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REGULAR ARTICLE

Frequency of mutation, lethality and efficiency of ethyl methane sulphonate and sodium azide on foxtail millet (*Setaria italica* [L.] P. Beauv.)

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Abstract

This study was carried out to determine the frequency of lethality, Mutagenic frequency, effectiveness and efficiency induced by ethyl methane sulphonate (EMS) and sodium azide on foxtail millet. The seeds were treated with different concentrations of EMS and sodium azide. Number of morphological mutant were observed visually and recorded. Mutagenic frequency, effectiveness and efficiency were highest for EMS at 0.1% concentration (Mutagenic frequency 7.50% effectiveness 18.75% and efficiency 7.50%) and sodium azide at 0.2% concentration (Mutagenic frequency 7.00%, effectiveness 1.84% and efficiency 1%). Lower concentrations of EMS and sodium azide were more effective and efficient in inducing mutation with low biological damages and high mutation frequency. EMS was more effective and efficient in inducing variability in foxtail millet than sodium azide. Therefore, mutants foxtail millet with low biological damages and high mutation frequency can be developed at low concentration of EMS and sodium azide for breeding of foxtail millet.

Key words: Mutagenic frequency; lethality; mutagenic effectiveness; mutagenic efficiency

Introduction

Cereals are most important food crop in many part of the world. In order to meet the food demand due to the ever increasing human population, suitable cereals to be developed for cultivation, particularly in the semi-arid tropics including the Africa (Curtis and Halford, 2014). Genotypes from domesticated cereals which are indigenous to the semi-arid regions should be improved for high yielding stable varieties (Oladosua et al., 2016).

Foxtail millet (*Setaria italica* [L.] P. Beauv.) is one among the less utilized crop in family of Poaceae (Diao, 2011). This cereal is mainly cultivated in arid parts in Asia, Europe, North America, Australia, and North Africa (Austin, 2006). This plant has relatively high tolerance to drought and extreme conditions of weather and external chemicals or nutrients (Majid *et al.*, 2012; Esson et al., 2017).

Mutation can be defined as a sudden heritable alteration in the structure or sequence of DNA of an organism which is not caused as a result of sagregation and recombination of genes (Harten, 1998). Mutations can be utilized for crop improvement (Adamu and Aliyu, 2007). Induced mutations can rapidly cause quantitative and qualitative variability in inherited traits in crops (Maduli and Mishra, 2007; Ahloowalia and Maluszynski, 2001). In plant research, chemical mutagen such as ethyl methane sulphonate (EMS) and sodium azide can produce single base substitutions with

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different mutation spectra (Sri Devi and Mullainathan, 2011). These chemicals induce many variations in structural traits in plants (Salim *et al.*, 2009). Mutations may be lethal or semi-lethal. Good selection of concentration is prerequisite for successful improvement of certain qualitative and quantitative characters (Kumar *et al.,* 2003)

Mutagenic effectiveness and efficiency are two different properties, which are important in mutation breeding programs (Kumar and Mani, 1997; Singh, 2011; Khan *et al.*, 2005).

Objective of the present investigation was to determine the frequency of lethality, Mutagenic frequency, effectiveness and efficiency induced by ethyl methane sulphonate (EMS) and sodium azide on foxtail millet

Materials and methods

Study area

The research was conducted in the Botanical garden of the Department of Biological Sciences, Ahmadu Bello University, Samaru, Zaria, (Lat 11° 11^{l} N; Long 7°E 38^{l} Altitude 660m above sea level). Samaru lies in the northern guinea savanna agro ecological zone of Nigeria with a mean annual rainfall of about 1011±16.1 mm from 1960 to 2003 (Oluwasemire and Alabi, 2004). Zaria has three distinct seasons; namely the hot dry season from March to May, the warm rainy season from June to September, and the cool dry season from November to February. The average temperature of 27°C where minimum and maximum temperatures recorded are 15.6 and 38.5°C respectively (NCAT, 2008).

Source of materials

Dry seeds (moisture content 10-12%) of foxtail millet were obtained from Institute for Agricultural Research/Faculty of Agriculture, Ahmadu Bello University, Zaria, Kaduna State

Treatment with mutagens

The treatment with chemical mutagens was conducted in the postgraduate laboratory of the Department of Biological Science, Ahmadu Bello University, Zaria. Seeds of foxtail millet were presoaked in distilled water for 4 hours in order to allow rapid and efficient diffusion of mutagens into the seeds. The seeds were soaked for 4hours in different concentrations of the chemical mutagens; Ethyl Methane Sulphonate (0.00%, 0.1%, 0.2%, 0.3% and 0.4%) and Sodium Azide (0.0%, 0.1%, 0.2%, 0.3% and 0.4%). The treated seeds were thereafter washed thoroughly in running tap water to remove the residual effects of mutagens.

Field experiment

Treated and untreated seeds were thereafter taken to the botanical garden of the department of Biological Science, Ahmadu Bello University, Zaria and sown at 40×75cm intra and inter row space on the 15th of July 2015. Each treatment was replicated four times in a Completely Randomized Block Design (CRBD). The experiment was conducted during between July-October 2015.

Data analysis

The effectiveness and efficiency of the mutagens in inducing mutations were estimated by adopting the formula suggested by Konzak *et al.* (1965).

Results and discussions

The result showed that the highest mutation frequency (7.5%) was caused by EMS 0.1mM while at 0.3 mM EMS and sodium azide at 0.1 mM, 0.2 mM, and 0.3 mM had lowest frequency of 2.5% (Fig. 1). Lethality generally increased with increase in concentration of the two mutagens. Lethality was higher in foxtail millet treated with sodium azide with highest lethality 15% at 0.4 mM and lowest lethality was 2.5% at 0.1 mM concentration of sodium azide. While highest lethality for EMS at 0.3 mM and 0.4 mM with 2.5% (Fig. 2). The mutagenic effectiveness was highest in EMS with 18.75% at 0.1 mM and increased with increase in concentration. Similarly, mutagenic effectiveness decreased with increase in concentration of sodium azide with highest 6.25% observed at 0.2 mM and lowest 1.56% observed at 0.4 mM fig. 3. Similarly, Mutagenic efficiency was highest in EMS 7.50% compared to sodium azide. The lowest 1.0% mutagenic efficiency observed EMS was at 0.3mM concentration which was the same as the highest in sodium azide at 0.1mM and 0.2mM Fig. 4. In general, EMS shows higher mutagenic frequency (7.5%), effectiveness (18.75%) and efficiency (7.5%) than sodium azide. While Sodium azide showed higher lethality (15%).

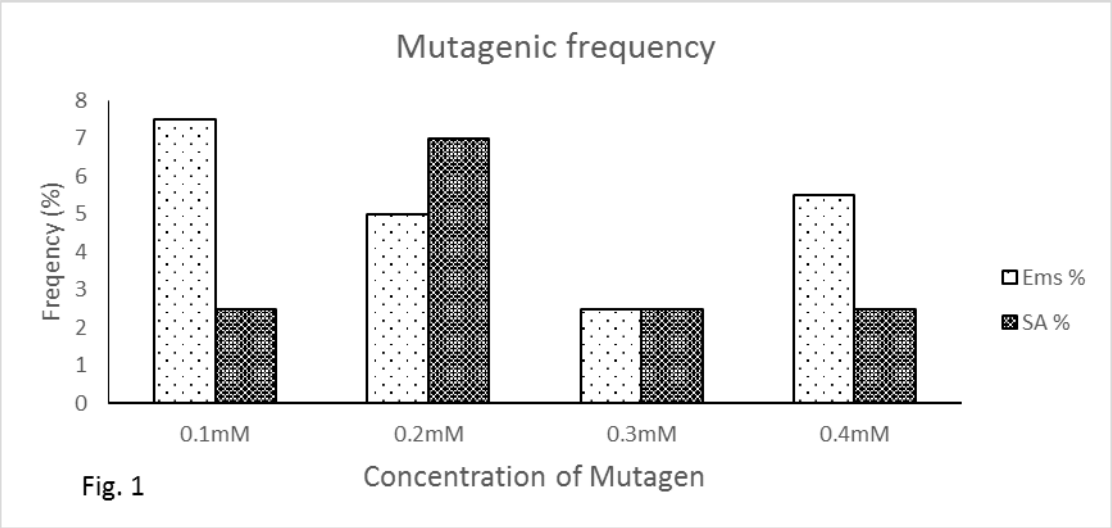

Fig. 1

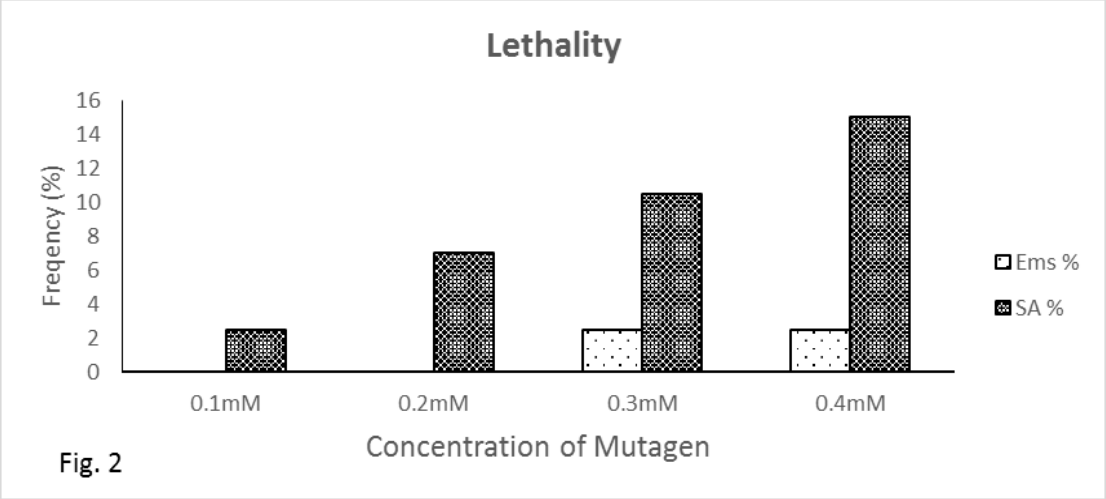

Fig. 2

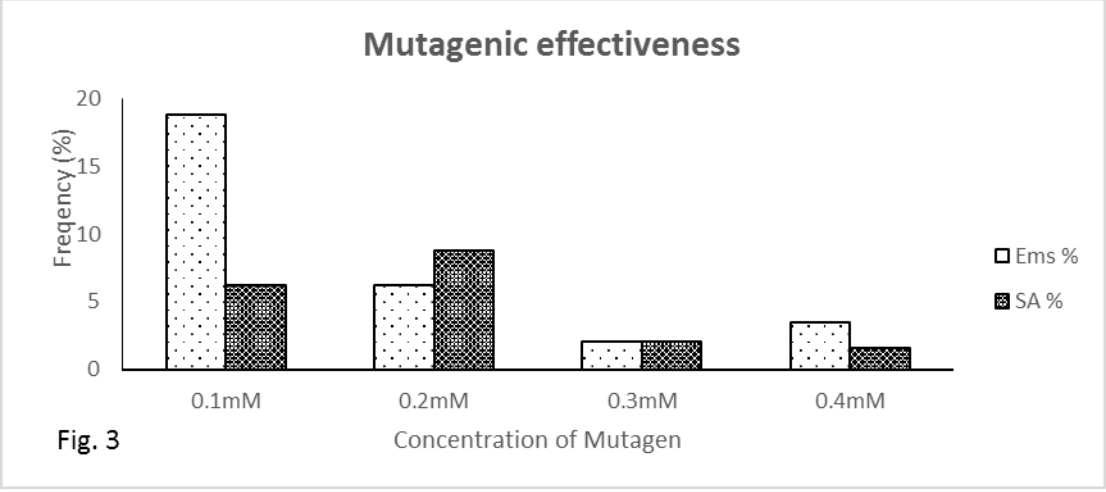

Fig. 3

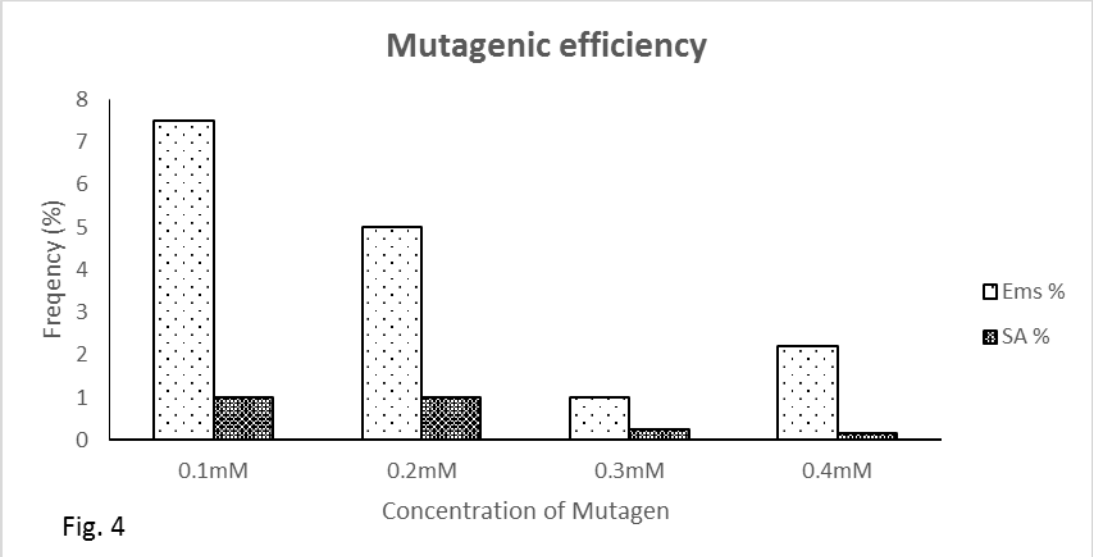

Fig. 4

This study showed varying effectiveness and efficiency with different mutagens. A marked decrease in effectiveness of mutagenesis with the increase in concentration of mutagen in both EMS and sodium azide, probably indicate the negative correlation of effectiveness and dose. In general, lower concentrations (0.1mM for EMS and 0.2mM for Sodium azide) were most effective. This may be due to the failure in proportional increase of mutation frequency induced at higher treatments (Bashir *et al.,* 2013). Similar result was reported in chickpea (Wani, 2009), and sunflower (Kumar and Ratman, 2010). In EMS, mutagenic effectiveness and efficiency were highest (18.75% and 7.50%) at 0.1mM EMS concentration and decreased with increase concentration. Similarly, mutagenic effectiveness and efficiency were highest (8.75% and 1%) at 0.2mM sodium azide concentration and decreased with increase concentration. This corroborated with the results in groundnut (Mensah and Obadoni, 2007) and (Dhanavel *et al.,* 2008) in cowpea.

Generally, EMS proved to be more effective and efficient than Sodium Azide. This may be because ethylating agents, being less toxic, can be applied at relatively higher concentrations to yield more mutations (Bashir *et al.,* 2013). Thilagavathi and Mullainathan (2009) in blackgram and Velu *et al.* (2008) in cluster bean also reported the greater efficiency and effectiveness of EMS.

Conclusion

The results from this study indicated that EMS and sodium azide were most effective and efficient at lower concentrations (EMS esp. 0.1mM, effectiveness 18.75%, efficiency 7.50% and Sodium azide 0.2mM effectiveness 1.84% and efficiency 1%). EMS was more effective and efficient in inducing variability in foxtail millet than sodium azide.

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