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DESIRABLE AND PRODUCTIVE MUTANT IN 296B GENOTYPE OF SORGHUM

Vinod Shripati Pawar

Department of Agricultural Botany (GPB), College of Agriculture, Vasantrao Naik Marathwada Agricultural University, Parbhani-431402. Email: agrilbot@gmail.com

ABSTRACT
A field experiment was conducted at Sorghum Research Station, VNMKV, Parbhani. In the investigation 296B sorghum genotype was selected and treated for physical mutagen gamma rays (Co_{60}) treatment in Nuclear and Agriculture Division, BARC, Trombay, Mumbai at five different concentrations *viz*., 10kR, 20kR, 30kR, 40kR and 50kR. Experiment was laid out in RBD design with three replications. Finding reported that gamma irradiation induced a wide range of morphological mutations. The maximum number of mutants was obtained at 50 kR (42), followed by 10 kR (35), 20 kR (29), 40 kR (27) and 30 kR (26). Total 159 mutants were recorded during investigation at M_2 generation. Reaction to grain mold disease revealed that the treatment 40kR and 50kR were moderately resistance to grain mold disease. Among all M_2 generation, number of mutant plants was recorded for dwarf, early, large panicle, less grain mold score and bold seed character. Early type mutants had significance to escape from terminal moisture stress. The eight dwarf plants were observed in M_2 generation of 296B. Bold seed mutants may have more consumer preference. Yellowish midrib mutants observed in all gamma rays' treatments having juicy stem may tolerant to moisture stress. One bold seeded mutant was observed in 50kR treatment. Single plant found resistant to grain mold in treatment 40 and 50kR treatment.

KEYWORDS: Early, Large Panicle, Bold Seed, Mutant, Less mold score.

1. INTRODUCTION
Sorghum [*Sorghum bicolor* (L.) Moench] is a major staple food and livestock fodder crop grown by more than 300 million people in Africa and Asia. After rice, wheat and maize it is the world's fourth most important cereal. The amount of response to selection depends on the amount of variety, and genetic variability for economic traits is necessary for successful breeding programs. Knowledge of the genetics of yield and its component traits and the relationship of each component trait with yield is important for developing an effective selection strategy in the development of high yielding genotypes.
Mutation breeding is considered as an important force in evolution process. Mutation breeding offers a quicker route to the development of many agricultural species. It is an important tool for generating variation for quantitative inherited characters in different plant species and is considered an alternative approach for increasing genetic variation in plant breeding (Camargo *et al*., 2000). It is often used to correct defects in cultivars with desirable agronomic characteristics (Sigurbjornson, 1977). Among the physical mutagens, such as X-rays, fast neutrons, thermal neutrons, ultraviolet, beta radiation, etc., gamma rays are more important in plant growth and development because of their effects in the form of cytological, physiological and morphological changes in cells and tissues (Thapa, 2004). Gamma radiation is one of the important methods to enhance genetic variation, increase production and enhance the characteristics related to yield.
As kharif sorghum is harvested in the rainy months of September and October, the mold builds up on the grain and makes it unfit for human consumption. Eating of grain contaminated with mold is also harmful to humans, dairy animals and fowl. Mold decreases the germination rate of the affected seeds, which decreases the grain and seed quality. The need for the evolution of grain-mold resistant genotype of *Kharif* sorghum.

2. MATERIAL AND METHODS
In the current investigation, 296B popular variants were selected as the base material. An IS 3922 x Karad local cross is the source of its development. The mid-late maturity male sterile line is involved in the development of a number of potential *Kharif* hybrids, including CSH-9 and CSH-13, as well as Rabi. It has a flowering period of 73 to 75 days.
Physical mutagen *i.e*. Gamma rays Co_{60} (Dose rate 2.39 kR min -1) were used for mutation creation.

2.1 Mutagenic treatment with gamma rays
Uniform, pure dry seeds of *kharif* sorghum variety 296B with a moisture content of about 10 ± 1 per cent were taken for gamma rays (Co_{60}) treatment in Nuclear and Agriculture Division, BARC, Trombay, Mumbai. The check consisted of the same number of untreated seeds of each variety. The seeds of M_1 generation were selected for M_2 generation after exposure to physical mutagen.

2.2 Experimental Details

1	**Experimental Design**		**Randomized Block Design**
2	Name of Genotype		296 B
3	Replication		Three (3)
4	Spacing	Row to row	45cm
		Plant to plant	15cm
5	Plot size		5.85 x 6.0 M
6	Fertilizer dose		80:40:40 NPK Kg/ha.

2.3 Details of treatments

Treatment	Dose of Mutagen Gamma Ray (kR)
T1	10kR
T2	20kR
T3	30kR
T4	40kR
T5	50kR
T6	Wet control
T7	Dry control

The M_1 generation was raised by sowing the treated seeds and two control seeds in a randomized block design at sorghum research station, Parbhani, one control treatment of seed was dry and other was water soaked. The experiment was repeated three times. The M_1 generation was screened for a variety of morphological mutants. Seeds were harvested separately from each M_1 generation. The harvested seeds were used for the experiment of M_2 generation.

3. RESULTS

3.1 Effect of Mutagen on development and stature

3.1.1 Tall mutants: These mutant plants (10kR-7, 20kR-6, 30kR-3, 40kR-1 & 50kR-1) are taller, with long internodes, and a height exceeding 270 cm. Lodging was not observed in any of the tall individuals. Nevertheless, they were 8-10 days behind the controls in 50% of the flowering process.

3.1.2 Semi dwarf mutant: These mutant plants (10kR-1, 20kR-2, 30kR-1, 40kR-1 & 50kR-4) were similar to the progenitor type, with the exception of a height reduction (in the range of 100-130 cm). All of the treatments exhibited these mutants.

3.1.3 Dwarf mutants: These mutants (10kR-1, 20kR-1, 30kR-1, 40kR-1 & 50kR-4) were under 90 cm in height. The internodal length and number of nodes were diminished in the dwarf mutants. All of the treatments exhibited these mutants.

3.1.4 Multiple tillering mutants: These mutants (40kR-1 & 50kR-1) had delicate, glabrous leaves and slim culms, and they were either as tall as the control or shorter. They possessed 2-3 tillers. These mutants maintained their green coloration even after the grains had reached maturity. These mutants were detected during the treatment with 50kR and 40kR gamma radiation.

3.1.5 Thick stem mutants: The stalk was nearly the same diameter as the normal stalk, but it had a reduced height. Compared to the control, these plants were 8-10 days behind schedule and exhibited a large panicle and broad foliage. All treatments exhibited these mutants (10kR-2, 20kR-1, 30kR-1, 40kR-2 & 50kR-2).

3.1.6 Thin stem mutants: These mutants (50kR-2) were distinguished by a reduced stem girth in comparison to controls. The plant height of these was comparable to that of the controls.

3.1.7 Very thin stem mutants: These mutants (10kR-1, 20kR-1, 30kR-2, 40kR-1 & 50kR-2) exhibited a smaller panicle and a stem girth of less than 2.5 cm in comparison to both controls. A portion of these exhibits early flowering. The presence of these mutants was observed in all treatments with gamma radiation.

3.1.8 Long internodes mutants: In all treatments with gamma radiation, plants (10kR-7, 20kR-6, 30kR-3, 40kR-1 & 50kR-1) with long internodes (>25 cm) were observed.

3.1.9 Short internodes mutants: These mutants (10kR-1, 20kR-1, 30kR-1, 40kR-2 & 50kR-1) were distinguished by a reduced height and an intermodal length of less than 12 cm in comparison to both controls. These mutants were observed in all treatments.

3.1.10 Long peduncle mutants: In the 50kR-2 and 40kR-2 treatments, plants were observed to have a longer peduncle than their controls.

3.1.11 Short peduncle length: In comparison to both controls, these mutants (10kR-1, 20kR-1, 30kR-2, 40kR-1 & 50kR-1) exhibited a shorter peduncle length. These were observed in all treatments.
3.1.12 Early mutant: The control plants flowered 7-8 days later than the mutant (40kR-1 & 50kR-2). Some of these variants were identical in height to the control. However, a portion of these mutants exhibited a reduced number of nodes and a reduced height. This mutant was observed in the 40kR and 50kR treatments.
3.1.13 Late mutants: These mutants exhibited delayed flowering and maturity by 12-14 days. In both the 10kR-3 and 20kR-2 treatments, these mutants were observed.

3.2 Effect of Mutation on characteristics of leaves
3.2.1 Broad leaf mutant: These mutants (10kR-1) were distinguished by their leaves having a greater width (> 11 cm) than those of the dry and moist control.
3.2.2 Narrow leaf mutant: These mutants (30kR-2) were identified by their narrow leaf widths (< 6 cm).
3.2.3 Drooping foliage mutant: A mutant with drooping leaves was observed after a 50kR-1 treatment. The blades of full-grown leaves exhibit a typical drooping appearance as they bend downward from the collar.
3.2.4 Yellowish midrib: Mutants with yellowish midribs (10kR-7, 20kR-6, 30kR-3, 40kR-1 & 50kR-1) were observed in all gamma ray treatments. These were observed in all treatments.
3.2.5 White midrib mutants: All gamma ray treatments resulted in the observation of mutants with white midrib (10kR-1, 20kR-2, 30kR-2, 40kR-1 & 50kR-2) to their leaves.

3.3 Mutants of the panicles
3.3.1 Compact panicle: The compact panicles of these mutants (40kR-1) were characterized by a reduced length and densely developed panicle branches.
3.3.2 Loose panicle/earhead: In contrast to the control, these mutants (10kR-1) exhibited sparse panicle branches and a very loose earhead in their compact panicles.
3.3.3 Long panicle/earhead: In comparison to both controls, these mutants (30kR-3) exhibited longer panicles. These were characterized by a reduced panicle breadth and grain.
3.3.4 Small earhead/panicle: Tall plants with small panicles and some dwarf plants with small panicles were observed in (40kR-1 & 50kR-1) all gamma ray treatments.
3.3.5 Large panicle: These mutants exhibited a thicker stalk and a larger dimension in (50kR-1) comparison to the control.
3.3.6 Deformed panicle: In the 30kR-1 treatment, mutants with small, compact deformed panicles were observed.
3.3.7 Conical and pointed shape: Panicle mutant plants (10kR-1, 20kR-1, 30kR-2, 40kR-1 & 50kR-1) were observed in all gamma ray treatments.
3.3.8 Sterile panicle: In the 50kR-1 treatment, a mutant's plant was observed to have a sterile panicle. The two mutants in the 20kR-2 and 40kR-3 gamma ray treatment exhibited incomplete exertion, whereas the control group exhibited complete exertion of the panicle.
3.3.9 Glume mutants: Straw-coloured controls were used to identify mutants (10kR-1 & 30kR-1) that exhibited glumes with black (10kR-1 & 30kR-1) and red colour (50kR-1).

3.4 Effect of Mutation on grain characteristics
3.4.1 Grain size: These mutants were observed to have a small (40kR-1 & 50kR-1) and bold size (50kR-1) when compared to both the dry and moist control.
3.4.2 Grain colour: In the 50kR-1 treatments, these mutants exhibited reddish brown grains.

3.5 Additional mutants
3.5.1 Mutant with awns: These mutants (10kR-2, 20kR-1, 30kR-2, 40kR-1 & 50kR-2) exhibited awns in contrast to their progenitor varieties.
Yellow anther: In the 50kR-1 treatment, a single mutant exhibited a yellow-coloured anther.
3.5.3 Grain mold resistant mutant: The mutant with grain mold resistance was observed in the 40kR-1 and 50kR-1 treatments.

3.6 Grain mold resistant mutant: The mutant with grain mold resistant was noticed in 40kR-1 and 50kR-1 treatment.
These results are in accordance with the reports of Bretaudeau (1997) identified mutants for several characters such as plant height, panicle length, panicle compactness, glume colour, flowering date (Early and late maturity) and tillering capacity. Singh and Balyan (2009) observed morphological mutant with reduced height, awnless ear, amber seed colour and bold seed. Soeranto (2001) noticed some desirable mutants such as high yielding, white colour of seed, big and condense head. Odeje, *et al*. (2016) and Anand, *et al*. (2014) also observed desirable mutant for grain yield.

Table 1: Desirable mutants' frequencies in M_2 generation of Kharif sorghum.

Nature of mutant	10kR	20kR	30kR	40kR	50kR
Mutations for stature and growth.					
Tall	7	6	3	1	1
Semi dwarf	1	2	1	3	4
Dwarf	1	1	1	1	4
Multiple tiller	0	0	0	1	1

Thick stem	2	1	1	2	2
Thin stem	0	0	0	0	2
Very thin stem	1	1	2	1	2
Long internodes	7	6	3	1	1
Short internodes	1	1	1	2	1
Long peduncle	0	0	0	2	2
Short peduncle	1	1	2	1	1
Early	0	0	0	1	2
Late	3	2	0	0	0
Mutation affecting leaf characteristics					
Broad leaf	1	0	0	0	0
Narrow leaf	0	0	2	0	0
Drooping leaves	0	0	0	0	1
Yellowish midrib	4	2	1	3	4
White midrib	1	2	2	1	2
Panicle mutants					
Compact panicle	0	0	0	0	1
Loose panicle/earhead	1	0	0	0	0
Large panicle	0	0	1	0	0
Small earhead / panicle	0	0	0	1	1
Long panicle / earhead	0	0	0	0	1
Deformed panicle	0	0	1	0	0
Conicle and pointed shape	1	1	2	1	1
Sterile panicle	0	0	0	0	1
Incomplete exsertion	0	2	0	3	0
Glume mutants					
Black	1	0	1	0	0
Red	0	0	0	0	1
Grain mutants					
Small	0	0	0	1	1
Bold	0	0	0	0	1
Reddish	0	0	0	0	1
Other mutants					
Awn contains	2	1	2	1	2
Yellow pollen grain	0	0	0	0	1
Grain Mold Resistant	0	0	0	1	1

CONCLUSION

The results showed that gamma irradiation induced a wide range of morphological mutations. The maximum number of mutants was obtained at 50 kR (42), followed by 10 kR (35), 20 kR (29), 40 kR (27) and 30 kR (26). Total 159 mutants were recorded. (98) The most common mutations observed were those involved in growth and height (18 mutants for tall plants and long internodes). Lower doses produced mainly tall, long-internode and late-maturing mutants, while higher doses produced more semi-dwarf, dwarf, early-maturing, leaf, panicle and grain mutants. The treatment with 50 kR induced the most diverse types of mutations including compact sterile panicle, robust and reddish grains, yellow pollen, etc. However, the frequency of mutation was not always proportional to the radiation dose. In general, higher doses of radiation, especially 50 kR, were more effective in producing a wide range of variability. The M_2 progenies of genotype with higher grain yield per plant; larger earhead length, dwarf, early, bold seed, yellowish midrib, higher 100 seed weight, broad leaf mutants, less grain mold and threshed grain mold were scored as desirable.

Dwarf types are important to resist lodging caused due to wind and moisture stress conditions. Early type mutants had significance to escape from terminal moisture stress. The eight dwarf plants were observed in M_2 generation of 296B. Bold seed mutants may have more consumer preference. Yellowish midrib mutants observed in all gamma rays' treatments having juicy stem may tolerant to moisture stress. One bold seeded mutant was observed in 50kR treatment.

Furthermore, useful mutants such as semi-dwarf, dwarf, early-maturing, multiple-tillering, thick-stem and bold-grain types were selected for crop-improvement programme.

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