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Mutagene induced variability in proso millet (*Panicum miliaceum* L.)

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Abstract
The local cultivar of proso millet *viz*. Vari No. 10 was selected. This cultivar was irradiated with six doses of gamma-rays *viz.,* 20 krad, 30 krad, 40 krad, 50 krad, 60 krad and 70 krad for inducing variability. Among gamma irradiated population 20 KR dose was more effective in creating variability for most of the traits in Vari No. 10. A large number of useful mutants were observed and selected among different doses. Induced variability indicated that significant improvement can be achieved by appropriate selection methods.

Keywords: proso millet, gamma rays, variability

Introduction

Proso millet (*Panicum miliaceum* L.) is also known as *Vari* (in marathi) or common millet. It was first introduced in Canada in the 17th Century. Most proso millet traded internationally is imported by the pet-food industry in industrialized countries which is used as bird feed. In tropical Africa, it is cultivated in Ethiopia, Eastern Kenya, Malawi, Botswana, Zimbabwe and Madagascar.

Now-a-days, proso millet is cultivated for human consumption mainly in Eastern and Central Asia and to a lesser extent in Eastern Europe (Russia, Danube region) and from Western Asia to Pakistan and India (Bihar, Andhra Pradesh, Maharashtra etc.). In India, small millet is cultivated over an area of 9.03 lakh ha with total production of 4.45 lakh tonnes during 2014-2015. In Maharashtra, the largest area is found in Konkan region comprising Raigad, Thane, Sindhudurg and Ratnagiri districts. The share of proso millet of the total recorded millet trade has been estimated at about two-thirds. It is an important staple food grain in semi-arid areas where hardly any cereal crop can be grown. Proso millet is considered a potentially useful quick-maturing crop for the drier regions to fill the hunger gap before the main cereals are harvested.

This crop has high nutritional value which could be well exploited for bio-fortification of tribles, the society where maximum malnutrition and under nutrition noticed remain overlooked.

The husked grains of proso millet are eaten whole, boiled like rice or eaten after roasting. A variety of products can be prepared from proso millet. They are used for making beer and brandy. The straw is used as forage. The forage quality of the straw is poor, and in India it is more often used for bedding for cattle. The straw is also made in to brooms. Starch from the grains has been used for sizing textiles (Kaume 2006) [11].

Proso millet ($2n = 36$) is an annual warm season grass. Proso millet is self-pollinated crop with less variability. Local genotypes are available but they are poor yielders having narrow genetic base. So, attempt on improvement of proso millet genotypes so a restricted to selection only due to complicated floral biology. In the above situation, mutation breeding can complement the conventional breeding methods in the improvement of Proso millet. Induced variability and applying selection can provide wider scope for evolving new varieties with desirable attributes. Therefore induced mutagenesis has been resorted to expand variability followed by efficient selection for non-lodging and high yielding varieties in Proso millet.

Wide ranges of character which have been improved through mutation breeding include plant architecture, yield, flowering and maturity duration, quality and tolerance to biotic and abiotic stresses. Mutation breeding has made significant contribution to the national economy of the countries like China, India, Japan, Pakistan and USA. Induced mutagenesis is gaining importance in plant molecular biology as a tool to identify and isolate genes and to study their structure and function.

The present investigation was taken to study Mutagen induced variability in Proso Millet (*Panicum miliaceum* L.) for to study the genetic variability for yield and yield components in M_3 generation and identification and isolation of desirable mutants.

Material and Methods

The present investigation was carried out at the Educational Research Farm, Department of Agricultural Botany, College of Agriculture, Dapoli, Dist. Ratnagiri.

The material for study comprises local proso millet variety, Vari No. 10. This variety having following characters like tall plant height, creamish white seed colour, plant height ranges from 140 – 150 cm, lodging at maturity, panicle length of 40 – 45 cm, days to flowering ranges from 96-100, days to maturity are 110-125 days, test weight 1.38 g and mean grain yield was 8-10 q/ha.

Seed of the genotype Vari No. 10 of proso millet was exposed to 20 krad, 30 krad, 40 krad, 50 krad, 60 krad and 70 krad of gamma rays. Dry seeds having storable moisture content i.e. 12 per cent were irradiated with gamma rays in first week of May 2013. The irradiation source used was^{60}Co gamma cell installed at the Biology and Agriculture Division of the Bhabha Atomic Research Centre (BARC), Trombay, Mumbai. To determine the effect of gamma-rays on yield contributing characters. The seeds of M_1 generation were sown on June 2013 and the plants were harvested on December 2013**.** Same way the M2 generation were studied in 2014, *Kharif.* And individual plants in M_2 generation were selected on the basis of their phenotypically characters and harvested separately for raising M_3 generation.

The seeds harvested from M2 were grown as M3 generation in Randomized Block Design (RBD). Seedlings were transplanted by plant to row progeny method. Four thousand nine hundred ninety-nine plants were transplanted comprising of all treatment including control at spacing of 30×15cm. All recommended package of practices were followed during growth period of crop. Observations were recorded on five randomly selected plants from each treatment. In M_3 generation, morphological mutants were identified and harvested separately.

Table 1: Total number of plants per treatment transplanted

Dose/ Treatment	No. of plants (progeny) grown in M_3 generation
Control	89
20 KR	2548
30 KR	348
40 KR	588
50 KR	184
60 KR	1056
70KR	186
Total	4,999

The data of all characters were statistically analyzed by mean performance of five randomly selected plants.

Result and Discussion

Mean values of all characters are presented in table. The wide range of variation was observed among the M_3 generation for all the characters studied. All the characters showing significant mean sum of squares indicated the extent of variability existed in the population. There was no much difference in mean performance of first flowering between control and irradiated population. However, it shows high range of variation for days to first flowering. No-54 (97.5 days) showed late flowering followed by No-1 (90 days) whereas No-46 and No-52 (79.5 days) early flowering followed by No-27 and No-47 (80.5 days). The mean number of days required for days to first flowering was 84.38 days which was lower than the control (86 days). It was observed that the mean numbers of days required for fifty per cent flowering was (90.69 days) less than the control (92.5 days). The range showed high variation. No-52 (83.5 days) showed earliness whereas No-54 requires more number of days (101.5 days). Early flowering was observed by No- 52 (83.5 days) followed by No-46 and No-47 (86 days) whereas late flowering was observed by No-54 (101.5 days) followed by No-1 (97 days). The result showed slightly earlier panicle maturity in mutated population than the control. The mean days required to days to panicle maturity (117.30 days) is slightly earlier than control (120 days). No-52 and No-47 (114 days) showed earliness followed by No-6, No-17, No-27, No-45, No-46 (114.5 days) and No-1 (125 days) showed late maturity followed by N0-54 (124 days). Such results were observed by Muduli and Misra (2007) [15] and Muduli *et al.* (2012) [17] in M_3 generation of finger millet and Hayat *et al.* (1990) for sorghum. The character plant height is an important character in proso millet. Water requirement of dwarf plant is definitely lesser than the tall plant. It was observed that the mean plant height at maturity (188.46 cm) was more than control (182.5 cm).It showed high range of variation (169.5 cm) for No-40 to (198.8 cm) for No-18. The taller plant were observed in No-18 (198.8 cm) followed by No-1(198.1 cm). The dwarf plant was observed in No-40 (169.5 cm) followed by No-41 (170.5 cm). Significant variation was seen due to irradiation in numbers of tillers per plant. In general, irradiation caused noticeable increase in number of tillers per plant. The maximum number of tillers was recorded by No-19 (7.2) and minimum number of tillers was recorded by No-17 (4). The mean number of tillers (5.65) was more than the control (4.8). The study revealed that the mutant showed higher frequency of variation in panicle length. The maximum panicle length was observed in No-28 (34.6 cm) and minimum was seen in No-53 (27.7 cm). The mean panicle length (31.15 cm) was slightly less than control (32.5 cm) Muduli and Misra (2008) [16] in finger millet, Mehta and Dhagat (1994), Ichitani *et al*. (2003) [10] in foxtail millet recorded similar result in ragi and Nirmala kumari *et al.* (2007) [21] in little millet.

Significant variation was observed in the irradiated population. The range showed high variation in grain yield per plant. Highest grain yield was recorded in No-26 (21.05 g) followed by No-11 (15.25 g) and lowest was recorded in No-47 (3.8 g) followed by No-49 (5.3 g). The mean grain yield per plant (9.52 g) was slightly higher than control (8.1 g). The character panicle weight showed less difference in mutated population and control. The mean panicle weight (4.87 g) was slightly less than control (5.05 g). Highest panicle weight was recorded in No-2 (7.95 g) and the lowest panicle weight was seen in No-44 (3.4 g). Mean performance for thousand grain weight (1.51 g) was slightly lower than control (1.43 g). Highest thousand grain weight was observed in No-35 (1.68 g) followed by No-37 (1.63 g) and lower was seen in No-46 (1.33 g) followed by No-42 (1.34 g). Similar trend was observed by Misra and Sahu (2005) in finger millet, Ganapaty *et al.* (2008) in little millet, Haradari *et al.* (2012) in finger millet and Bhave *et al.* (2016) in proso millet. For the character grain yield per plot highest grain yield was observed in No-17 (939.75 g) followed by No-18 (788.25 g) and lowest was found in No-32 (244.25 g) followed by No-51 (310.75 g). The mean grain yield per plot (511.49 g) was higher than control (422.5 g). The mean performance for harvest index (21.51%) was much higher than control (15.93%). There was much variation between the mutant genotypes. The highest harvest index was recorded by No-54 (32.48%) and lowest was recorded by No-11 (11.78%). Such result was observed by Misra and Sahu (2005) [14] in little millet, Eswari *et al.* (2013) in finger millet, Muduli and Misra (2008) [16] in finger millet and Anand (2013) [2,] in *kharif* sorghum.

Table 2. Mean performance of M_3 generation of proso millet for different quantitative characters

Genotypes	Days to First Flowering	Days to 50% Flowering	Days to Panicle Maturity	Plant Height (cm) at Maturity	Number Of Tillers Per plant	Panicle Length (cm)	Grain Yield Per Plant (g)	Panicle Weight (g)	Thousand Grain Weight (g)	Grain Yield Per Plot (g)	Harvest Index (%)
No.1	90.50	97.00	125.00	198.10	5.40	34.50	11.70	6.10	1.60	661.40	21.72
No.2	86.50	92.00	120.00	182.00	4.90	32.40	8.75	7.95	1.56	419.90	23.87
No.3	83.50	91.50	116.50	195.20	6.10	32.10	10.15	5.35	1.50	534.25	14.82
No.4	84.50	91.00	117.50	189.70	6.60	30.30	8.95	4.45	1.46	549.50	18.86
No.5	81.50	88.00	115.00	189.30	6.60	31.60	11.60	6.15	1.57	676.50	13.88
No.6	86.50	92.50	114.50	184.20	6.70	32.10	7.60	5.45	1.49	502.25	19.34
No.7	82.50	89.50	116.50	195.20	5.90	31.30	11.05	5.65	1.43	569.50	19.98
No.8	84.50	90.00	117.50	188.90	5.70	31.20	11.55	5.65	1.54	370.55	13.71
No.9	83.50	92.00	116.50	187.50	6.70	29.80	7.80	3.55	1.57	544.75	21.54
No.10	86.50	93.00	119.00	187.00	4.85	32.50	13.90	5.10	1.49	538.75	15.11
No.11	84.50	91.50	118.00	188.00	5.40	29.80	15.25	4.80	1.55	515.10	11.78
No.12	88.00	96.50	119.50	190.20	6.10	33.30	9.40	5.55	1.57	596.25	26.50
No.13	82.00	89.50	116.00	181.50	6.00	32.00	8.60	5.90	1.44	587.50	25.23
No.14	83.50	90.00	115.50	184.60	4.70	31.90	8.25	4.85	1.49	639.75	22.10
No.15	83.50	90.00	116.50	190.20	6.10	32.30	8.10	5.40	1.54	770.25	19.25
No.16	84.50	87.50	117.50	197.50	7.10	30.70	12.70	5.20	1.53	753.50	20.97
No.17	82.50	86.50	114.50	186.00	4.00	30.85	7.20	4.90	1.52	939.75	25.05
No.18	85.00	92.00	118.50	198.80	6.00	32.20	11.45	5.30	1.40	788.25	20.23
No.19	83.50	90.00	116.50	197.70	7.20	28.40	9.30	4.70	1.52	639.00	20.41
No.20	83.00	89.00	115.50	197.30	5.90	31.20	10.55	4.75	1.56	529.75	21.57
No.21	83.00	89.00	116.00	192.20	5.80	30.60	8.70	5.60	1.56	613.25	26.18
No.22	83.00	89.00	116.00	189.50	6.00	32.40	8.40	5.35	1.47	485.75	21.98
No.23	85.00	91.00	118.50	193.00	5.70	30.40	10.40	5.45	1.49	667.75	23.19
No.24	84.00	90.00	117.50	185.00	6.00	29.10	11.70	4.55	1.49	392.25	20.68
No.25	85.50	92.50	119.00	186.50	5.10	27.90	10.75	3.60	1.45	523.25	26.01
No.26	84.00	91.00	117.00	187.00	5.20	30.80	21.05	5.10	1.50	558.25	23.21
No.27	80.50	87.00	114.50	176.50	5.80	32.30	12.20	6.20	1.47	679.75	16.18
No.28	84.50	91.00	117.50	193.50	6.10	34.60	11.10	6.85	1.45	715.75	19.29
No.29	84.00	89.50	116.00	196.80	6.00	30.90	8.75	4.10	1.43	610.25	26.43
No.30	84.50	90.50	116.50	195.00	5.10	30.60	7.00	4.25	1.46	426.00	25.66
No.31	85.50	93.50	118.00	187.30	5.70	30.50	7.65	4.60	1.50	446.25	28.63
No.32	85.50	91.50	118.00	184.70	5.90	31.10	10.50	5.15	1.61	244.25	24.85
No.33	83.00	89.00	116.50	192.20	5.95	31.60	7.50	4.40	1.52	311.50	26.46
No.34	83.50	89.50	117.00	188.00	5.90	32.00	12.00	3.60	1.54	434.00	22.89
No.35	85.00	91.50	118.50	186.20	5.70	32.60	9.10	4.35	1.68	385.00	25.94
No.36	84.50	90.50	117.00	191.20	5.00	31.70	6.70	4.25	1.52	408.25	19.01
No.37	84.00	90.00	116.00	183.50	6.1	30.60	9.61	5.5	1.63	583.00	22.80
No.38	87.00	93.00	120.00	182.00	6.30	32.70	15.00	4.60	1.47	377.50	11.90
No.39	87.50	93.00	119.00	181.00	5.10	31.40	8.75	4.75	1.49	414.75	28.34
No.40	89.50	95.50	120.50	169.50	4.30	32.20	6.20	4.85	1.41	362.50	19.10
No.41	85.50	92.50	118.50	170.50	5.40	30.30	9.50	4.00	1.48	394.00	16.14
No.42	85.00	91.00	118.00	189.50	4.60	32.20	5.70	4.30	1.34	416.00	27.09
No.43	84.50	90.00	117.50	188.00	5.70	31.60	7.00	4.55	1.50	481.00	17.59
No.44	82.50	88.50	116.00	192.40	4.70	29.95	5.50	3.40	1.56	520.90	26.15
No.45	81.00	89.00	114.50	196.00	5.60	29.70	6.80	4.00	1.47	366.00	27.41
No.46	79.50	86.00	114.50	196.20	6.10	30.00	13.75	3.60	1.33	352.25	12.28
No.47	80.50	86.00	114.00	198.00	5.80	31.80	3.80	4.20	1.59	314.00	27.41
No.48	83.00	89.00	116.00	190.50	5.80	29.40	11.10	4.55	1.48	376.50	16.45
No.49	81.50	90.50	117.00	188.50	5.20	31.10	5.30	3.50	1.53	475.25	25.73
No.50	84.00	91.00	117.50	176.50	5.70	28.80	7.90	4.15	1.58	439.50	18.20
No.51	84.00	89.50	117.50	182.00	5.30	29.80	12.45	4.70	1.60	310.75	12.99
No.52	79.50	83.50	114.00	189.50	5.50	30.70	8.50	5.10	1.48	560.75	22.99
No.53	84.00	91.00	118.00	184.50	4.80	27.70	6.00	4.30	1.47	483.5	29.75
No.54	97.50	101.50	124.00	191.50	5.30	31.50	5.55	4.95	1.49	453.50	32.48
No.55	86.00	92.50	120.00	182.50	4.80	32.50	8.10	5.05	1.43	422.50	15.93
GM	84.38	90.69	117.30	188.46	5.65	31.15	9.52	4.87	1.51	511.49	21.51
MIN.	79.50	83.50	114.00	169.50	4.00	27.70	3.80	3.40	1.33	244.25	11.78
MAX.	97.50	101.50	125.00	198.80	7.20	34.60	21.05	7.95	1.68	939.75	32.48
SE	1.30	1.33	1.22	4.09	0.52	0.35	0.43	0.35	0.03	65.61	2.49
CD @5%	3.65	3.74	3.42	11.48	1.46	0.99	1.22	1.002	0.09	183.90	6.99

Conclusion

On the basis of result obtained from this investigation, it is concluded that, 20 krad dose is more beneficial for improvement of character like panicle weight. 20 krad dose is more useful for the improvement of characters like, number of tillers per plant, panicle weight, grain yield and 1000 grain weight as compared to other doses. 50 krad treatments is more effective treatment for improvement plant height.70 krad treatment is more effective treatment for improvement of harvest index. Induced variability indicated that significant improvement can be achieved by appropriate selection methods. A large number of useful mutants were observed and selected among different doses.

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