.01 and 0.11, respectively).

In Arka Anamika variety, maximum PCV and GCV values were recorded in 0.4 per cent colchicine (6.52 and 4.63, respectively) while minimum PCV and GCV values were recorded in 0.6 per cent colchicine (3.10 and 1.78, respectively). High heritability value was noted in 0.4 per cent colchicine (50.40) and low heritability value was noted in 0.6 per cent colchicine (33.04). Higher genetic advance and genetic advance as per cent of mean were noticed in 0.4 per cent colchicine (0.39 and 6.77, respectively) while lower genetic advance and genetic advance as per cent of mean value were noticed in 0.6 per cent colchicine (0.11 and 2.11, respectively).

Number of fruits per plant: In MDU-1 variety, maximum PCV and GCV values were recorded in 0.4 per cent colchicine (14.61 and 9.65, respectively) while minimum PCV and GCV values were recorded in 0.8 per cent EMS and 0.6 per cent colchicine (6.037 and 1.72, respectively). High heritability value was noted in 1.2 per cent EMS (51.89) and low heritability value was noted in 0.6 per cent Colchicine (7.88). Higher genetic advance and genetic advance as per cent of mean was noticed in 0.4 per cent colchicine (1.30 and 13.13, respectively) while lower genetic advance and genetic advance as per cent of mean was noticed in 0.6 per cent colchicine (0.10 and 0.99, respectively).

In Arka Anamika variety, maximum PCV and GCV values were recorded in 0.4 per cent colchicine and 0.8 per cent colchicine (7.34 and 4.89, respectively) while minimum PCV and GCV values were recorded in 0.6 per cent colchicine and 0.4 per cent colchicine (6.87 and 3.52, respectively). High heritability value was noted in 0.8 per cent colchicine (54.67) and low heritability value was noted in 0.4 per cent colchicine (23.02). Higher genetic advance and genetic advance as per cent of mean was noticed in 0.8 per cent colchicine (0.92 and 7.02, respectively) while lower genetic advance and genetic advance as per cent of mean was noticed in 0.4 per cent colchicine (0.34 and 3.48 respectively).

Fruit Weight: In MDU-1 variety, maximum PCV and GCV values were recorded in 0.4 per cent colchicine (6.83 and 5.33, respectively) while minimum PCV and GCV values were recorded in 0.8 per cent EMS and 1.0 per cent EMS (1.15 and 0.56, respectively). High heritability value was noted in 0.8 per cent EMS (70.23) and low heritability value was noted in 0.6 per cent colchicine (16.80). Higher genetic advance and genetic advance as per cent of mean values were noticed in 0.4 per cent (1.42 and 8.58, respectively) while lower genetic advance and genetic advance as per cent of mean values were noticed in 1.0 per cent EMS (0.07 and 0.50, respectively).

In Arka Anamika variety, maximum PCV and GCV values were recorded in 0.6 per cent colchicine (4.15 and 2.00, respectively) while minimum PCV and GCV values were recorded in 0.8 per cent colchicine (1.37 and 0.26,

respectively). High heritability value was noted in 0.6 per cent colchicine (23.36). Higher genetic advance and genetic advance as per cent of mean was noticed in 0.6 per cent colchicine (0.35 and 1.94, respectively) while lower genetic advance and genetic advance as per cent of mean value was noticed in 0.8 per cent colchicine (0.01 and 0.10, respectively).

Fruit yield per plant: In MDU-1 variety, maximum PCV and GCV values were recorded in 0.4 per cent colchicine (17.43 and 10.49, respectively) while minimum PCV and GCV values were recorded in 0.8 per cent colchicine (9.17 and 0.89, respectively). High heritability value was noted in 0.8 per cent EMS (91.39) and low heritability value was noticed in 0.8 per cent colchicine (0.95). Higher genetic advance and genetic advance as per cent of mean was noticed in 0.8 per cent colchicine (25.49 and 17.41, respectively) while lower genetic advance and genetic advance as per cent of mean value was noticed in 0.8 per cent colchicine (0.35 and 0.17, respectively).

In Arka Anamika variety, maximum PCV and GCV values were recorded in 0.6 per cent colchicine (9.40 and 5.08, respectively) while minimum PCV and GCV values were recorded in 0.8 per cent colchicine and 0.4 per cent colchicine (7.37 and 2.18, respectively). High heritability value was noted in 0.8 per cent colchicine (44.64) and low heritability value was noted in 0.4 per cent colchicine (6.65). Higher genetic advance and genetic advance as per cent of mean was noticed in 0.6 per cent colchicine and 0.8 per cent colchicine (10.87 and 8.09, respectively) while lower genetic advance and genetic advance as per cent of mean value was noticed in 0.8 per cent colchicine and 0.4 per cent colchicine (1.03 and 1.16, respectively).

Variability

In the present study, the phenotypic coefficient of variation (PCV) was higher than genotype coefficient of variation (GCV) for all the characters in all the treatments.

Plant Height: In MDU-1, maximum PCV was observed in 0.4 per cent colchicine treatment followed by 0.6 per cent colchicine treatment. In Arka Anamika and Mahyco hybrid, maximum PCV and GCV was observed in 0.4 per cent colchicine followed by 0.6 per cent colchicine treatment. Among these varieties, maximum PCV was recorded in MDU-1 for 0.4 per cent colchicine treatment. High PCV and GCV for plant height were already reported by Yadav (1984)^[21]. However, Sonia Sood *et al.* (1995)^[19] reported a moderate PCV and GCV for this character.

Number of Branches per Plant: In MDU-1 variety maximum PCV was noticed in 0.4 per cent colchicine followed by 0.8 per cent colchicine while maximum GCV was observed in 1.0 per cent EMS followed by 0.4 per cent colchicine treatment. In Arka Anamika, maximum PCV and GCV were recorded in 0.8 per cent colchicine followed by 0.4 per cent colchicine treatment.

Among the varieties, maximum PCV and GCV were noted in 0.8 per cent colchicine treatment Arka Anamika followed by 0.8 per cent colchicine treatment in Arka Anamika.

High PCV and GCV for number of branches were observed by Bindu *et al.* (1997)^[3]. However, Thaker *et al.* (1989)^[20] and Ariyo (1990)^[2] recorded low PCV and GCV for this trait.

Number of nodes per plant: In MDU-1 variety, maximum

PCV and GCV were observed in 1.0 per cent EMS followed by 0.4 per cent colchicine for PCV and 0.8 per cent colchicine for GCV. In Arka Anamika, maximum PCV and GCV were observed in 0.4 per cent colchicine followed by 0.6 per cent colchicine treatment. Among these varieties, maximum PCV and GCV were noticed in 1.0 per cent EMS in MDU-1. High PCV and GCV were observed by Patil *et al.* (1996)^[13] for this character. Sonia Sood *et al.* (1995)^[19] recorded low values of PCV and GCV for this character.

Fruit Length: In MDU-1, maximum PCV and GCV were noticed in 0.4 per cent colchicine followed by 0.8 per cent EMS for PCV and 0.8 per cent colchicine for GCV. In Arka Anamika, maximum PCV and GCV were noticed 0.8 per cent colchicine followed by 0.4 per cent colchicine for PCV and 0.6 per cent colchicine for GCV. Ariyo (1990)^[2] also obtained high PCV and GCV for this character. However, moderate PCV and GCV for this trait was observed by Rajani and Manju (1997)^[15].

Fruit Girth: In MDU-1 variety, maximum PCV was observed in 0.4 per cent colchicine followed by 0.8 per cent colchicine treatment while maximum GCV was noticed in 0.6 per cent colchicine followed by 0.4 per cent colchicine. In Arka Anamika, maximum PCV and GCV were observed 0.4 per cent colchicine followed by 0.8 per cent colchicine treatment. Among these varieties, maximum PCV and GCV were noted in 0.4 per cent colchicine in MDU-1. Low PCV and GCV were already observed for this character by Dash and Mishra (1998)^[4]. But high PCV and GCV were observed by Patil *et al.* (1996)^[13] for this trait.

Number of fruits per plant: In MDU-1, maximum PCV and GCV were recorded in 0.4 per cent colchicine followed by 1.2 per cent EMS treatment. In Arka Anamika, maximum PCV was observed in 0.4 per cent colchicine followed by 0.8 per cent colchicine while maximum GCV was noticed in 0.8 per cent colchicine followed by 0.6 per cent colchicine treatment. Among these varieties, maximum PCV and GCV was recorded in 0.4 per cent colchicine in MDU-1. High PCV and GCV were noticed by Sharma (1984)^[8] for this trait. Similarly Meghwal and Khandelwal (1994)^[9] observed moderate PCV and GCV for this character. However, high estimates PCV and comparatively low GCV were observed by Palaniveluchamy *et al.* (1983)^[11] for this trait.

Fruit weight: In MDU-1, maximum PCV and GCV were recorded in 0.4 per cent colchicine followed by 1.2 per cent EMS. In Arka Anamika, maximum PCV and GCV were observed in 0.6 per cent colchicine followed by 0.4 per cent colchicine.

Fruit yield per plant: In MDU-1 variety, maximum PCV and GCV were observed in 0.4 per cent colchicine followed by 0.6 per cent colchicine for PCV and 0.8 per cent EMS for GCV. In Arka Anamika, maximum PCV and GCV were noted in 0.6 per cent colchicine followed by 0.4 per cent colchicine for PCV and 0.8 per cent colchicine for GCV. Among these varieties, maximum PCV and GCV were observed in 0.4 per cent colchicine in MDU-1. High PCV and GCV were already estimated for this trait by Singh *et al.* (1998)^[18].

Heritability and genetic advance: Heritability estimates along with genetic advance as percent of mean normally more

helpful in predicting the gain under selection than heritability estimates alone.

Plant height: In MDU-1 variety, high heritability and low genetic advance as per cent of mean were observed in 0.6 per cent colchicine treatment and moderate heritability and low genetic advance was been found in 1.0 per cent and 1.2 per cent EMS treatment while low heritability and low genetic advance have been found in all other treatments which are ineffective for selection - since this character was highly influenced by environmental effects.

In Arka Anamika, high heritability with low genetic advance as per cent of mean was found in 0.8 per cent colchicine treatment while for all other treatments moderate heritability and low genetic advance were observed. This indicated that induced variability for this character was of non-additive in nature. Similar results were obtained by Bindu *et al.* (1997)^[3]. High heritability with high genetic advance for plant height was obtained by Singh *et al.* (1998)^[18] while moderate heritability with high genetic advance for this trait was observed by Yadav and Chankar (1991)^[22]. But low heritability with low genetic advance was observed by Mohamed Yassin.

Number of branches per plant: In MDU-1, all the treatments showed low heritability with low genetic advance as per cent of mean. Thus the selection would be ineffective. This view was earlier brought out by Senthil Kumar (2000).

In Arka Anamika, high heritability with high genetic advance as per cent of mean of mean was found in 0.8 per cent colchicine. Similar results were already reported by Singh *et al.* (1998)^[18] suggested that the characters exhibiting high heritability and high genetic advance were governed by additive genes and hence selection for this character would be most effective.

High heritability with low genetic advance was noticed already by Rajani and Manju (1997)^[15] for number of branches, while moderate heritability with high genetic advance was observed by Gondane and Lai (1994)^[6]. Similarly moderate heritability and genetic advance was observed by Thaker *et al.* (1989)^[20] while low heritability with high genetic advance was obtained by Meghwal and Khandelwal (1994)^[9] for this trait.

Number of nodes per plant: In MDU-1, high heritability with moderate genetic advance as per cent of mean was found at 0.8 per cent colchicine and 1.2 per cent EMS. Selection will be more effective for this character. In Arka Anamika, moderate heritability with low genetic advance was found in all the treatments. Since this character was highly influenced by environment, selection will be ineffective.

Among these varieties, high heritability with moderate genetic advance as percentage of mean was found in 0.8 per cent colchicine and 1.2 per cent EMS in MDU-1. High heritability and genetic advance were reported by Meghwal and Khandelwal (1994)^[9] while high heritability with low genetic advance was observed by Patil *et al.* (1996)^[13] for number of nodes. Similarly low heritability with moderate genetic advance was reported by Sonia Sood *et al.* (1995)^[19] for this character.

Fruit length: In MDU-1, high heritability with low genetic advance was found in 0.8 per cent colchicine and most of the other treatments showed low heritability with low genetic advance. In Arka Anamika and Mahyco hybrid, low

heritability with low genetic advance was found in all the treatments and so selection will be ineffective. Bindu *et al.* (1997)^[3] obtained high heritability and genetic advance for fruit length while high heritability with low genetic advance was reported by Singh (1997)^[12]. Similarly moderate genetic advance was noticed by Dash and Mishra (1998)^[4] and Singh *et al.* (1998)^[18]. Thaker *et al.* (1989)^[20] recorded low heritability and genetic advance for this trait.

Fruit girth: In MDU-1, high heritability with low genetic advance was found in 0.6 per cent colchicine while most of other treatments showed low heritability with low genetic advance. Thus, selection will be ineffective for this character. In Arka Anamika, low to moderate heritability with low genetic advance was found in all the treatments. Thus, selection will be ineffective for this character. High heritability and genetic advance were already reported by Patil *et al.* (1996)^[13]. Similarly moderate heritability with low genetic advance was observed by Panda and Singh (1997)^[12] and Dash and Mishra (1998)^[4] for this character.

Number of fruits per plant: In MDU-1, moderate heritability with moderate genetic advance was found in 0.4 per cent colchicine 1.2 per cent EMS while the rest of the treatments showed low heritability and low genetic advance as percentage of mean and so selection will be ineffective. In Arka Anamika, moderate heritability with low genetic advance was found in all treatments and so selection will be ineffective. High heritability with high genetic advance was already reported by El-Maksoud *et al.* (1984)^[5] while moderate heritability with high genetic advance was noticed by Bindu *et al.* (1997)^[3] for number of fruits per plant. Similarly low heritability with low genetic advance was reported by Rajani and Manju (1997)^[15] for this trait.

Fruit weight: In MDU-1, high heritability with low genetic advance was found in 0.4 per cent and 0.8 per cent colchicine and 0.8 per cent EMS followed by 1.2 per cent EMS with moderate heritability and low genetic advance while the rest of the treatments showed low heritability with low genetic advance as percent of mean and so selection will be ineffective. In Arka Anamika, all the treatments showed low heritability with low genetic advance as percentage of mean and so selection will be ineffective.

High heritability and genetic advance for fruit weight was obtained by Bindu *et al.* (1997)^[3]. Moderate heritability with low genetic advance was obtained by Rajani and Manju (1997)^[15]. Low heritability with high genetic advance was observed by Sheela *et al.* (1988)^[17] while low heritability with low genetic advance was noted for this trait by Mohammed Yassin and Anbu (1997)^[10].

Fruit yield per plant: In MDU-1, high heritability with moderate genetic advance was found in 0.8 per cent EMS, moderate heritability with moderate genetic advance was found in 1.2 per cent EMS and 0.4 per cent colchicine and so selection will be more effective. While the rest of the treatment showed low heritability with low genetic advance as percentage of mean and so selection will be ineffective. In Arka Anamika, most of the treatments showed low heritability with low genetic advance as percentage of mean and so selection will be ineffective. High heritability and genetic advance was observed for fruit yield by Bindu *et al.* (1997)^[3]. But low heritability with low genetic advance was observed by Rai *et al.* (1997)^[14] for this trait.

Table 2: Determination of LD₅₀

Treatment	EMS		Treatment	Colchicine	
	Seed germination (%)	Percent of decrease over control		Seed germination (%)	Percent of decrease over control
Control 0.0	90.6	--	Control 0.0	88.9	--
0.2	87.3	-3.65	0.2	76.2	-14.29
0.4	83.4	-7.85	0.4	68.3	-23.17
0.6	74.8	-17.44	0.6	50.9	-42.74
0.8	67.1	-25.94	0.8	42.3	-52.42
1.0	51.6	-43.05	1.0	36.8	-58.61
1.2	43.8	-51.66	1.2	32.3	-63.67
1.4	24.8	-72.63	1.4	27.5	-69.07
1.6	16.3	-82.01	1.6	19.8	-77.73
1.8	8.4	-90.73	1.8	12.7	-85.71
2.0	3.6	-96.03	2.0	5.8	-93.48

Table 3: Variability, heritability and genetic advance as per cent of mean for yield and its component traits in M₂ generation

Treatments (Cone. Per cent)	Plant Height					Number of branches per plant				
	PCV (%)	GCV (%)	h ² (%)	GA	GA as% of mean	PCV (%)	GCV (%)	h ² (%)	GA	GA as% of mean
MDU-1 0.4% COL	4.57	2.47	29.35	2.87	2.76	39.90	13.12	10.81	0.14	8.88
0.6% COL	3.14	2.70	73.68	4.98	4.78	28.17	5.42	3.70	0.04	2.14
0.8% COL	2.03	0.34	2.89	0.12	0.12	36.70	10.59	8.33	0.08	6.30
0.8% EMS	1.57	0.55	12.58	0.40	0.52	29.39	7.58	6.658	0.05	4.02
1.0% EMS	0.85	0.56	43.74	0.81	0.77	33.86	14.35	17.95	0.24	12.52
1.2% EMS	1.30	0.75	33.97	0.99	0.91	36.26	11.46	10.00	0.09	7.46
CONTROL	0.93	0.21	5.26	0.157	0.10	41.92	18.75	20.01	0.30	17.28
Arka Anamika 0.4% COL	1.95	1.48	53.96	2.32	2.17	40.28	23.79	34.88	0.41	28.95
0.6% COL	1.58	1.18	55.45	1.95	1.81	37.03	12.34	11.11	0.10	8.472
0.8% COL	1.58	1.08	65.46	2.58	2.35	74.33	57.70	60.26	0.84	92.27
Control	2.23	0.85	14.73	0.77	0.67	41.92	18.75	20.01	0.30	17.28
Treatments (Cone. Per cent)	Number of nodes per plant					Fruit length				
	PCV (%)	GCV (%)	h ² (%)	GA	GA as% of mean	PCV (%)	GCV (%)	h ² (%)	GA	GA as% of mean
MDU-1 0.4% COL	13.34	7.85	34.64	1.19	9.51	5.20	3.86	53.20	0.83	5.80
0.6% COL	6.031	4.05	45.29	0.71	5.63	2.47	1.16	22.15	0.16	1.12
0.8% COL	11.14	9.18	67.87	2.19	15.58	1.66	1.34	65.38	0.32	2.25
0.8% EMS	7.40	5.05	46.58	0.86	7.10	2.62	1.13	18.62	0.14	1.00
1.0% EMS	27.27	11.05	16.44	1.09	9.23	1.03	0.52	25.66	0.07	0.54
1.2% EMS	9.67	7.51	60.33	1.61	12.02	2.03	0.78	14.99	0.09	0.62
CONTROL	9.16	4.40	23.08	0.57	4.35	2.28	2.02	78.38	0.51	3.68
Arka Anamika 0.4% COL	7.11	3.98	31.41	0.55	4.60	3.21	0.54	2.92	0.03	0.19
0.6% COL	5.29	3.38	48.86	0.58	4.40	1.78	0.85	22.72	0.13	0.83
0.8% COL	5.27	3.33	40.00	0.65	4.34	4.75	1.80	14.48	0.22	1.41
CONTROL	9.58	3.28	11.76	0.33	2.32	1.75	1.67	91.50	0.52	3.30

Table 3: (Conti.)

Treatments (Cone. Per cent)	Fruit girth					Fruits per plant				
	PCV (%)	GCV (%)	h ² (%)	GA	GA as% of mean	PCV (%)	GCV (%)	h ² (%)	GA	GA as% of mean
MDU-1 0.4% COL	19.60	2.24	26.31	0.12	2.37	14.61	9.65	43.65	1.30	13.13
0.6% COL	4.057	3.70	83.40	0.37	6.99	6.15	1.72	7.88	0.10	0.99
0.8% COL	4.80	1.13	5.56	0.02	0.55	8.87	3.23	10.8	0.16	1.38
0.8% EMS	1.43	0.28	4.00	0.00	0.11	6.03	2.42	16.14	0.19	2.00
1.0% EMS	1.79	1.30	52.43	0.09	1.94	9.91	4.43	20.00	0.40	4.08
1.2% EMS	1.07	0.59	29.89	0.03	0.65	9.98	7.19	51.89	1.08	10.67
CONTROL	4.04	2.66	43.48	0.18	3.61	6.01	2.02	12.15	0.18	2.00
Arka Anamika 0.4% COL	6.52	4.63	50.40	0.39	6.77	7.34	3.52	23.02	0.34	3.48
0.6% COL	3.10	1.78	33.04	0.11	2.11	6.87	4.59	44.64	0.81	6.31
0.8% COL	3.18	1.98	38.04	0.14	2.32	6.89	4.89	54.67	0.92	7.02
CONTROL	2.09	0.53	6.56	0.01	0.28	8.05	2.01	6.25	0.11	1.03
Treatments (Cone. Per cent)	Fruit weight					Fruit yield per plant				
	PCV (%)	GCV (%)	h ² (%)	GA	GA as% of mean	PCV (%)	GCV (%)	h ² (%)	GA	GA as% of mean
MDU-1 0.4% COL	6.83	5.33	6.09	1.42	8.58	17.43	10.49	36.20	21.47	13.00
0.6% COL	1.78	1.24	16.80	0.10	0.61	15.86	8.32	13.46	23.12	15.18
0.8% COL	2.11	1.74	68.17	0.49	2.97	9.17	0.89	0.95	0.35	0.17

0.8% EMS	1.15	0.96	70.23	0.25	1.67	9.24	8.84	91.39	25.49	17.41
1.0% EMS	1.30	0.56	18.91	0.07	0.50	10.05	4.12	10.84	5.37	3.48
1.2% EMS	4.20	3.20	58.21	0.81	5.03	10.10	7.55	55.85	19.02	11.62
CONTROL	0.13	0.09	58.33	0.02	0.15	4.88	4.73	93.94	14.83	9.45
Arka Anamika 0.4% COL	3.04	1.27	17.48	0.19	1.09	8.46	2.18	6.65	2.01	1.16
0.6% COL	4.15	2.00	23.36	0.35	1.99	9.40	5.08	29.31	10.87	5.67
0.8% COL	1.37	0.26	3.60	0.01	0.10	7.37	4.44	44.64	1.03	8.09
CONTROL	2.09	0.07	10.14	0.07	0.43	5.52	3.56	41.59	8.54	4.73

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