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RESEARCH ARTICLE

Mutagenic effect of Gamma rays and EMS on yield attributes of Sorghum (*Sorghum bicolor* (L.) Moench) in M_1 generation

V.Suthakar, L. Mullainathan[1], M. Elangovan[2]

1 Department of Botany, Annamalai University, Annamalainagar. And

2 Directorate of Sorghum Research (DSR), Rajendiranagar, Hyderabad-500 030, Andhra Pradesh

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***Corresponding Author**

V.Suthakar

Abstract

The traditional varieties of Sorghum have low potentiality and restricted variability with respect to economic characters. Broadening the genetic base for crop improvement can be quickly achieved through induced mutagenesis. The present study was undertaken in order to comparing the effectiveness and efficiency of mutagens in M_1 generation. In this regard, CSV-23 Variety of Sorghum was subjected to different concentration of Gamma rays (20, 30, 40, 50 and 60 Kr) and EMS (20, 30, 40, 50 and 60mM) for inducing mutation. The effect of Gamma rays and EMS with different doses/conc. On mutation frequency and mutagenic effectiveness were observed in M_1 generation. The survival percentage and mean value of M_1 generation were decreased with increasing doses/conc. of treatment. Mean performance of different quantitative traits were observed better in control when compared to treated plant and also I observed that the LD_{50} was found at 30Kr of Gamma rays and 40mM of EMS. And these two treatments will be observed and concentrated for the further studies to develop the good yield and crop improvement in qualitatively and quantitatively.

Introduction

Sorghum bicolor is typically an annual, but some cultivars perennial. Sorghum has a wide agroeclogical adaptation, drought tolerance, high production, low input crop and more resistant to pest and disease than other food crops. Mean while sorghum also has high nutritive value so that it is very good to be used us alternative food animal feed source. The sorghum area in India was more than 16 million ha in1981, but has gradually decreased to7.8 million ha in 2007-2008. The present investigation will be mainly focused on crop improvement, especially qualitative and quantitative character through mutation breeding by the application of physical and chemical mutagens. According to HOUSE (1985) Sorghum might to be originated from the headwaters of the Niger River in Africa. Cultivated Sorghum originated about 5000-7000 years ago or earlier in north east Africa, probably in Ethiopia or Sudan. Now about 80% of Sorghum cultivated is found in the Africa and Asian regions. However, the world Sorghum production is still dominated by the USA, India, Nigeria, China, Mexico, Sudan and Argentina. Genetic variability of this crop is still low, thus, plant breeding program is required to support Sorghum development in the country. The objective is to develop superior genotype to improve Sorghum production and quality, as food, animal feed or for industry (FAO/IAEA, 1970).

Genetic variability in base population becomes indispensable when breeding objective is more composite. The focal point of a plant breeder is quantitative traits, which are controlled by polygenic interactions. Among other breeding techniques, induced mutagenesis seems to be a supreme methodology for the induction of desirable genetic variability.

Sorghum is a self-pollinated crop with narrow variability is a prerequisite for selection of better ideotypes. It is the most important serials crop of the Indian subcontinent conventional approaches to plant breeding have exploited the available genetic variability in the Sorghum, which has in lead to a narrow genetic base for this crop.

M_1 seedlings growth is widely used as an index in determining the biological effect of various physical and chemical mutagens. Mutagens differ in their mechanism and mode of action in the biological system. Hence, the extent of reduction in growth is related to the mechanism of action for a given mutagen. The parameters of M_1 generation help in comparing the effectiveness and efficiency of mutagens, besides identifying the plants with maximum genetic damage that are likely to carry the high frequency of micro mutations in further generations.

The present study was carried out to obtain practical knowledge about the utilization of physical and chemical mutagens in inducing genetic variability in sorghum genotypes and to estimate the effect of mutagens on the population.

2. MATERIALS AND METHOD

2.1. Mutagenic treatment: **-** The mature health y and non-dormancy uniform size 50 seed of sorghum variety were subjected to the chemical mutagen in EMS (Ethyl Methane Sulphonate) and Physical mutagen Gamma irradiations. Prior to treatment, the seed was presoaked fine distilled water for five hrs. at room temperature(25 ± 2^0c)there after the seed treated with following concentration viz.,20mM,30mM,40mM, 50mM,and 60mM for six hrs. After treatment, seed were thoroughly washed in distilled water for ten times. These treated seed were sown in the field. Sorghum was irradiated with 20kr, 30kr, 40kr, 50kr and 60kr at ^{60}co gamma cell, at Indira Gandhi Atomic Research Centre, Kalpakkam. Treated on 20, 30, 40, 50, and 60kr. The treated seeds were sown in the field. Another 50 seeds were soaked in distilled water and used as control.

2.2. Rising M_1 Generation**:** for raising M_1 generation (produced directly from mutagen treated seeds) was grown in the field culture experiment at the Botanical garden, Department of Botany, Annamalai University. All the recommended culture practices were carried out, during the plant growth period all the treatment including control were raised number of row to row distance 60cm plant to plant distance 15cm, number of replication was 4 between rows and plant respectively. Data of yield attributes were collected and all the data statistically analyzed for each character separately. The mean data of each genotype for different characters were used for statistical analysis. The data's were analyzed by using NPRC software.

2.3. Results

2.3.1. Quantitative traits:

The experimental conducted in the present investigation pertains in attempting to create genetic variability for crop improvement by induced mutagenesis through physical and chemical mutagenesis in CSV-23 varieties of Sorghum(Sorghum bicolor).the data recorded for total number of seeds and100 seed weight Sorghum are presented in Table1-6.

2.3.2. Days to first flowering

Days to first flowering showed different effect with different doses of gamma rays and EMS. This character ranged from 81.00 to 90.00 days in gamma rays and 78.00 to 84.00. The first flowering was seen at the controlled plants; in higher dose/concentration of both gamma rays and EMS is the delayed one to set of flower. These finding showed that gamma ray can change the flowering time of plants.

2.3.3. Days to 50% flowering

The days to 50% flowering was ranged between 81.00 to 87.00 days. Days to50% flowering in control were (76.00) days. As the doses/concentration increased the days to 50% also subsequently increased.

2.3.4. Plant height at maturity (cm)

The plant height was observed was higher in control (175.08 cm) when compared to the treated population the plant height was ranged from 164.03 to138.03cm in control. In gamma treated population. The height was observed in 20kR (164.03cm) and lowest was observed in 60kR (138.03cm). In EMS the plant height was observed between 159.05 to 144.03cm and both treatments show a decreasing tendency while increasing the dose/concentration. In EMS, at highest concentration the plant show stunted and retardants in some plants.

2.3.5. Total number of leaves

The number of leaves was ranged between10.07to9.00.the highest numbers of leaves were observed in control (11.03).in gamma rays, there is no any mean difference between 20,30,40and 50Kr.comparatively less number of leaves was observed in 60kR. In EMS also maximum numbers of leaves were observed (10.08) in20mM. And lowest numbers of leaves were observed in 60mM (9.09) of EMS. Among the treated population, a gradual reduction in mean performance was noted in Total number of leaves per plant for all the mutagenic dose/concentrations.

2.3.6. Leaf length (cm)

The control plant had lower size of leaf length (cm) per plant when compared to the segregating population. The sizes of leaf length (cm) were decreased with increasing dose/concentration of mutagen. In both treatments 20Kr (68.07cm) gamma and 20Mm (68.01cm) EMS exhibited highest size of leaf length per plant. Though the size of leaf length may high, the size of leaf length were very less compared to control.

2.3.7. Ear head length (cm)

The Ear head length was observed higher in control (23.05cm) when compared to the treated population. The Ear head length was ranged from 23.03 to 23.07cm in control. In gamma treated population, the length was observed in 20kR (22.05cm) and lowest was observed in 60kR (18.05cm). In EMS the Ear head length was observed between 22.05to18.09cm. And both treatments show a decreasing tendency while increasing the dose/concentration.

2.3.8. Ear Head width (cm)

The Ear head width was observed higher in control (17.04cm) when compared to the treated population. The Ear head width was ranged from 16.09 to 17.07cm in control. In gamma treated population, the width was observed in 20kR (17.02cm) and lowest was observed in 60kR (15.05cm).in EMS the Ear head width was observed between 16.05to14.02cm.And both treatments show a decreasing tendency while increasing the dose/concentration.

2.3.9. Panicle branch

The range of number of Panicle branch was 67.03when compared to the treated population. The panicle branch was ranged from 66.0 to 68.03 in control. In gamma treated population was observed in 20kR (66.08) and lowest was observed in 60kR (60.04). In EMS the Panicle branch was observed between66.04to53.08.

2.3.10. Number of seed per panicle branch

The effect of all the mutagenic treatments on number of seeds per Panicle branch revealed statistically significant negative shift in mean values. The maximum number of seeds was observed in control (67.03) in treated population, the highest seed number was observed in 20kR (66.07) of gamma rays and 20mM (64.09) in EMS and the lowest was in 60kR (57.06) of gamma rays and 60mM (59.06) of EMS.

2.3.11. 100-seed weight (gm)

The range of 100-seed weight was (02.35 to 02.67 gm).the highest seed was obtained in control (02.67gm) and lowest was in60mM of EMS .it is evident from the pertinent observation that statistically significant decrease in mean value for 100-seed weight was observed.

2.3.12. Total number of seed

Data on mean value for total plant of the seed in M_1 generation shows a gradual decrease with increasing concentrations. The highest seeds of plant were observed in control (1527).the mean value of the mutants showed a moderately high but insignificant improvement over the control in M_1 generation.

Table 2.Effect of mutagens on plant height (cm) and number of leaves in M_1 generation

Mutagens	Treatments (Dose/conc.)	Plant height(cm)			Total number of leaves		
		Range	Mean ±SE	% over control	Range	Mean ±SE	% over control
Control		174.1-179.7	175.82±5.27	00.00	10.25-13.3	11.30±0.33	00.00
Gamma rays	20kR	163.0-166.5	164.28±4.92	-6.56	08.50-13.8	10.70±0.32	-5.31
	30kR	157.6-161.4	159.31±4.77	-9.39	09.25-10.8	10.00±0.30	-11.50
	40kR	144.9-152.9	149.14±4.47	-15.17	09.00-10.0	09.50±0.29	-15.92
	50kR	134.8-141.5	139.43±4.18	-20.70	08.8-10.0	09.30±0.28	-17.69
	60kR	133.8-141.1	138.31±4.14	-21.33	08.5-10.0	09.00±0.27	-20.35
EMS	20mM	157.5-162.1	159.48±4.78	-9.29	09.0-12.4	10.80±0.32	-4.42
	30mM	148.1-149.5	148.37±4.45	-15.61	09.3-11.0	10.30±0.31	-8.84
	40mM	147.1-149.2	148.26±4.44	-15.67	09.3-10.8	10.25±0.30	-9.29
	50mM	146.6-148.7	147.57±4.42	-16.06	09.3-11.0	10.20±0.30	-9.73
	60mM	142.4-145.50	144.31±4.32	-17.92	09.5-10.3	09.90±0.28	-12.38
		SE : 1.34 SED : 1.90 CD (P=0.05) : 3.17 CD (P=0.01) : 5.11			SE : 0.37 SED : 0.69 CD (P=0.05) : 1.53 CD (P=0.01) : 1.98		

Table 3.Effect of mutagens on leaf length (cm) and first flowering (days) in M_1 generation

Mutagens	Treatments (Dose/conc.)	leaf length (cm)			first flowering (days)		
		Range	Mean ±SE	% over control	Range	Mean ±SE	% over control
Control		68.07-69.02	68.09±2.04	0.000	89.00-91.00	90.00±2.70	0.00
Gamma rays	20kR	68.04-68.08	68.07±2.03	-0.029	88.00-90.00	89.00±2.67	-1.11
	30kR	67.04-68.03	68.01±2.02	-0.117	86.00-89.00	88.00±2.64	-2.22
	40kR	65.07-66.07	66.01±1.98	-3.054	84.00-87.00	86.00±2.58	-4.44
	50kR	65.03-66.07	65.09±1.95	-4.405	80.00-82.00	81.00±2.43	-10.00
	60kR	64.04-64.06	64.05±1.92	-5.933	72.00-78.00	76.00±2.28	-15.55
EMS	20mM	67.09-68.03	68.01±2.04	-0.117	82.00-86.00	84.00±2.52	-6.66
	30mM	67.07-68.04	68.00±2.03	-0.132	81.00-83.00	82.00±2.46	-8.88
	40mM	67.04-67.06	67.05±2.01	-1.527	80.00-82.00	81.00±2.43	-10.00
	50mM	64.06-64.08	64.07±1.93	-5.903	79.00-82.00	80.00±2.40	-11.11
	60mM	64.02-64.04	64.03±1.92	-5.962	77.00-79.00	78.00±2.34	-13.33
		SE : 0.14			SE : 0.62		
		SED : 0.20			SED : 1.08		
		CD (P=0.05) : 0.41			CD (P=0.05) : 1.80		
		CD (P=0.01) : 0.55			CD (P=0.01) : 2.65		

Table 4.Effect of mutagens on Ear Head Length (cm) and Ear Head Width (cm) in M_1 generation

Mutagens	Treatments (Dose/conc.)	Ear Head length (cm)			Ear Head Width (cm)		
		Range	Mean ±SE	% over control	Range	Mean ±SE	% over control
Control		23.03-23.07	23.05±0.69	0.00	16.09-17.07	17.04±0.51	0.00
Gamma rays	20kR	22.05-22.08	22.05±0.66	-4.33	17.00-17.03	17.02±0.52	-0.11
	30kR	21.03-21.07	21.05±0.63	-8.67	16.06-16.09	16.07±0.48	-5.69
	40kR	20.06-20.07	20.05±0.60	-13.01	16.04-16.07	16.06±0.47	-5.75
	50kR	19.03-19.08	19.05±0.57	-17.35	15.08-16.01	16.01±0.47	-6.04
	60kR	18.04-18.08	18.05±0.54	-21.69	15.02-15.06	15.05±0.45	-11.67
EMS	20mM	22.02-22.08	22.05±0.66	-4.33	16.03-16.07	16.05±0.48	-5.80
	30mM	21.07-22.04	22.00±0.65	-4.55	15.09-16.04	16.01±0.48	-6.04
	40mM	19.07-21.03	20.06±0.60	-12.97	15.00-15.05	15.02±0.45	-11.85
	50mM	18.08-19.03	19.01±0.57	-17.52	14.07-15.01	14.09±0.42	-17.31
	60mM	18.07-19.05	18.09±0.54	-21.51	13.09-14.04	14.02±0.42	-17.72
		SE : 0.12			SE : 0.11		
		SED : 0.16			SED : 0.16		
		CD (P=0.05) : 0.33			CD (P=0.05) : 0.34		
		CD (P=0.01) : 0.44			CD (P=0.01) : 0.46		

Table 5.Effect of mutagens on Panicle branch and No. of seeds per Panicle branch in M_1 generation

Mutagens	Treatments (Dose/conc.)	Panicle branch			No. of seeds per Panicle branch		
		Range	Mean ±SE	% over control	Range	Mean ±SE	% over control
Control		66.00-68.03	67.03±2.01	0.00	65.03-69.03	67.03±2.01	0.00
Gamma rays	20kR	65.08-67.05	66.08±1.98	-1.41	64.08-68.00	66.07±1.98	-1.43
	30kR	63.08-68.00	65.04±1.95	-2.96	63.08-66.03	65.01±0.95	-3.01
	40kR	61.05-63.05	62.05±1.86	-7.42	62.08-64.08	63.07±1.89	-5.90
	50kR	59.05-61.08	61.00±1.83	-8.99	57.03-59.08	58.05±1.74	-13.39
	60kR	58.05-63.00	60.04±1.80	-10.44	56.03-59.05	57.06±1.71	-14.87
EMS	20mM	64.00-67.08	66.04±1.98	-1.47	64.00-65.05	64.09±1.92	-4.38
	30mM	60.05-63.00	61.05±1.83	-8.92	63.07-65.00	63.07±1.89	-5.90
	40mM	56.05-60.05	58.01±1.74	-13.45	61.05-64.00	62.05±1.86	-7.42
	50mM	56.00-58.05	56.08±1.68	-16.33	59.08-61.05	60.05±1.80	-10.41
	60mM	52.05-55.00	53.08±1.59	-20.81	58.03-62.03	59.06±1.77	-11.89
		SE : 0.92			SE : 0.84		
		SED : 1.31			SED : 1.11		
		CD (P=0.05) : 2.64			CD (P=0.05) : 2.23		
		CD (P=0.01) : 3.17			CD (P=0.01) : 2.98		

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Table 6.Effect of mutagens on 100 seed weight (gm) and total number of seed in M_1 generation

Mutagens	Treatments (Dose/conc.)	100 seed weight(gm)			Total number of seed		
		Range	Mean ±SE	% over control	Range	Mean ±SE	% over control
Control		02.57-02.75	02.67±0.080	0.00	1511-1545	1527±45.8	0.00
Gamma rays	20kR	02.47-02.85	02.66±0.079	-0.37	1473-1485	1480±44.4	-3.07
	30kR	02.44-02.55	02.56±0.076	-4.11	1432-1450	1440±43.2	-5.69
	40kR	02.41-02.58	02.49±0.075	-6.74	1426-1444	1439±43.1	-5.76
	50kR	02.42-02.49	02.47±0.074	-7.49	1424-1442	1433±42.9	-6.15
	60kR	02.24-02.50	02.37±0.071	-11.23	1415-1431	1424±42.7	-6.74
EMS	20mM	02.46-02.82	02.67±0.080	0.00	1491-1505	1497±44.9	-1.96
	30mM	02.56-02.77	02.66±0.079	-0.37	1476-1486	1479±44.3	-3.14
	40mM	02.45-02.52	02.49±0.074	-6.74	1458-1429	1470±44.1	-3.73
	50mM	02.36-02.42	02.39±0.072	-10.48	1450-1459	1454±43.6	-4.78
	60mM	02.33-02.37	02.35±0.071	-11.98	1426-1443	1436±43.0	-5.95
		SE : 0.04			SE : 4.33		
		SED : 0.06			SED : 6.13		
		CD (P=0.05) : 0.13			CD (P=0.05) : 12.34		
		CD (P=0.01) : 0.18			CD (P=0.01) : 16.47		

Table1.

Dose/conc.	Plant height(cm)	Total number of leaves	leaf length (cm)	first flowering (days)	Ear Head length (cm)	Ear Head Width (cm)	Panicle branch	No. of seeds per Panicle branch	100 seed weight(gm)	Total number of seed
Control	175.82±5.27	11.30±0.33	68.09±2.04	90.00±2.70	23.05±0.69	17.04±0.51	67.03±2.01	67.03±2.01	02.67±0.080	1527±45.8
20kR	164.28±4.92	10.70±0.32	68.07±2.03	89.00±2.67	22.05±0.66	17.02±0.52	66.08±1.98	66.07±1.98	02.66±0.079	1480±44.4
30kR	159.31±4.77	10.00±0.30	68.01±2.02	88.00±2.64	21.05±0.63	16.07±0.48	65.04±1.95	65.01±0.95	02.56±0.076	1440±43.2
40kR	149.14±4.47	09.50±0.29	66.01±1.98	86.00±2.58	20.05±0.60	16.06±0.47	62.05±1.86	63.07±1.89	02.49±0.075	1439±43.1
50kR	139.43±4.18	09.30±0.28	65.09±1.95	81.00±2.43	19.05±0.57	16.01±0.47	61.00±1.83	58.05±1.74	02.47±0.074	1433±42.9
60kR	138.31±4.14	09.00±0.27	64.05±1.92	76.00±2.28	18.05±0.54	15.05±0.45	60.04±1.80	57.06±1.71	02.37±0.071	1424±42.7
20mM	159.48±4.78	10.80±0.32	68.01±2.04	84.00±2.52	22.05±0.66	16.05±0.48	66.04±1.98	64.09±1.92	02.67±0.080	1497±44.9
30mM	148.37±4.45	10.30±0.31	68.00±2.03	82.00±2.46	22.00±0.65	16.01±0.48	61.05±1.83	63.07±1.89	02.66±0.079	1479±44.3
40mM	148.26±4.44	10.25±0.30	67.05±2.01	81.00±2.43	20.06±0.60	15.02±0.45	58.01±1.74	62.05±1.86	02.49±0.074	1470±44.1
50mM	147.57±4.42	10.20±0.30	64.07±1.93	80.00±2.40	19.01±0.57	14.09±0.42	56.08±1.68	60.05±1.80	02.39±0.072	1454±43.6
60mM	144.31±4.32	09.90±0.28	64.03±1.92	78.00±2.34	18.09±0.54	14.02±0.42	53.08±1.59	59.06±1.77	02.35±0.071	1436±43.0

2.4. Discussion

In general, there was dose-dependent relationship in respect of plant height(cm), Total number of leaves, leaf length(cm), day to first flowering, Ear head length(cm), Ear head width(cm), panicle branch, Panicle branch per seed, 100 seed weight(gm), total number of seeds Plant from the study of range, mean and control over percentage of M_1 population .it appears that considerably variation has been induced in the quantitative characters after treatment with gamma rays and EMS (Velu, S., L. Mullainathan, D. Arulbalachandran and E. Sudhakar, (2008)

As might be expected, the variation in M_1 generation of the treated population was constantly higher than the control population in all these characters, in both negative and positive directions. The plant height was increased and decreased in both treatments of EMS and gamma rays. Maximum number of leaves was higher in the case of control and all the panicle fertile too. Days to first flowering was increased with increasing the concentrations. Plant yield shows considerable decrease in the treated plants when compared to the control. Increase in plant yield may be due to the increase in the fertile panicles, total number of seeds and 100 seed weight (Dhanavel, D., P. Pavadai, L. Mullainathan, D. Mohana, G. Raju, M. Girija and C. Thilagavathi (2008)

As the dose increased, the days to flowering has increased. In both treatments at highest dose/concentrations were showed a significant variation in days to first flowering. This was supported by the earlier report of (Singh M, VP Singh (2001) and (Deepalakshmi AJ, CR Anandakumar (2004).similar inhibitory effects in quantitative characters have reported (Kajjidoni ST, Roopalakshmi K, Revanappa S, Nagara I (2009) and (Kharkwal, M.C., (1998) in Sorghum. To found that mutagenesis could wide variability to both positive and negative direction which resulted sufficient variability in the treated population, which could be utilized for selection of late flowering plants.

The plant height was reduced with increasing in dose/concentrations of mutagens. Created variability in plant height in Sorghum through gamma rays. The reduction in plant height was observed in sorghum (Hariprasanna, K., Rajendrakumar, P. and Patil, J.V. (2012).inhibitory effect in number seeds per plant in gamma radiation (Jabeen N, Mirza B (2004).

Suggested that the increased in the mean plant yield might have resulted from the purposeful elimination of all the mutants which produce abnormal spike morphology. In this study, it was observed that most of the quantitative characters show improvement in a negative direction when compared to the control. It may because of the stress in treated plant caused by the application of mutagens. So it may be give a positive result in further generation.

Reported that mutagen-derived variability for quantitative characters in crop plants is heritable and that the response to selection is good. the relative value of this source of variability for used in crop improvement, therefore depends almost entirely upon the nature of phenotypic expression caused by the mutations induced polygenic loci from this present study. It can be concluded that there is a scope for further improvement of this variety of mutagen with regard to the quantitative characters in the further generations (Maduli, K.C. and Mishra, 2007).

3. CONCLUSION

The result indicated the possibilities of evolving higher yielding variants through proper selection. Thus, economic trait like, plant height (cm), Total number of leaves, leaf length (cm), first flowering(days), Ear head length(cm), Ear head width (cm), Panicle branch, Number of seeds per Panicle branch , Total number of seeds per plant and 100 seed weight (gm) in M_1 generation offer scope for selection and Crop improvement.

Mutagenic treatments increase the genetic variability, which can be utilized for selection and improvement of plants. This aspect has been advised by Swaminathan M.S (1963) and Elangovan, M. et al., (2013) in different plants. The mutagens used in the present investigation have definitely proved successful in broadening the genetic base to an appreciable extent. It is hoped that the mutagenic treatment induced polygenic variability may have further scope in Sorghum improvement through its incorporation in conventional breeding.

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