International Journal of Technical Research and Applications e-ISSN: 2320-8163,
www.ijtra.com Volume 3, Issue 6 (November-December, 2015), PP. 139-144

STUDY ON THE VARIABILITY OF INDUCED MUTATION FOR IMPROVEMENT OF LOCAL CULTIVAR SORGHUM (SHWENI-15)

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Abstract— **Seeds of local cultivar Sorghum (Shweni-15) were treated with doses (0Gy- 800Gy) from Gamma ray ^{60}Co source. The objective was to study the genetic variability of induced mutation for the improvement of local cultivar Sorghum in M2 generation. The lethal dose 50% (LD-50) value for Sorghum (Shweni-15) was found in 830Gy. The agronomic traits of heritability (h^2) genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) and genetic advance of mean (GAM) were studied in M2 generation. The traits like plant height, stem width and seed yield per plant exhibited high heritability accompanied with high GAM in the treatment with 300Gy. The treatment with 300 Gy also showed moderate heritability with low GAM was observed for number of leaves per plant, brix % and 100 seed weight. The treatment with 400Gy had high heritability with high GAM for stalk weight and moderate heritability with low GAM for panicle width and branches per panicle. In this study, gamma radiation induced wide variation with the treatment of 300Gyand 400Gy in most of the traits in Sorghum (Shweni-15).**

*Key words: **Agronomic traits, Gamma rays, Sorghum, Variability***

I. INTRODUCTION

Sorghum [Sorghum *bicolor (L.)* Moench] is the fifth most important cereal crop in the world, after wheat, maize, rice and barley. Sorghum was grown in 100 countries of the world in the year 2003, covering an area of approximately 44 million ha with grain production of 59 million t and average productivity of 1.34t ha $^{-1}$(FAO website: http://www.fao.org). Sorghum occupies 24 m ha in Africa (mostly in Ethiopia, Mali, Nigeria and Sudan), 12 m ha in Asia (China, India, Myanmar, Pakistan, Saudi Arabia, Thailand and Yemen), 3.5 m ha in Central and South America, 3.1 m ha in the USA and 0.5 m ha in Australia. Sorghum is also grown for green forage. Varieties with sweet, juicy stems (sweet sorghum) are used to produce syrup. Sorghum grain is used to make bread, biscuits, starch, sugar, syrups, and alcohol beer and malt products. The stalks are used as fuel, fencing and roofing material [1].

Sweet sorghum has many good characteristics such as a drought resistance ,water lodging tolerance, salinity resistance and with a high yield of biomass [2].Induced mutations are highly effective in enhancing natural genetic resources and have been used in developing improved cultivars of cereals, fruits and other crops [3]. There are many kinds of ionizing radiation however, gamma rays are widely employed for mutation studies as they have shorter wave length and possess more energy per photon than x-rays and penetrate deep into tissue [4]. Gamma-rays were more effective for inducing viable mutants [5].Worldwide efforts on mutation-based plant breeding have resulted in the official release to farmers of over 2700 new crop cultivars in approximately 170 species [6].

Development of high-yielding cultivars requires a thorough knowledge of the existing genetic variation for yield and its components. The observed variability is a combined estimate of genetic and environmental causes, of which only the former is heritable. However, estimates of heritability alone do not provide a full anticipation of the outcome in plant response to selection, but should be combined with other estimates such as genetic advance, the change in mean value between generations, phenotypic and genotypic coefficients of variation [7].

In dry zone area Myanmar, sweet sorghum is also a promising new crop for bioethanol production. According to data from Ministry of agriculture, Sorghum growing area in Myanmar is 210,000ha. Sorghum is mainly cultivated in Mandalay, Sagaing, Kayar and Magway division. The present study will be mainly focused on local crop improvement, especially for study on the genetic variability of induced mutation in Sorghum (Shweni-15) through gamma radiation.

II. MATERIALS AND METHODS

A. Handling for M1 and M2 Generation

Seeds of Sorghum (Shweni-15) were obtained from the Department of Agriculture Research (DAR), Yezin. Dry seeds were irradiated with (0Gy – 800Gy) doses of Gamma radiation from ^{60} Co source. The gamma radiation was carried out at the Department of Atomic Energy (DAE), Ministry of Science and Technology, Yangon. The lethal dose 50% (LD-50) value for sorghum was found at 830Gy. All treated along with control were sown in the field at a spacing of 15cm within plants and 45cm between plants to raise the M1 generation during the growing season in 2013. All M1 plants were used bulk harvesting method to raise M2 generation. Screening and evaluation of M2 generation was performed during the 2014 growing season, using a randomized complete block design (RCBD) with 3 replications. The effect of gamma rays on variability of induced mutation on twelve agronomic characters of plant height, stem width, stalk weight, number of branches per plant, panicle length, panicle width, number of leaves per plant, number of seed per plant, 100 seed weight, seed yield, brix% and juice volume were studied in M2 generation.

B. Statistical analysis

Data were subjected to analysis of variance (ANOVA) using SPSS 16.0 software. In order to evaluate the effects of mutagenic treatments on induction variation the following parameter were studied; broad sense heritability (h^2), genotypic and phenotypic coefficient of variation (GCV) (PCV) and expected genetic advance as percent to mean (GAM). The estimate of expected genetic advanced for each traits with assumed 1%selection intensity was computed using the formula given by Allard (1960) [8].

$$GCV (\%) = [(\sigma^2 g)^{1/2} / \bar{X}] \times 100$$
$$PCV (\%) = [\sigma^2 p)^{1/2} / \bar{X}] \times 100$$
$$h2 (\%) = (\sigma^2 g/ \sigma^2 p) \times 100$$
$$GAM = (k \times \sigma p \times h^2) / \bar{X}$$

Where;

h^2 = broad sense heritability

$\sigma^2 g$ = genotypic variance

$\sigma^2 p$ = phenotypic variance

k = 2.64, constant for 1% selection intensity

III. Results and Discussion

In the present study, estimation of mean value, heritability, phenotypic and genotypic coefficient of variation for twelve characters were studied in M2 generation.

Mutagen treatments have increased the plant height of local cultivar Sorghum (Shweni-15) in M2, where the doses 300Gy had the highest mean values (Table 1). The lowest mean value for plant height was found in 500Gy. The highest heritability (h^2), GCV, PCV and GAM for plant height were observed at doses in 300Gy followed by the doses in 200Gy. In general, all treated plants had high heritability GCV, PVC and GAM for plant height.

In stem width, mutagenic treatment with 100Gy had the highest mean value and the lowest was found in 800Gy (Table 1).Treatment with 300Gy had the highest heritability, GCV, PCV and GAM followed by the treatment with 200Gy. On the other hand, control possessed the lowest amount of heritability GCV, PCV and GAM than all of the treated plants with the exception in 800Gy for stem width.

In number of leaves per plant, the highest mean value was recorded in the treatment with 100 Gy followed by 300Gy (Table 2). The highest heritability was observed the treatment with 300Gy and the lowest found in 800Gy. Treatment with 300Gy also induced the highest value of GCV, PCV and GAM for number of leaves per plant. The rest of all treated plants had moderate heritability and low GCV, PCV and GAM.

Gamma rays increased the stalk weight of Sorghum (Shweni-15) cultivar than the control in M2 generation (Table 2). The highest mean value was recorded in 100Gy followed by the treatment with 300Gy.Treatment with 300Gy induced the highest heritability for stalk weight while the treatment with 400Gy possessed the highest GCV, PCV and GAM. Most of the treated plants had high heritability, GCV, PCV and GAM. In the case of brix (%), treatment with 600Gy produced the highest mean value than all of the treated plants (Table 3). The treatment with 700Gy and 800Gy had the same mean value for brix %. In general, all of the treated plants possessed moderate heritability and low GCV, PCV and GAM. In this trait, the treatment with 600 had the highest heritability while the treatment with 300 exhibited the highest GCV, PCV and GAM.

Gamma irradiation treatment induced variability in the extraction of juice volume in M2 generation (Table 3). The highest mean value was recorded in 300Gy followed by 100Gy.In this result, the highest heritability estimates was obtained in 300Gy while the treatment with 200Gy and 400Gy showed the high GCV, PCV and GAM. Almost all of the treated plants had high heritability with moderate GAM for juice volume. But the treatment with 800Gy had lower heritability than that of the control plant.

In the result of panicle length, the highest mean value was recorded in the treatment with 800Gy.The lowest mean value found in 600Gy (Table 4). The highest heritability estimates was observed in the treatment with 400Gy. The treatment with 800 showed the lower heritability than that of the control plants and the rest of all treated plants .In this case, the highest GCV and GAM were recorded in the treatment with 600Gy while the treatment with 700Gy showed the highest PCV.

Gamma rays induced variations in panicle width of Sorghum in M2 generation (Table 4).The highest mean value were observed in 300Gy and the lowest found in 700Gy. The highest heritability was recorded in the treatment with 400Gy followed by 500Gy.In this result, the treatment with 700Gy and 800Gy had low heritability estimates when compared to the control. In general, all of the treated plants possessed moderate heritability with low GCV, PCV and GAM.

In the present study, treatment with 500Gy possessed the highest mean value for the number of branches per plant in M2 generation (Table 5). The highest heritability estimates was noticed in 400Gy. The treatment with 800Gy had low heritability when compared to the control plants. The highest GCV, PCV and GAM were also observed in 400Gy. In general, all of the treated plants exhibited moderate heritability with low GCV, PCV and GAM.

Gamma rays increased the number of seed per plant in M2 of Sorghum (Shweni-15). The highest mean value was found in 400Gy. Mutagenic treatments reduced the mean value of this trait in 800Gy when compared to the control plant. The highest heritability value was observed irradiating seeds with 400Gy while the treatment with 300Gy showed the highest GCV, PCV and GAM. Most of the treated plants had high heritability and moderate GAM.

In this study, the highest mean value for 100 seed weight was found in the treatment with 300Gy (Table 6). The lowest mean value was noticed in the treatment with 800Gy. The highest heritability estimates was obtained in the treatment with 300Gy.The highest expected GAM was recorded in 300Gy. Almost all of the treated plants had moderate heritability and low GAM with the exception in 300Gy and 400Gy. The highest GCV was noticed in the treatment with 200Gy while the treatment with 500Gy showed the highest PCV.

Seed yield per plant were increased in Local cultivar Sorghum (Shweni -15) in M2 generation (Table 6). Treatment with 300Gy dose induced the highest seed yield per plant. In this generation, the treatment with 300Gyexhibits the highest mean value, heritability, GCV, PCV and GAM followed by400Gy. All of the treated plants had high heritability, high GCV, PCV and GAM.

In the present study, gamma radiation treatment induced

wide variation for most of the traits in M2 generation. The mean value observed in the treatment with 300Gy was higher than all of the treatments such as plant height, juice volume, panicle width, branches per plant, 100 seed weight and seed yield per plant. These results are agreed with the reported by Wani and Anis (2001) in Chickpea who also observed similar results for plant height, 100seed weight and grain yield per plant [9]. Therefore these result showed that mutagenic treatments could alter mean value. Heritability plays an important role in deciding the strategy for selection of a character. The highest heritability indicated that heritability may be due to higher contribution of genotypic component. High estimates of heritability (above 80%) were recorded for the characters such as plant height, stem width, stalk weight, juice volume, seeds per plant and seed yield per plant.

High heritability were reported by Panwar and Singh, (2000) and Asif et al., (2004) for plant height and Rasal et al., who also observed high value of heritability for most of the traits studied [10][11][12]. Heritability alone is not a reliable parameter to predict the effective selection. High heritability with high genetic advance indicates the preponderance of additive gene. High heritability with high genetic advanced were noticed for the characters such as plant height, stem width, seeds per plant and seed yield per plant. These traits may be creates additional genetic variability. High heritability and high genetic advance gene affect was reported by (Panse, 1967) [13]. This result consistent with that of Veerabadhiram and Kennedy (2001), Unche *et al,* (2008) in Sorghum who also reported for seed yield per plant that high heritability should be accompanied with high genetic advance[14][15]

TABLE I. Means, heritability (h2), phenotypic (PCV), genetic (GCV) coefficient of variation and genetic advance over mean for plant height and stem width in M2 generation

Treatments	Plant Height (cm)					Stem Width (cm)				
	Mean	h2 (%)	GCV (%)	PCV (%)	GAM (% of mean)	Mean	h2 (%)	GCV (%)	PCV (%)	GAM (% of mean)
Control	215.31	75.59	17.74	20.41	40.72	8.61	62.73	19.3	24.36	40.35
100 Gy	224.37	89.33	26.32	27.85	65.68	10.0	76.74	28.55	32.59	66.02
200 Gy	218.94	92.47	36.12	37.57	91.71	9.17	80.19	37.43	41.8	88.5
300 Gy	229.36	95.46	36.91	37.78	95.21	9.76	86.43	39.4	42.36	96.65
400 Gy	195.58	90.83	30.28	31.77	76.18	8.19	78.6	32.16	36.28	75.3
500 Gy	181.44	87.0	28.77	30.85	70.85	8.84	73.41	30.28	35.33	68.48
600 Gy	191.77	81.33	23.64	26.20	56.26	8.38	71.43	27.44	32.47	61.22
700 Gy	198.88	79.12	22.19	24.94	52.10	9.64	68.8	22.32	26.9	48.9
800 Gy	188.81	76.6	21.41	24.45	49.45	8.02	64.18	19.0	23.73	40.20

TABLE II. Means, heritability (h2), phenotypic (PCV) and genetic (GCV) coefficient of variation and genetic advance over mean for number of leaves per plant and stalk weight in M2 generation

Treatments	Number of Leaves per plant					Stalk Weight (g)				
	Mean	h2 (%)	GCV (%)	PCV (%)	GAM (% of mean)	Mean	h2 (%)	GCV (%)	PCV (%)	GAM (% of mean)
Control	11.23	33.85	10.11	17.38	15.53	404.4	63.80	31.39	39.27	66.16
100 Gy	12.6	42.23	11.35	17.46	19.47	521.8	79.93	35.76	40.0	84.42
200 Gy	10.6	46.34	13.0	19.1	23.36	430.77	87.35	36.63	39.19	90.38
300 Gy	12.2	58.49	14.98	19.59	30.24	471.0	89.26	36.23	38.34	90.37
400 Gy	11.2	53.56	12.27	16.76	23.70	341.0	85.22	38.36	41.55	93.47
500 Gy	11.5	51.02	12.28	17.19	23.16	211.1	77.70	31.79	36.06	74.89
600 Gy	11.83	47.03	12.06	17.59	21.84	162.7	74.37	30.19	35.01	68.75
700 Gy	12.03	36.19	10.25	17.03	16.28	416.3	68.53	30.72	37.11	67.15
800 Gy	11.27	29.35	10.31	19.03	14.89	94.1	62.08	28.2	35.78	58.65

TABLE III. Means, heritability (h2), phenotypic (PCV) and genetic (GCV) coefficient of variation and genetic advance over mean for Brix% and Juice volume in M2 generation

Treatments	Brix %					Juice Volume (ml)				
	Mean	h2 (%)	GCV (%)	PCV (%)	GAM (% of mean)	Mean	h2 (%)	GCV (%)	PCV (%)	GAM (% of mean)
Control	21.67	36.47	4.35	7.21	6.94	85.0	76.57	16.75	19.14	38.69
100 Gy	21.33	55.61	7.23	9.7	14.24	97.0	82.69	16.68	18.34	40.04
200 Gy	22.6	58.06	4.53	5.95	9.11	93.0	92.04	26.61	27.73	67.4
300 Gy	20.48	68.87	12.21	14.72	26.76	102.0	93.0	24.75	25.66	63.01
400 Gy	21.57	59.4	4.6	6.0	9.37	87.0	91.81	26.40	27.55	66.79
500 Gy	22.40	68.93	6.2	7.47	13.59	75.0	87.59	21.80	23.29	53.87
600 Gy	22.63	73.85	4.38	5.1	9.94	62.0	84.95	23.23	26.52	59.49
700 Gy	19.67	41.37	8.1	12.6	13.76	81.0	81.37	17.78	19.71	42.35
800 Gy	19.67	38.97	6.4	10.25	10.54	70.0	73.81	18.62	21.7	41.87

TABLE IV. Means, heritability (h2), phenotypic (PCV) and genetic (GCV) coefficient of variation, and genetic advance over mean for Panicle length and panicle width in M2 generation

Treatments	Panicle Length (cm)					Panicle Width (cm)				
	Mean	h2 (%)	GCV (%)	PCV (%)	GAM (% of mean)	Mean	h2 (%)	GCV (%)	PCV (%)	GAM (% of mean)
Control	24.68	11.45	5.47	16.2	4.89	14.5	31.35	13.74	23.98	19.86
100 Gy	24.7	12.12	5.46	15.69	5.02	15.13	35.81	14.28	23.87	22.56
200 Gy	23.98	19.72	6.59	14.85	7.73	14.74	40.87	10.79	16.88	23.82
300 Gy	24.12	23.9	6.57	13.41	8.45	16.64	39.19	13.73	21.93	22.69
400 Gy	26.7	30.09	9.32	16.99	13.49	14.76	50.25	16.64	23.47	31.13
500 Gy	25.97	22.64	6.29	13.22	7.9	15.82	46.7	13.72	16.54	20.42
600 Gy	23.39	26.7	10.15	19.66	13.86	15.22	31.98	19.85	35.11	29.63
700 Gy	26.64	17.55	9.57	22.84	10.58	13.95	30.6	14.69	26.55	21.45
800 Gy	27.12	10.27	6.02	18.8	5.1	14.21	28.55	10.27	20.02	15.09

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TABLE V. Means, heritability (h2), phenotypic (PCV) and genetic (GCV) coefficient of variation and genetic advance over mean for branches per panicle and seeds per plant in M2 generation

Treatments	Branches per panicle					Seeds per plant				
	Mean	h2 (%)	GCV (%)	PCV (%)	GAM (% of mean)	Mean	h2 (%)	GCV (%)	PCV (%)	GAM (% of mean)
Control	33.27	26.91	6.49	12.76	9.07	862.73	65.54	17,55	21.68	37.51
100 Gy	37.07	51.69	9.81	13.65	18.63	891.6	82.07	19.97	21.84	47.33
200 Gy	34.4	49.39	8.29	12.30	14.75	929.57	76.69	20.51	22.97	46.51
300 Gy	36.06	48.27	6.39	9.2	11.72	932.77	85.52	25.99	28.10	63.45
400 Gy	31.34	56.75	11.40	15.13	22.66	936.5	87.64	25.28	27.0	62.48
500 Gy	38.3	45.72	9.71	14.37	17.34	892.87	80.0	21.9	24.52	51.79
600 Gy	33.48	46.71	6.27	11.32	13.96	894.5	83.89	18.63	18.48	45.04
700 Gy	32.14	29.09	8.2	15.2	11.66	865.47	75.51	18.25	19.7	39.27
800 Gy	30.78	17.57	5.57	13.29	6.16	860.47	72.91	14.06	16.64	31.69

TABLE VI. Means, heritability (h2), phenotypic (PCV) and genetic (GCV) coefficient of variation, and genetic advance over mean for 100 seed weight and seed yield per plant in M2 generation

Treatments	100 seed weight (g)					Seeds yield per plant (g)				
	Mean	h2 (%)	GCV (%)	PCV (%)	GAM (% of mean)	Mean	h2 (%)	GCV (%)	PCV (%)	GAM (% of mean)
Control	2.27	48.53	8.0	11.49	14.72	19.33	77.39	19.58	22.25	45.47
100 Gy	2.35	51.11	9.13	12.76	17.22	21.02	82.21	29.86	32.94	71.48
200 Gy	2.32	64.52	10.56	13.14	22.39	21.61	83.87	32.29	35.25	78.06
300 Gy	2.59	75.79	10.36	11.90	23.81	24.19	91.64	37.2	38.86	94.02
400 Gy	2.53	71.0	10.53	12.50	23.42	23.76	90.67	36.52	38.35	91.8
500 Gy	2.46	63.72	10.91	13.66	22.99	22.08	85.78	33.45	36.12	81.79
600 Gy	2.37	59.22	9.43	12.23	19.22	21.23	87.61	28.55	27.87	70.54
700 Gy	2.19	44.73	8.42	12.59	14.68	19.01	79.07	26.71	30.0	62.7
800 Gy	2.17	37.33	5.54	8.86	8.70	18.69	76.67	20.47	20.47	47.32

IV. CONCLUSION

From the present finding, the treatment with 100Gy had the highest mean value for the number of leaves per plant and stalk weight. The treatment with 200 Gy showed the highest GCV, PCV and GAM for juice volume. The treatment with 300 exhibited high heritability accompanied with high GAM for the traits like plant height, stem width and seed yield per plant. The expression of these traits was due to additive gene effect and selection may be more effected. The treatment with 300 Gy also showed moderate heritability and low GAM was observed for number of leaves per plant, brix % and 100 seed weight. These traits are probably governed by non additive gene action. The treatment with 400Gy had high heritability with high genetic advance for stalk weight and moderate heritability with low GAM for panicle width and branches per panicle. The treatment with 500Gy had the highest GCV and PCV for 100seed weight. The treatment with 600 Gy showed the highest GCV and GAM for panicle length. The treatment with 700 Gy and 800Gy showed the lower heritability, GCV, PCV and GAM than all other treatments in Sorghum (Shweni-15). The highest average genetic variation in M2 generation plants occurred in most of the traits in 300Gy followed by 400Gy. In this study, gamma ray irradiation with the treatment of 300Gy and 400Gy were effectively leads to genetic variation for Sorghum (Shweni15). The induced genetic variability was more important as it can be utilized to improve in Sorghum breeding program through gamma radiation.

V. ACKNOWLEDGMENT

The author would like to thank to the honorable Minister, Ministry of Science and Technology, for allowing her to do this research. Deeply thanks to her parents for their love, understanding, and continuous support. Sincere thanks are to teachers and colleagues from the Department of Biotechnology for their advices.

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