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Influence of chemical mutagens in bhendi (*Abelmoschus esculentus* (L) Moench) varieties of Mahyco hybrid and TCR 2086 for genetic variability, heritability and genetic advance

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Abstract

Mutation breeding in crop plants is an effective approach in improvement of crop having narrow genetic base such as Bhendi (or) Okra (*Abelmoschus esculentus* (L) Moench). The main objective of the present study to determine the effect of different concentrations of ethyl methane sulphonate (EMS) and colchicine on Mahyco hybrid and TCR2086 varieties of bhendi. The observations were recorded in M₂ generations on different morphology and yield characteristics. 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 mutations for these characters in two varieties. However the PCV and GCV were low for plant height and fruit length indicating low frequency of micro mutation for those character in two varieties. Moderate to high heritability was observed for characters such as plant height number of nodes per plant, fruit girth and fruit yield. This indicated that the induced variability for these characters were less influenced by the environment. High heritability coupled with high genetic advance for fruit yield was observed in 0.4 per cent colchicine treatment in Mahyco hybrid and 1.2 per cent EMS treatment in TCR 2086. This indicated that the variability induced by these treatment in these variety is highly heritable and additive in nature and hence selection will be effective.

Keywords: EMS Colchicine, PCV, GCV, h², Bhendi

Introduction

Bhendi (*Abelmoschus esculentus* (L.) Moench), commonly known as okra or ladies finger. It is widely cultivated in tropical and topical regions of the world. In addition to the use of its immature pods as vegetable, mature pods are sometimes used as animal feed and as a source of mucilage. The nutritional and economic importance of orka. It is imperative that adequate attention be given to ways of producing the seed in such a way the high quality ensured.

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) [8].

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. | TCR 2086 | Trichur, Kerala | Medium tall plants. Dark green fruits |
| 4. | Mahyco hybrid | Maharashtra Hybrid Company, Maharashtra | Tall plans. Dark green and long fruits |

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. The analysis of Heritability in broad sense (h^2) was calculated using formula suggested by Lush (1940) [10] and genetic advance was calculated by the method suggested by Johnson *et al.*, (1955) [7]

Table 2: Determination of LD_{50}

| 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 |

Results

Plant height: In Mahyco hybrid, maximum PCV and GCV values were recorded in 0.4 per cent colchicine (3.16 and 2.64, respectively) while minimum PCV and GCV values were recorded in 0.8 per cent EMS (1.69 and 1.02, respectively). High heritability value was noticed in 0.4 per cent colchicine (69.92). Higher genetic advance and genetic advance as per cent of mean values were noticed in 0.4 per cent colchicine (5.14 and 4.56, respectively) while lower genetic advance and genetic advance as per cent of mean values were noticed in 0.8 per cent EMS (1.02 and 0.89, respectively).

In TCR 2086 variety, maximum PCV and GCV values were recorded in 0.6 per cent colchicine (3.63 and 3.38, respectively) while minimum PCV and GCV values were recorded in 0.4 per cent colchicine (1.59 and 0.39, respectively). High heritability value was noticed in 0.6 per cent colchicine (86.76) while low heritability value was noticed in 0.4 per cent colchicine (6.23). Higher genetic advance and genetic advance as per cent of mean values were noticed in 0.6 per cent colchicine (7.36 and 6.49, respectively) while lower genetic advance and genetic advance as per cent of mean values were noticed in 0.4 per cent colchicine (0.21 and 0.26, respectively).

Number of branches per plant: In Mahyco hybrid, maximum PCV and GCV values were recorded in 0.4 per cent colchicine and 0.8 per cent colchicine (56.09 and 42.54, respectively) while minimum PCV and GCV values were recorded in 0.6 per cent colchicine (33.17 and 9.02, respectively). High heritability value were noticed in 0.8 per cent colchicine (62.27). Higher genetic advance and genetic advance as per cent of mean values were noticed in 0.4 per cent colchicine (0.52 and 44.95, respectively).

In TCR 2086 variety, maximum PCV and GCV values were recorded in 0.4 per cent colchicine (42.12 and 20.37, respectively) while minimum PCV and GCV values were recorded in 1.2 per cent EMS (34.48 and 10.28, respectively). High heritability value was noticed in 0.6 per cent colchicine (24.88) while low heritability value was noticed in 1.2 per cent EMS (8.89). Higher genetic advance and genetic advance as per cent of mean values were noticed in 0.4 per cent colchicine (0.28 and 20.30, respectively) while lower genetic advance and genetic advance as per cent of mean values were noticed in 1.2 per cent EMS (0.09 and 6.31, respectively).

Number of nodes per plant: In Mahyco hybrid, maximum PCV and GCV values were recorded in 0.8 per cent EMS and 0.6 per cent colchicine (8.18 and 5.97, respectively) while minimum PCV and GCV values were recorded in 0.4 per cent colchicine and 0.8 per cent EMS (7.64 and 1.29, respectively). High heritability value was noted in 0.6 per cent colchicine (57.14) while low heritability was noted in 0.8 per cent EMS (2.51). Higher genetic advance and genetic advance as per cent of mean value were noticed in 0.6 per cent colchicine and 0.8 per cent colchicine. (1.58 and 9.13, respectively) while lower genetic advance and genetic advance as per cent of mean values were noticed in 0.8 per cent EMS (0.05 and 0.42, respectively).

In TCR 2086 variety, maximum PCV and GCV values were recorded in 1.2 per cent EMS (12.14 and 7.35, respectively) while minimum PCV and GCV values were recorded in 0.6 per cent colchicine and 0.4 per cent colchicine (7.09 and 1.90, respectively). High heritability value was noted in 0.8 per cent colchicine (61.99) while low heritability value (5.59) was noted in 0.4 per cent colchicine. Higher genetic advance and

genetic advance as per cent of mean values were noticed in 0.8 per cent colchicine (1.62 and 12.35, respectively) while lower genetic advance and genetic advance as percent of mean values were noticed in 0.4 percent colchicine (0.10 and 0.92, respectively).

Fruit Length: In Mahyco hybrid, maximum PCV and GCV values were recorded in 0.8 per cent colchicine (6.81 and 3.39, respectively) while minimum PCV and GCV values were recorded in 0.8 per cent EMS (1.79 and 0.60, respectively). High heritability value was noted in 0.8 per cent colchicine (24.82) while low heritability value noted in 0.6 per cent colchicine (8.84). Lower genetic advance and genetic advance as per cent of mean was noticed in 0.8 per cent EMS (0.06 and 0.41, respectively).

In TCR 2086 variety, maximum PCV and GCV values were recorded in 0.8 per cent colchicine (10.21 and 5.3, respectively). High heritability value was noted in 1.2 per cent EMS (33.76) and low heritability value was noted in 0.6 per cent colchicine (20.05). Higher genetic advance and genetic advance as per cent of mean value were noticed in 0.8 per cent EMS (0.97 and 6.08, respectively) while lower genetic advance and genetic advance as per cent of mean values were noticed in 1.2 per cent EMS (0.01 and 0.12, respectively).

Fruit Girth: In Mahyco hybrid, maximum PCV and GCV values were recorded in 0.4 per cent colchicine (5.70 and 4.26, respectively) while minimum PCV and GCV values were recorded in 0.6 per cent colchicine (1.85 and 0.98, respectively). Low heritability value was noted in 0.8 per cent colchicine (22.93) and high heritability value was noted in 0.4 per cent colchicine (55.81). Higher genetic advance and genetic advance as per cent of mean values were noticed in 0.4 per cent colchicine (0.38 and 6.55, respectively) while lower genetic advance and genetic advance as per cent of mean value was noticed in 0.6 per cent colchicine (0.06 and 1.10, respectively).

In TCR 2086 variety, maximum PCV and GCV values were recorded in 1.0 per cent EMS (11.11 and 10.69, respectively) while minimum PCV and GCV values were recorded in 1.2 per cent EMS (2.41 and 1.17, respectively). High heritability value was noted in 0.8 per cent EMS (93.48) and low heritability value was noted in 1.2 per cent EMS (23.78). Higher genetic advance and genetic advance as per cent of mean values were noticed in 1.0 per cent EMS (1.14 and 21.18, respectively) while lower genetic advance and genetic advance as per cent of mean value was noticed in 1.2 per cent EMS and 0.8 per cent EMS (0.06 and 0.92, respectively).

Number of Fruits per plant: In Mahyco hybrid, maximum PCV and GCV values were recorded in 0.8 per cent colchicine (10.09 and 7.17, respectively) while minimum PCV and GCV values were recorded in 0.4 per cent colchicine and 0.8 per cent EMS (7.02 and 3.36, respectively). High heritability values was noted in 0.8 per cent colchicine (58.37) and low heritability value was noted in 0.4 per cent colchicine (2.02). Higher genetic advance and genetic advance as per cent of mean value was noticed in 0.8 per cent colchicine (1.39 and 10.97, respectively) while lower genetic advance as percent of mean value was noticed in 0.8 per cent EMS (0.35 and 3.03, respectively)

In TCR 2086 variety, maximum PCV and GCV values were recorded in 0.8 per cent colchicine and 1.2 per cent EMS (12.44 and 6.41, respectively) while minimum PCV and GCV values were recorded in 0.4 per cent colchicine (4.50 and

1.33, respectively). High heritability value was noted in 1.0 per cent EMS (50.82) and low heritability value was noted in 0.8 per cent colchicine (7.92). Higher genetic advance and genetic advance as per cent of mean value was noticed in 1.0 per cent EMS (0.86 and 8.88, respectively).

Fruit Weight: In Mahyco hybrid, maximum PCV and GCV values were recorded in 0.8 per cent EMS (2.99 and 2.00, respectively) while minimum PCV and GCV values were recorded in 0.6 per cent colchicine (2.21 and 0.25, respectively). High heritability value was noted in 0.8 per cent colchicine (98.43) and low heritability value was noted in 0.6 per cent colchicine (1.31). Higher genetic advance and genetic advance as per cent of mean was noticed in 0.8 per cent EMS and 0.6 per cent colchicine (0.47 and 5.62, respectively) while lower genetic advance and genetic advance of mean was noticed in 0.6 per cent colchicine and 0.4 per cent colchicine (0.01 and 0.37, respectively).

In TCR 2086 variety, maximum PCV and GCV values were recorded in 0.6 per cent colchicine (12.01 and 11.53, respectively) while minimum PCV and GCV values were recorded in 1.2 per cent EMS and 1.0 per cent EMS (2.40 and 1.28, respectively). High heritability value was noted in 0.6 per cent colchicine (92.11) and low heritability value was noticed in 0.4 per cent colchicine (8.84). Higher genetic advance and genetic advance as per cent of mean was noticed in 0.6 per cent colchicine (3.55 and 22.80, respectively) while lower genetic advance and genetic advance as per cent of mean value was noticed in 0.4 per cent colchicine (0.14 and 0.81, respectively).

Fruit yield per plant: In Mahyco hybrid, maximum PCV and GCV values were recorded in 0.8 per cent colchicine (9.88 and 6.98, respectively) while minimum PCV and GCV values were recorded in 0.8 per cent EMS (8.01 and 4.85, respectively). High heritability value was noted in 0.4 per cent colchicine (66.02) and low heritability value was noted in 0.8 per cent EMS (36.69).

Higher genetic advance and genetic advance as per cent of mean was noticed in 0.4 per cent colchicine (23.79 and 11.24, respectively) while lower genetic advance and genetic advance as per cent of mean value was noticed in 0.8 per cent EMS (12.27 and 6.05, respectively).

In TCR 2086 variety, maximum PCV and GCV values were recorded in 1.2 per cent EMS (10.86 and 7.83, respectively) while minimum PCV and GCV values were recorded in 0.8 per cent colchicine (4.76 and 1.08, respectively). High heritability value was noted in 1.2 per cent EMS (52.03) and low heritability value was noticed in 0.8 per cent colchicine (6.42). Higher genetic advance and genetic advance as per cent of mean was noticed in 1.2 per cent EMS (17.89 and 11.64, 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 (1.29 and 1.45, respectively).

Discussion

Variability Studies

Information on the variability for induced mutations is essential for formulating an efficient breeding programme. This variability induced is due to the combined effect of genetic and environmental causes. A knowledge of genetic variability would provide realistic estimate and help to fix up traits in selection programme. Thus the success of any breeding programme depends upon the magnitude of genetic variability in the population and extent to which desirable

characters are heritable besides several other factors.

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 TCR 2086 variety, maximum PCV and GCV were noticed in 0.6 per cent colchicine followed by 1.0 per cent EMS treatment/Among these varieties, maximum 0.4 per cent colchicine treatment GCV was noticed in TCR 2086 for 0.6 per cent colchicine treatment. High PCV and GCV for plant height were already reported by Yadav (1984)^[23]. However, Sonia Sood *et al* (1995)^[21] reported a moderate PCV and GCV for this character.

Number of Branches per plant: In Mahyco hybrid, maximum PCV was recorded in 0.4 per cent colchicine followed by 0.8 per cent colchicine while maximum GCV was observed in 0.8 per cent colchicine followed by 0.4 per cent colchicine. In TCR 2086 maximum PCV and GCV were recorded in 0.4 per cent colchicine followed by 0.8 per cent colchicine for PCV and 0.6 per cent colchicine for GCV. High PCV and GCV for number of branches were observed by Bindu *et al* (1997)^[3]. However, Thaker *et al* (1989)^[22] and Ariyo (1990)^[2] recorded low PCV and GCV for this trait.

Number of nodes per plant: In TCR 2086, maximum PCV and GCV were observed in 1.2 per cent EMS followed by 1.0 per cent EMS treatment. High PCV and GCV were observed by Patil *et al.* (1996)^[15] for this character. Sonia Sood *et al* (1995)^[21] recorded low values of PCV and GCV for this character.

Fruit Length: In Mahyco hybrid, maximum PCV and GCV were noticed in 0.8 per cent colchicine followed by 0.6 per cent colchicine for PCV and 0.4 per cent colchicine for GCV. In TCR 2086, maximum PCV and GCV were observed in 0.8 per cent EMS followed by 0.8 per cent colchicine treatment. Among these varieties, maximum PCV and GCV were noted in 0.8 per cent EMS followed by 0.8 per cent colchicine treatment in TCR 2086 variety. Yadav (1984)^[23] and 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)^[17].

Fruit girth: In TCR 2086, maximum PCV and GCV were observed in 1.0 per cent EMS followed by 0.8 per cent EMS treatment. 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)^[15] for this trait.

Number of fruits per plant: In Mahyco hybrid, maximum PCV and GCV were recorded in 0.8 per cent colchicine followed by 0.6 per cent colchicine treatment/ In TCR 2086, maximum PCV was observed in 0.8 per cent colchicine followed by 0.8 per cent EMS treatment while maximum GCV was noted in 1.2 per cent EMS followed by 1.0 per cent EMS treatment. High PCV and GCV were noticed by Korla and Sharma (1984) for this trait. Similarly Meghwal and Khandelwal (1994)^[11] observed moderate PCV and GCV for this character. However, high estimates PCV and comparatively low GCV were observed by Palaniveluchamy *et al* (1983)^[13] for this trait.

Fruit weight: In Mahyco hybrid, maximum PCV and GCV

were noticed in 0.8 per cent EMS followed by 0.4 per cent colchicine. In TCR 2086, maximum PCV and GCV were noted in 0.6 per cent colchicine followed by 0.8 per cent colchicine for PCV and 0.8 per cent EMS for GCV. Among these varieties, maximum PCV and GCV were observed in 0.6 per cent colchicine followed by 0.8 per cent colchicine for PCV and 0.8 per cent EMS for GCV in TCR 2086 variety. High PCV and GCV were observed by Patil *et al* (1996) [15] for this character. However low PCV and GCV were obtained by Singh *et al* (1998) [20]. Moderate PCV and GCV were observed by Meghwal and Khandelwal (1994) [11] for this trait.

Fruit yield per plant: In Mahyco hybrid, maximum PCV and GCV were recorded in 0.8 per cent colchicine followed by 0.6 per cent colchicine for PCV and 0.4 per cent colchicine for GCV. In TCR 2086, maximum PCV and GCV were noticed in 1.2 per cent EMS followed by 0.8 per cent EMS. High PCV and GCV were already estimated for this trait by Singh *et al* (1998) [20].

Heritability and Genetic Advance Studies

Plant height: In Mahyco hybrid, high / moderate heritability with low genetic advance as per cent of mean were found in all treatments. This indicated that induced variability for this character was of non-additive in nature. Similar results were obtained by Rajani and Manju (1997) [17] and Bindu *et al* (1997) [3].

In TCR 2086, high heritability with low genetic advance was found in 0.6 per cent colchicine treatment, moderate heritability with low genetic advance was been found in 1.0 per cent and 1.2 per cent EMS while low heritability and low genetic advance was found in all other treatments. It indicated that this character is highly influenced by environmental effects and selection would be ineffective. High heritability with high genetic advance for plant height was obtained by Singh *et al* (1998) [20] while moderate heritability with high genetic advance for this trait was observed by Yadav and Chankar (1991) [24]. But low heritability with low genetic advance was observed by Mohamed Yassin and Anbu.

Number of branches per plant: In Mahyco hybrid, high heritability with high genetic advance as per cent of mean was found in 0.8 per cent colchicine. Thus, this character was governed by additive gene action and selection will be more effective. In TCR 2086, all the treatments showed low heritability with low to high genetic advance as per cent of mean which was governed by non-additive genes and hence selection will be ineffective. High heritability with low genetic advance was noticed already by Rajani and Manju (1997) [17] 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) [22] while low heritability with high genetic advance was obtained by Meghwal and Khandelwal (1994) [11] for this trait.

Number of nodes per plant: In TCR 2086, high heritability with moderate genetic advance was found in 0.8 per cent colchicine while moderate heritability with low genetic advance was found in 0.8 per cent EMS and 1.2 per cent EMS and the rest showed low heritability with low genetic advance as per cent of mean. Therefore, selection will be ineffective since it was highly influenced by environment. 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 followed by 0.8 per cent colchicine in TCR 2086.

High heritability and genetic advance were reported by Meghwal and Khandelwal (1994) [11] while high heritability with low genetic advance was observed by Patil *et al* (1996) [15] for number of nodes. Similarly low heritability with moderate genetic advance was reported by Sonia Sood *et al* (1995) [21] for this character.

Fruit length: In Mahyco hybrid, most of the treatments showed low heritability and low genetic advance as percentage of mean and so selection will be ineffective. In TCR 2086, most of the treatments showed low heritability and low genetic advance as per cent of mean 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 Panda and Singh (1997) [14]. Similarly moderate genetic advance was noticed by Dash and Mishra (1998) [4] and Singh *et al* (1998) [20]. Thaker *et al.*, (1989) [22] recorded low heritability and genetic advance for this trait.

Fruit girth: In TCR 2086, high heritability with high genetic advance was found in 1.0 per cent EMS. Thus, selection will be most effective for this character in this treatment while other treatments showed low to high heritability with low genetic advance. Hence selection will be ineffective. High heritability and genetic advance were already reported by Patil *et al* (1996) [15]. Similarly moderate heritability with low genetic advance was observed by Panda and Singh (1997) [14] and Dash and Mishra (1998) [4] for this character.

Number of fruits per plant: In Mahyco hybrid, moderate heritability with moderate genetic advance was found in 0.6 per cent and 0.8 per cent colchicine treatment and so selection will be effective since the environmental influence in not high. In TCR 2086, moderate heritability with low genetic advance was found in 1.0 per cent and 1.2 per cent EMS while rest of the treatments showed low heritability and low genetic advance 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) [17] for this trait.

Fruit weight: In Mahyco hybrid, high heritability with low genetic advance was found in 0.8 per cent colchicine, followed by 0.8 per cent EMS with moderate heritability and low genetic advance and the rest of the treatments showed low heritability with low genetic advance and hence selection will be ineffective.

In TCR 2086, high heritability with high genetic advance was found in 0.6 per cent colchicine. Therefore selection will be very effective. High heritability with moderate genetic advance was found in 0.8 per cent EMS and selection will be somewhat useful. High heritability with low genetic advance was found in 1.2 per cent EMS and the rest of the treatments showed low heritability with low genetic advance as per cent 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) [17]. Low

heritability with high genetic advance was observed by Sheela *et al* (1988) [19] while low heritability with low genetic advance was noted for this trait by Mohammed Yassin and Anbu (1997) [12].

Fruit yield per plant: In Mahyco hybrid, high heritability with moderate genetic advance was found in 0.4 per cent colchicine while the other treatments showed moderate heritability with low genetic advance as percentage of mean. In TCR 2086, moderate heritability with moderate genetic advance was found in 1.2 per cent EMS while the most of the

other treatments showed low heritability with low genetic advance as percentage of mean. Low heritability with moderate genetic advance was found in 1.2 per cent EMS. Among these varieties, high heritability with moderate genetic advance was found in 0.8 per cent EMS in MDU-1 and 0.4 per cent colchicine in Mahyco hybrid and so selection will be effective. 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) [16] for this trait.

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 |
| MAHYCO 0.4% COL | 3.16 | 2.64 | 69.92 | 5.41 | 4.56 | 56.09 | 34.99 | 38.89 | 0.52 | 44.95 |
| 0.6% COL | 2.68 | 1.78 | 48.48 | 2.91 | 2.86 | 33.17 | 9.028 | 7.40 | 0.06 | 5.06 |
| 0.8% COL | 2.63 | 1.73 | 43.48 | 2.72 | 2.35 | 53.91 | 42.54 | 62.27 | 0.25 | 24.18 |
| 0.8% EMS | 1.69 | 1.02 | 36.39 | 1.02 | 0.89 | 34.98 | 15.64 | 20.01 | 0.16 | 14.42 |
| Control | 2.68 | 0.40 | 2.246 | 0.14 | 0.12 | 42.86 | 26.25 | 37.50 | 0.51 | 33.12 |
| TCR2086 0.4% COL | 1.59 | 0.39 | 6.23 | 0.21 | 0.20 | 42.12 | 20.37 | 23.40 | 0.28 | 20.30 |
| 0.6% COL | 3.63 | 3.38 | 86.76 | 7.36 | 6.49 | 35.74 | 17.62 | 24.88 | 0.24 | 18.32 |
| 0.8% COL | 1.59 | 0.58 | 13.48 | 0.49 | 0.44 | 41.74 | 15.50 | 13.79 | 0.16 | 11.86 |
| 0.8% EMS | 1.71 | 0.65 | 14.63 | 0.54 | 0.51 | 40.63 | 14.92 | 12.68 | 0.19 | 14.15 |
| 1.0% EMS | 2.33 | 1.49 | 40.80 | 2.13 | 1.96 | 36.27 | 16.86 | 21.62 | 0.20 | 16.15 |
| 1.2% EMS | 1.73 | 1.14 | 43.13 | 1.67 | 1.54 | 34.48 | 10.28 | 8.89 | 0.09 | 6.31 |
| CONTROL | 2.19 | 1.98 | 81.65 | 3.92 | 3.69 | 47.91 | 21.42 | 20.00 | 0.30 | 19.73 |
| 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 |
| MAHYCO 0.4% COL | 7.64 | 5.03 | 43.40 | 0.97 | 6.83 | 3.71 | 1.57 | 17.94 | 0.22 | 1.37 |
| 0.6% COL | 7.90 | 5.97 | 57.14 | 1.58 | 9.10 | 4.64 | 1.38 | 08.84 | 0.13 | 0.84 |
| 0.8% COL | 7.80 | 5.87 | 53.14 | 1.37 | 9.31 | 6.81 | 3.39 | 24.82 | 0.53 | 3.48 |
| 0.8% EMS | 8.18 | 1.29 | 2.51 | 0.05 | 0.42 | 1.79 | 0.60 | 11.20 | 0.06 | 0.41 |
| CONTROL | 12.2 | 5.75 | 22.06 | 0.88 | 5.56 | 2.36 | 0.76 | 10.39 | 0.08 | 0.50 |
| TCR2086 0.4% COL | 8.051 | 1.90 | 5.59 | 0.10 | 0.92 | 2.21 | 1.08 | 24.11 | 0.15 | 1.10 |
| 0.6% COL | 7.09 | 3.17 | 20.00 | 0.35 | 2.92 | 6.45 | 2.89 | 20.05 | 0.36 | 2.66 |
| 0.8% COL | 9.67 | 2.35 | 61.99 | 1.62 | 12.35 | 9.24 | 5.07 | 30.13 | 0.76 | 5.73 |
| 0.8% EMS | 8.53 | 2.01 | 50.52 | 1.16 | 8.46 | 10.21 | 5.53 | 32.16 | 0.97 | 6.08 |
| 1.0% EMS | 11.18 | 5.98 | 28.65 | 0.82 | 6.60 | 2.73 | 1.29 | 22.38 | 0.17 | 1.26 |
| 1.2% EMS | 12.14 | 7.35 | 36.71 | 1.16 | 9.18 | 2.77 | 1.61 | 33.76 | 0.27 | 1.08 |
| CONTROL | 10.64 | 8.13 | 58.33 | 1.61 | 12.79 | 7.12 | 0.29 | 4.26 | 0.01 | 0.12 |

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 |
| MAHYCO 0.4% COL | 5.70 | 4.26 | 55.81 | 0.38 | 6.55 | 7.02 | 5.53 | 2.02 | 1.08 | 8.07 |
| 0.6% COL | 1.83 | 0.98 | 29.25 | 0.06 | 1.10 | 10.07 | 7.14 | 50.34 | 1.31 | 10.44 |
| 0.8% COL | 3.86 | 1.84 | 22.93 | 0.09 | 1.82 | 10.09 | 7.17 | 58.37 | 1.38 | 10.97 |
| 0.8% EMS | 3.11 | 2.00 | 41.44 | 0.15 | 2.65 | 7.68 | 3.36 | 19.17 | 0.35 | 3.03 |
| CONTROL | 1.47 | 0.69 | 22.07 | 0.03 | 0.67 | 6.15 | 2.75 | 20.01 | 0.30 | 2.53 |
| TCR2086 0.4% COL | 4.12 | 2.16 | 27.68 | 0.13 | 2.35 | 4.50 | 1.33 | 8.84 | 0.18 | 1.05 |
| 0.6% COL | 4.06 | 3.15 | 60.34 | 0.27 | 5.04 | 11.16 | 4.31 | 15.00 | 0.00 | 0.03 |
| 0.8% COL | 6.51 | 5.16 | 62.89 | 0.44 | 8.44 | 12.44 | 3.50 | 7.92 | 0.21 | 2.03 |
| 0.8% EMS | 6.84 | 5.52 | 93.48 | 0.59 | 0.92 | 11.70 | 5.79 | 24.55 | 0.55 | 5.91 |
| 1.0% EMS | 11.11 | 10.69 | 92.58 | 1.14 | 21.18 | 8.48 | 6.05 | 50.82 | 0.86 | 8.88 |
| 1.2% EMS | 2.41 | 1.17 | 23.78 | 0.06 | 1.18 | 9.48 | 6.41 | 45.71 | 0.83 | 8.03 |
| CONTROL | 1.16 | 0.60 | 27.50 | 0.03 | 0.65 | 9.62 | 5.55 | 33.33 | 0.59 | 6.60 |
| 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 |
| MAHYCO 0.4% COL | 2.50 | 0.67 | 7.35 | 0.06 | 0.37 | 8.26 | 6.71 | 66.02 | 23.79 | 11.2 |

| | | | | | | | | | | |
|------------------|-------|-------|-------|------|-------|-------|------|-------|-------|-------|
| 0.6% COL | 2.21 | 0.25 | 1.310 | 0.01 | 5.62 | 9.50 | 6.03 | 40.34 | 17.68 | 7.89 |
| 0.8% COL | 2.43 | 0.46 | 98.43 | 0.05 | 2.98 | 9.88 | 6.98 | 48.37 | 17.90 | 7.98 |
| 0.8% EMS | 2.99 | 2.00 | 44.67 | 0.47 | 2.75 | 8.01 | 4.85 | 36.69 | 12.27 | 6.05 |
| Control | 1.83 | 1.29 | 49.73 | 0.31 | 1.88 | 6.44 | 5.96 | 85.65 | 22.42 | 11.3 |
| TCR2086 0.4% COL | 4.50 | 1.33 | 8.84 | 0.14 | 0.81 | 8.66 | 2.47 | 8.16 | 2.50 | 1.45 |
| 0.6% COL | 12.01 | 11.53 | 92.11 | 3.55 | 22.80 | 6.73 | 4.40 | 42.71 | 9.82 | 5.92 |
| 0.8% COL | 8.08 | 5.46 | 15.98 | 0.92 | 5.08 | 4.76 | 1.08 | 6.42 | 1.29 | 3.86 |
| 0.8% EMS | 7.21 | 6.16 | 72.96 | 1.80 | 10.84 | 10.84 | 5.79 | 28.48 | 9.72 | 6.36 |
| 1.0% EMS | 2.83 | 1.28 | 20.59 | 0.20 | 1.20 | 8.60 | 4.23 | 24.26 | 7.03 | 4.29 |
| 1.2% EMS | 2.40 | 1.91 | 63.05 | 0.51 | 3.12 | 10.86 | 7.83 | 52.03 | 17.89 | 11.64 |
| CONTROL | 1.44 | 0.94 | 42.24 | 0.20 | 1.25 | 9.67 | 4.19 | 18.80 | 5.61 | 3.74 |

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