IMPROVING FORAGE PRODUCTION OF ELEPHANT GRASS (*Pennisetum purpureum*) AND SORGHUM (*Sorghum bicolor*) THROUGH INDUCED MUTATION

H. Soeranto[1]

ABSTRACT

Elephant grass and sorghum plants have long been cultivated in the tropics as feed crops. In some areas, sorghum is also cultivated as food crops while its by products are used for feeding. Researches on breeding these plants have been carried out at PAIR-BATAN with the objective to improve their forage production for ruminant feed. Genetic variability of the plants were induced through mutations using gamma irradiation treatments from Cobalt-60 source to the vegetative parts of elephant grass and to the seeds of local sorghum variety *Keris*. The irradiation dose up to 0.5 kgy with the dose rate of about 39 gy/minute was used. The first generations of the treated plant (M1) were grown in the greenhouse. The M2 and M3 plants were planted individually in the experimental stations nearby using completely randomized design. Samples of about 200 plants were chosen randomly for each population in the M2 and M3. The sample plants were cut 20 cm above ground surface at 40 days after planting/sowing. Two weeks later observations were done for the ability of plants to produce new buds or tillers. The stem/leaf ratio and the plant total biomass, measured by its dry weight, were observed 40 days after cutting. Plants having superior attributes for bud (tiller) production, stem/leaf ratio, and biomass production in the M2 were selected and replanted in the M3. Some promising lines were found to have better attributes than the control plants, but they seemingly segregated in the M3. Research on breeding these segregated lines would be continued until they become homozygotes. Feed quality (nutrition values, digestibility, and palatability) will be analysed for the homozygote plants.

Key words: Elephant grass, Sorghum, Induced mutation, Breeding lines

INTRODUCTION

Ruminant feeding is one topic that should be taken into account when talking about tropical animal industry towards the 21st century. Feed demand, especially for forage, will continue to increase as the industry develops. Grass is a kind of forage that most farmers use for feed. Traditional Indonesian farmers have commonly used roadside grass as their ruminant feed. They seem to have problems to grow cultivated grasses such as elephant grass (*Pennisetum purpureum*) in their fertile land since there is a competition with food crops. Meanwhile, land with unfertile or marginal soils is found in abundant especially outside Java and they seem to remain unproductive. It is a great challenge to build animal industry in such unproductive land.

Indonesian plant breeder has so far concentrated their research works mainly on food crops while breeding feed crops especially for grasses has not much done yet. In order to support the development of tropical animal industry towards the 21st century, PAIR-BATAN has started research on breeding feed crops since 1995. The objective is to improve production and quality of the feed crops. One of the breeding program is aimed at improving adaptability of some feed crops in the marginal areas which are much prone to environmental stresses (drought, soil acidity etc.). Elephant grass (*Pennisetum purpureum*) and sorghum (*Sorghum bicolor*) are among crops now being investigated. As ruminant feed, elephant grass and sorghum have good attributes for nutrition values, digestibility, and palatability. These crops can grow normally in unfertile or

[1]Center for Application of Isotopes and Radiation, National Atomic Energy Agency, Jakarta.

other feed crops (Rismunandar, 1986; DEPTAN, 1995; Ibrahim *et al.*, 1996). Besides supporting the animal production, thus, cultivating these crops can help increase productivity of unfertile or marginal land.

In Indonesia sorghum is cultivated mostly by small farmers as food crop (Mudjisihono *et al.*, 1987) while in many countries it has intensively cultivated as ruminant feed given in its fresh form (*green chop*) or in its products of *hay*, *silage*, or *pasture* (House, 1985). Breeding elephant grass and sorghum will be directed firstly to increase their biomass production (through improving agronomic traits) and secondly to increase their quality (nutrition values, digestibility, and palatability). The traits need to be improved in plant breeding program include the ability of plants to produce new buds or tillers after harvesting, the stem/leave ratio, and the plant total biomass production. In this program plant genetic variability was induced by mutation using mutagenic agent (gamma rays) and then followed by successive selection processes. Referring to the success of mutation breeding programs in improving production of some food crops such as rice, soybean, wheat, sorghum, barley etc. (IAEA, 1977 and IAEA, 1984), it is expected that elephant grass and sorghum could also be improved though induced mutations. The hypothesis is that some gene or chromosome mutations are more superior to their origins in controlling agronomic traits, and that superior grass and sorghum (as feed crops) can be resulted from this mutation breeding program.

MATERIAL AND METHOD

Plants being investigated were elephant grass (*Pennisetum purpureum*) and sorghum (*Sorghum bicolor*). Genetic variability of the plants were induced with gamma irradiation treatments generated from Gamma Chamber (recorded activity at the time is equal to 54444.12807 Curie) on the plant materials. For vegetatively propagated plants such as elephant grass, vegetative parts (cutting stem nodes) were commonly used as plant material. Seeds were commonly used as plant material for self-pollinated plants such as sorghum (IAEA, 1977). Gamma irradiation with dose levels up to 0.5 kgy and dose rates of about 39 gy/minute were treated to the plant materials.

Breeding methods for elephant grass followed procedures for vegetatively propagated plants and for sorghum followed those for self-pollinated plants (Allard, 1964 and Kuckuck *et al.*, 1991). The first generation of the treated plant (M1) was planted in the greenhouse. The M2 and M3 plants were planted individually in the experimental stations nearby using completely randomized design. Samples of about 200 plants were chosen randomly for each population in the M2 and M3. The sample plants were cut 20 cm above ground surface at 40 days after planting/sowing. Two weeks later observations were done for the ability of plants to produce new buds. The stem/leaf ratio and the plant total biomass, measured by its dry weight, were observed 40 days after cutting.

All of the data were managed and analysed by the computer program of MSTAT (Bricker, 1989). Plants having superior attributes for bud (tiller) production, stem/leaf ratio, and biomass production in the M2 were selected (selections were done by the MSTAT program) and replanted in the M3 (as clones for elephant grass and as progenies for sorghum). Plant selections on the basis of their superior attributes as feed were continued in the M3 populations. Segregated plants were replanted and selected in the next generations until they become homozygotes. Feed quality (nutrition values, digestibility, and palatability) will be analysed for the homozygotes plants.

RESULT AND DISCUSSION

As a physical mutagen, gamma irradiation treatments on plant materials might result in three types of effects that are of special interest in genetics and plant breeding. These effects could be physiological damage, gene mutations, or chromosome aberrations (IAEA, 1977). Gene and chromosome mutations might be transferred from M1 to the following generations, while what so-called physiological effects are generally restricted to the M1 generation. These physiological effects might be in the forms of plant injury, lethality, sterility, or chimeras.

Figure 1. Visual phenotype variations in the M2 generation after gamma irradiation treatments on elephant grass (*Pennisetum purpureum*)

Based on the above considerations, selecting mutants in most plant breeding program is generally started in the M2 generation where genetic variations are expected to be visible. These expectations seemed to be the truth for phenotypic variations of elephant grass as it is shown in Figure 1. These variations were visually visible for some traits such as plant height, number of buds (tillers), leaf morphology and so on. For both elephant grass and sorghum, observations in the M2 were focussed on number of buds (tillers), stem/leaf ratio, and dry-weight biomass production (Table 1). Plant selections in this generation were based on these traits which had better values than the control plants. The selected plants were then replanted in the M3, and the M3 data for these traits are presented in Table 2.

The M3 data for both elephant grass and sorghum (Table 2) indicated that some of their mutant populations showed significantly different from the control plants with respect to their buds (tillers) production, stem/leaf ratio, and total biomass production. Because these

Table 1. Average number of buds (tillers), stem/leaf ratio, and dry-weight biomass production of elephant grass and sorghum in different M2 population

Gamma irradiation dose (kgy)	Elephant Grass			Sorghum		
	Number of bud/tiller	Stem/leaf ratio	Total biomass (gr)	Number of bud/tiller	Stem/leaf ratio	Total biomass (gr)
0	3.25	1.39	43.09	2.64	1.28	23.65
0.1	4.73	1.45	40.17	2.38	1.16	28.17
0.2	3.30	1.83	51.25	2.64	1.52	22.81
0.3	5.12	1.22	38.80	2.22	1.67	31.65
0.4	4.46	1.57	44.12	2.38	1.23	30.24
0.5	5.03	1.17	40.63	2.63	1.34	27.51

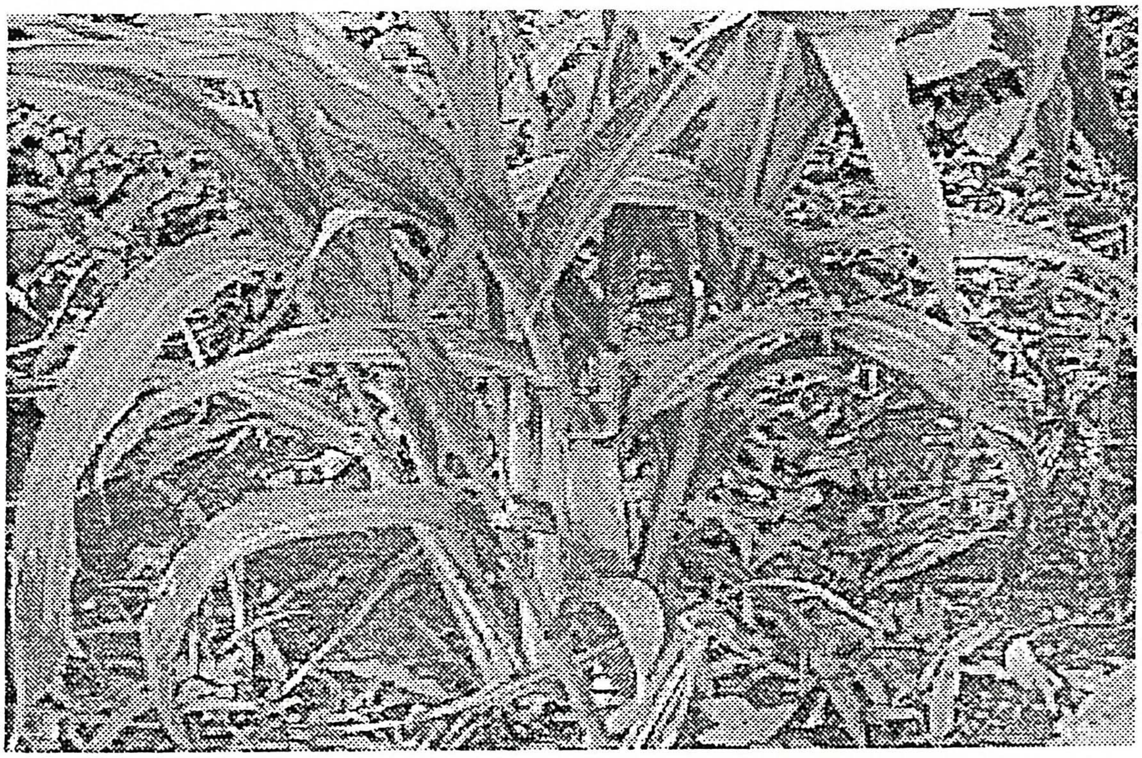

Figure 2. Selected sorghum lines having more buds (tillers) than the control plants.

Figure 3. Selected sorghum lines having better attributes for buds (tillers) capacity, stem/leaf ratio, and total biomass production in the M2 are let to produce seeds for inheritance study in the next generations.

Table 2. Average number of buds (tillers), stem/leaf ratio, and dry-weight biomass production of elephant grass and sorghum in different M3 population derived from selected M2 plants

Gamma irradiation dose (kgy)	Elephant Grass			Sorghum		
	Number of bud/tiller	Stem/lea f ratio	Total biomass (gr)	Number of bud/tiller	Stem/leaf ratio	Total biomass (gr)
0	4.71	1.28	35.01	3.07	0.94	21.04
0.1	7.52	0.71	78.76	3.42	0.49	36.22
0.2	6.39	0.79	70.79	4.16	0.47	48.53
0.3	7.21	0.77	66.01	5.39	0.56	65.40
0.4	7.02	0.91	77.94	4.50	0.73	42.47
0.5	5.06	0.90	54.89	3.11	0.62	24.91
LSD	1.46	0.39	29.32	0.95	0.30	26.18

mutant populations came from the selected M2 plants, thus, the results implied that selections had given significant improvements to the buds (tillers) production, stem/leaf ratio, and total biomass production. The selected sorghum lines with higher buds (tillers) production are visually shown in Figure 2. The selected lines were maintained to produce seeds (Figure 3) which will be replanted in the next generations. Any segregation in the following generations will be recorded as data for studying the inheritance mode of the concerned traits. Research on breeding the segregated lines will be continued until they become homozygotes.

Vegetative propagation was used for reproducing selected M2 clones of the elephant grass in the M3 generation. The phenotypic performance of the buds (tillers) production, stem/leaf ratio, and total biomass production were recorded as data for studying the inheritance mode of these traits i.e, the possible appearance of chimeras or sectoral mutations. Some promising clones were found to have better attributes than the control plants, but they seemingly segregated in the M3. This segregation indicated that chimeras contributed in variation of the M2 plants. Research on breeding these segregated clones will be continued until the homozygotes and homogenous populations are obtained. Feed quality (nutrition values, digestibility, and palatability) for either elephant grass or sorghum will be analysed for the homozygotes plants.

CONCLUSION

Gamma irradiation treatments on plant materials could increase phenotypic variations in the M2 generations for either elephant grass or sorghum. Plant selections in the M2 generation had resulted breeding clones and lines having bud/tiller production, stem/leaf ratio, and total biomass production better than the control plants in the M3 generation. Results of this research accepted the hypothesis that some gene or chromosome mutations (might be due to irradiation treatments) are more superior than their origins in controlling some agronomic traits. Some mutant clones and lines were still segregating in the M3 generation. Research on breeding these segregated clones and lines and their comparative tests would be continued in the next generations until superior grass and sorghum varieties (as feed crops) are finally obtained. These superior varieties of feed crops are badly needed to support the development of tropical animal industry towards the 21st century.

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