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Effect of physical and chemical mutagens on seed germination and seedling shoot and root development in grain amaranth [*Amaranthus spp.* (L.)]

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ABSTRACT

An investigation was undertaken to study the effect of physical (Gamma rays) and chemical mutagens (Ethylmethane Sulphonate and Sodium Azide) on germination per cent, shoot length and root length in grain amaranth [*Amaranthus Spp.* (L.)] cultivated varieties of *viz.,* Gujarat amaranth-1, Gujarat amaranth-2 and Suvarna. The seeds were irradiated with different doses (5, 10, 15, 20, 25 kR) of gamma rays, and for chemical mutagens EMS (0.1, 0.2, 0.3, 0.4, 0.5 %) and SA (0.01, 0.02, 0.03, 0.04, 0.05 %) were used at different concentrations level. The biological parameters like germination, shoot and root length were recorded at 4 days after sowing and at 7 days after sowing, respectively. The studies indicated that germination, shoot length and root length were decreased with the increase of all the mutagen treatments except 15 kR gamma rays. LD-50 value not found for GA-1 and GA-2 varieties but found in Suvarna in this study. LD-50 of the gamma rays for germination was found between 20 and 25 kR in Suvarna, for EMS and SA it was found between 0.3 to 0.4 per cent and 0.03 to 0.04, respectively Suvarna has higher sensitivity to mutagens than other two cultivars and EMS is more effective mutagens than other two mutagens.

Key words : Grain amaranth, mutagens, gamma rays, ethylmethane sulphonate, sodium azide, germination, shoot length, root length.

Grain amaranthus have been cultivated since ancient times in several countries of the world and one of oldest food crops in the new world. Among the three pseudocereals (Buck wheat : *Fagopyrum spp.*, Chenopods : *Chenopodium spp.* and Amaranth : *Amaranthus spp.*) grain amaranth is most important. Amaranth is a potential cereal crop belonging to family Amaranthusaceae. The genus Amaranth includes other species of grain type Amaranth viz., *Amaranthus hypochondriacus* L. (2n=32), *A. cruentus* L. (2n=34), *A. caudatus* L. (2n=32 and occasionally 2n=34 also), *A. adulis* Spegazzini (2n=32) and *A. tricolor* (2n=34). The grain amaranth is thought to be of American origin. Grain amaranthus (Amaranthus spp.) is one of the underutilized crop offering lot of potentiality to be explored as future food crop by virtue of its high quality of protein rich grain and carotene rich leaves. The crop is important and widely spread in India. However, it is mainly grown for grain especially in Uttarakhand, Maharashtra and in some parts of Gujarat. Hybridization is difficult in grain amaranth due to small flower structure, so mutation breeding is a better way to create variability. Mutation induced in self-pollinated crops, is of great value in plant breeding and is recognized as a potential tool for crop improvement by way of creating variability in the population (Hagberg *et al.*1963). Mutagenesis is as effective as hybridization in supplying the genetic variability for selection (Virupakashappa *et al.*1980).

MATERIALS AND METHODS

Pure, healthy and mature seeds of the three varieties of Amaranth *viz.*, Gujarat amaranth-1, Gujarat amaranth-2 and Suvarna were exposed to different doses of gamma rays at Bhabha Atomic Research

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Centre (BARC), Trombay with gamma rays intensity of 1.8 kR per minute. The doses were given *viz.*, 0, 5, 10, 15, 20, and 25 kR to all the three varieties. For chemical treatments, the solution of Ethylmethane sulphonate (EMS) 0.1, 0.2, 0.3, 0.4, 0.5 % and sodium azide 0.01, 0.02, 0.03, 0.04, 0.05 % concentration were prepared in phosphate buffer at pH 7.0. About 50 gm dry seeds pre-soaked in distilled water for two hours before they were treated with chemical mutagens for each treatment. Pre-soaked seeds were immersed in freshly prepared solutions of chemical mutagens ie., Ethylmethane sulphonate (EMS) for four hours and sodium azide for six hours at room temperature. Seeds of all the treatments were planted in germination paper. In each germination paper, hundred seeds were placed with three replications under control condition at room temperature. Germination was recorded on fourth day and seedling growth was measured on seventh day after sowing.

RESULTS AND DISCUSSION

Effect of physical and chemical mutagen on seed germination, shoot length and root length are presented in Table 1, 2 and 3. All the three varieties exhibited variation due to mutagenic treatments. Germination percent, shoot and root length decreased with the increase in levels of all the mutagenic treatments except 15 kR gamma rays in GA-1 and GA-2. EMS produced more effect on germination, shoot length and root length than gamma rays and SA. LD-50 value not found in GA-1 and GA-2 at these levels of doses of all three mutagens but in Suvarna (0.5 % EMS and 0.05 % SA) doses/concentrations showed LD-50. Higher germination was found with control in all the varieties. The maximum shoot and root length was reported with 15 kR gamma rays in GA-2 and lowest germination, shoot and root length was found in 0.5 per cent EMS treatment in all the three varieties. LD-50 of gamma rays for germination was found at 20 to 25 kR, for EMS 0.3 to 0.4 per cent and in SA 0.03 to 0.04 per cent levels in Suvarna (Table 1, 2 & 3).

Seed germination is the most important parameter used to detect the response of the crops to mutagenic treatments. Physical and chemical mutagens induce physiological damages, in different biological materials during M_1 generation (Gaul, 1970), the increase doses of mutagens caused a progressive increase in the biological damages in term of reduction in germination, shoot and root length in many crops (Kirtane, 2003, Rao, 1988 and Sharma and Sharma 1986). Similar trend was observed in the present study with respect to germination, shoot and root length.

The severe effect of gamma radiation on germination, shoot and root length observed in the present investigation is in accordance with the results observed by Amir and Khavar (2012) in grain amaranth. They also observed significant reduction in all the three characters with increase dose of gamma radiations. Srivastava *et al.*, (2011) reported the effect of sodium azide on wheat that the increase in doses resulted into decrease in germination, shoot and root length. Datir *et al.*, (2007) observed in his study increase the dose of gamma rays and EMS decrease germination per cent.

Table 1 Effect of Gamma radiation on per cent germination, shoot length (cm) and root length (cm) in grain amaranth.

Treatment/ Cultivar kR	GA-1			GA-2			Suvarna		
	Germination (%)	Shoot length (cm)	Root length (cm)	Germination (%)	Shoot length (cm)	Root length (cm)	Germination (%)	Shoot length (cm)	Root length (cm)
Control	87.33	3.93	4.63	89.33	3.97	4.47	84.67	4.13	4.70
5	84.33	3.90	4.37	88.67	3.77	4.33	78.33	4.10	4.60
10	84.00	3.70	4.40	87.67	3.63	4.23	77.67	3.77	4.60
15	87.00	4.07	4.70	89.33	3.60	4.27	65.67	3.43	4.43
20	80.33	3.60	4.23	85.67	4.07	4.57	57.33	3.27	4.50
25	78.33	3.53	4.20	82.33	3.37	4.10	49.00	2.90	3.97

Table 2 Effect of Ethylmethane sulphonate on per cent germination, shoot length (cm) and root length (cm) in grain amaranth.

Treatment / Cultivar	GA-1			GA-2			Suvarna		
	Germination (%)	Shoot length (cm)	Root length (cm)	Germination (%)	Shoot length (cm)	Root length (cm)	Germination (%)	Shoot length (cm)	Root length (cm)
Control	87.33	3.93	4.63	89.33	3.97	4.47	84.67	4.13	4.70
0.1	83.68	3.83	4.43	82.67	3.37	4.23	75.00	3.73	4.50
0.2	78.33	3.57	4.17	79.67	3.47	4.37	68.00	3.73	4.03
0.3	75.33	3.43	4.27	77.33	3.27	3.97	57.00	2.90	3.97
0.4	71.33	3.60	4.07	74.67	3.40	3.97	45.67	2.70	3.50
0.5	65.67	3.10	3.83	68.67	3.07	3.83	37.00	2.57	3.47

Table 3 Effect of Sodium azide on per cent germination, shoot length (cm) and root length (cm) in grain amaranth.

Tretment / Cultivar	GA-1			GA-2			Suvarna		
	Germination (%)	Shoot length (cm)	Root length (cm)	Germination (%)	Shoot length (cm)	Root length (cm)	Germination (%)	Shoot length (cm)	Root length (cm)
Control	87.33	3.93	4.63	89.33	3.97	4.47	84.67	4.13	4.70
0.01	84.67	3.47	4.43	86.67	3.37	4.27	84.33	3.97	4.63
0.02	81.00	3.47	4.27	84.67	3.43	4.13	77.67	3.53	4.47
0.03	80.00	3.53	4.57	87.33	3.57	4.40	59.33	3.17	4.23
0.04	76.67	3.20	4.07	80.67	3.37	4.13	47.33	2.77	3.80
0.05	74.33	3.37	4.13	78.67	3.20	4.03	43.33	2.77	3.63

The effect of mutagenic treatments on the initiation of germination has been attributed to changes in chromosomal organization (Evans and Sparrow, 1961) and different biochemical and physiological processes (Sparrow and Woodwell, 1962). The lowered respiratory quotient in mutagen treated seeds may be cause for inhibition of seed germination (Woodstock and Justice, 1967). The reduction in germination may be due to the enhanced production of the active free radicals, causing lethality (Selima *et al.*, 1974).

CONCLUSION

The overall studies confirmed that EMS could be more useful for inducing the genetic variability in grain amaranth than other two mutagens *viz.*, gamma rays and sodium azide. The cultivar Suvarna has higher sensitivity to mutagens compared to GA-1 and GA-2. LD-50 of gamma rays for germination was found at 20 to 25 kR, for EMS 0.3 to 0.4 per cent and in SA 0.03 to 0.04 per cent levels in Suvarna, which indicates that below these doses or concentrations are suitable for induce mutations in Suvarna. The LD-50 value in respect of germination was not found at any levels of concentrations or doses for present study for the cultivar GA-1 and GA-2.

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