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Effect of Chemical Mutagens on Seed Germination and Seedling Traits of Jamun

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ABSTRACT: Jamun is raised through seed and requires proper maintenance until graftable stage. Chemical mutagenesis is an important approach for the improvement of crop plants. The efficiency and effectiveness of chemical mutagens are a prerequisite to assess the effective dose for variability. In the present study, five different concentrations (0.1, 0.2, 0.3, 0.4 and 0.5%) of colchicine, ethyl methane sulphonate (EMS) and sodium azide were used to treat jamun seeds to assess morphological, physiological and biochemical analyses. It was noted that with an increase in dosage of colchicine, EMS and sodium azide germination percentage, survivability and growth traits were decreased. Among the different concentrations of chemical mutagens colchicine @ 0.1 per cent were proportional to early seedling emergence, increased germination percentage, improved plant morphological traits and enhanced leaf biochemical compounds in terms of total phenolic and carbohydrate content. The effectiveness of the three chemicals on jamun is ranked as colchicine; EMS; sodium azide. Jamun seeds treated with colchicine 0.1 % can aid for the propagation of superior quality planting material on commercial basis.

Keywords: Colchicine, germination, jamun, morphological traits, mutagens, seed treatment.

INTRODUCTION

Jamun (*Syzygium cumini* L.) is cheaply available, seasonal and perishable fruit and is considered as an underutilized due to the lack of practice of organized farming (Sehwag and Das 2016). It is an evergreen versatile tree of family Myrtaceae reflecting its adaptation to wide range of edapho-climatic conditions (Mahalakshmi *et al*., 2022). Regarding health benefits various pharmacological researchers have proven it as anantioxidant (Benherlal and Arumugha 2007), antidiabetic (Helmstadte, 2008), hypolipidemic (Ravi *et al*., 2005), hepatoprotective (Das and Sarma 2009), radio protective (Jagetia *et al*., 2005), diuretic (Raza *et al*., 2017). The presence of various essential oils, flavonoids and molecules such as oxalic acid, betulic acid, malic acid, gallic acid, phytosterols, tannins and resins attempts on post-harvest processing of this fruit to squash, jam, juice (Shahnawaz and Sheikh 2011), wine (Chowdhury and Ray 2007) and fruit powder (Sonawane *et al*., 2013). Jamun is mostly propagated through seed. Improved varieties with superior characters contributing towards good quality, early maturity and stress tolerance can be produced through mutations (Mohamed *et al*., 2014). Induction of variability in jamun can be achieved by seed treatment with chemical mutagens having point mutations (Barman *et al*., 2015). Improvement of specific traits for hastening germination, plant biomass and physiological adaptation to biotic and abiotic stress for the production of healthy rootstock and advancement of the grafting time in jamun is a need for the day. Chemical mutagens are more effectual than physical mutagens (Bhat *et al*., 2005). Due to the higher potency, EMS, a compound of the alkaline sulfonate series is most frequently used for chemical mutagenesis in higher plants capable of inducing chemical modification of nucleotides resulting in various point mutations with an aim to improve the productivity, yield and fruit quality of plants and more stress tolerance (McCallum *et al*., 2000). They have been applied in various plants such as banana, cassava, potato and hot pepper for creating polyploidy with an aim to improve the productivity, yield and fruit quality of plants and more stress tolerance (Sattler *et al*., 2016). Colchicine ($C_{22}H_{25}NO_6$) is capable of changing gene expression level, morphological, cytological and histological stages (Murali *et al*., 2013). Sodium azide (NaN_3) is also considered as one of the powerful mutagen in plants to induce mutations to improve their physical and quality parameters has been advocated (Adeoti *et al.,* 2021). However, no accessible information is available on seed treatment with mutagens in jamun. Therefore the effects of chemical mutagens as pre-sowing treatments in jamun seeds was investigated.

MATERIALS AND METHODS

The seeds of jamun were procured from an open-pollinated seedling progeny of 10 years age with medium canopy from the mother block of orchard of Department of Horticulture, Khalsa College Amritsar (31°61′N latitude and 74°92′E longitude). The procured fruits for seed extraction were of 8.76 g average fruit weight, 3.56 cm length and 2.84 cm diameter. The seeds were large with an average weight of 1.38 g. The freshly extracted seeds were wash edthoroughly with running tap water, shade dried and then treated with the chemical mutagens colchicine, ethyl methane sulfonate (EMS) and sodium azide each @ 0.1-0.5% respectively for 12 h prior to sowing. Control seeds were soaked in cold water for the same interval. The seeds were sown during the first week of August in polybags of 10 × 8 cm (300 gauge) with two punch holes for drainage, filled with 760 g of a mix of soils (1:1) filled with two different propagation substrates; i.e., a mixture of soil and sand in the proportion 1:1. The observations on the germination, shoot and root characters were taken at 120 DAS. The germination was calculated after the completion of entire germination by dividing number of seeds germinated by total number of seeds sown expressed in percentage. Polyembryony was calculated from the seeds producing multiple seedlings in relation to the total number of seeds germinated expressed in percentage.Shoot length was measured from the base to growing tip in centimetres with the help of scale. Vigour index-I (cm) was calculated by dividing mean seedling length × germination per cent and vigour II was calculated by multiplying dry weight of seedlings with their corresponding germination percentage (Vasantha *et al.,* 2014). Total carbohydrates were determined using the anthrone method (Yemm and Wills 1954). The amount of total carbohydrates in the leaf sample was determined by comparing with the standard curve prepared by taking a known concentration of D-glucose in the range of 20–100 μg mL^{-1} and expressed as a percentage. Total phenols were estimated using the method of Singleton and Rossi (1965). The root length was measured for five tagged seedlings from the point of initiation of roots to the tip of the root with the help of scale and average length was calculated. The data on germination and growth parameters recorded was subjected to (Randomised Blok Design). The data was analysed with the help of R studio software. Mean values significantly different $p \leq 0.05$ and significant differences between means were compared by Duncan's multiple range test.

RESULTS AND DISCUSSION

Germination. To measure the counteract of the plants to mutagenic treatments seed germination is an important trait (Shah *et al*., 2008). Earliness in germination is an indicative of the active growth in a shorter time. According to data presented in Table 1 colchicine treatment induced earlier germination followed by EMS while delayed germination was noticed in the seeds treated with sodium azide. It was noticed that the quicker seedling emergence (13.03 days) was in the treatment of colchicine 0.1 % while the seedling emergence was delayed in untreated seeds. Also half germination stage and completion of germination was earlier in 18.23 days and 26.62 days in the colchicine 0.1 % while sodium azide treated seeds germinated late commencing 27-31 days with maximum (31.69 days) in sodium azide 0.4 %. Earliest germination with low concentration might be due to its stimulatory effect on seedling emergence and also did not deteriorate the seed viability significantly. With the imbibition, the embryo activation might have initiated the germination. De nova synthesis of hydrolysing enzymes particularly a-amylase converts the starch into simple sugars during the process of germination thus providing energy required for various metabolic and physiological process associated with germination. The seed coat weakens allowing the axis to burst resulting in seedling emergence. Seed germination decreased with the increasing doses of colchicine (Lv *et al.,* 2021). The present findings results are in agreement with the findings of Barman *et al.* (2015) in jamun and Tiwari and Mishra (2012) in *Phlox drummondi* in which they found the stimulatory effects of low dose colchicine treatment which is similar to the present findings. The findings of Chen *et al.* (2018) in cucumber, Adeoti *et al.* (2021) in tomato contradict the present results. The effect of chemical mutagens on germination percentage was studied and results thus obtained are depicted in Table 1. It was noticed that there was a reduction in the germination with treatment of chemical mutagens over control. The untreated seeds germinated at the highest rate (81.89%) as than chemical mutagens treated jamun seeds. Among the treatments it was noticed that the lower dosage of the chemicals increased the germination as compared to the higher ones. The treatment of colchicine affected the germination rate than EMS and sodium azide with the maximum (80.67%) in T_6 (colchicine 0.1%) and least (54.73 %) in sodium azide 0.5 per cent (T_{15}). Depletion in germination of seeds treated with chemical mutagens than control can be due to the effect of mutagens on the meristematic tissues of the seeds (Padavai and Dhanavel 2004.). It might also be due to the damaged cell constituents (Khan *et al.,* 2010).

According to Roychowdhury and Tah (2011) disturbance in the enzyme formation responsible for germination may be one of the physiological effects caused by chemical mutagens leading to the reduction in germination. The present results are in accordance with the findings of Singh and Kole (2005) in mung bean, Essel *et al* (2015) in cowpea and Jabeen and Mirza (2002) in *Capsicumannum*. Barman *et al* (2015) reported the same in jamun.

Polyembryony. Polyembryony is the production of two or more than two embryos from a single seed in plants

(Kashyap *et al*., 2018). According to a research evidence it has already been reported in jamun (Sivasubramaniam and Selvarani 2012). Significant effect of the chemical mutagens was found on the emergence of multiple seedlings in jamun (Table 1). Among the chemical mutagens the highest polyembryony was observed in the colchicine treated seeds than EMS and sodium azide being the maximum (44.59%) recorded in colchicines 0.1 % followed by the untreated seeds with 42.49 % . It reduced with the increasing dosage to 34.81 % in colchicine 0.5 %. EMS reduced the polyembryony to 32.59% in EMS 0.1%with the lowest range of 18-28 % in sodium azide treated seeds. The occurrence of polyembryony might be due to the significant deviation from the normal reproduction process (Barman *et al*., 2015) which might be due to the effect of chemical mutagens resulting in the formation of numerous embryos (Kader *et al*., 2000).

Shoot length. The chemical mutagens showed significant differences ($p \leq 0.05$) in shoot length (Table 2). Progressively decrease was noticed with an increased dosage of the chemical mutagens applied. Colchicine treated seeds (0.1%) produced the longest jamun seedlings (18.24 cm) followed by EMS and sodium azide mutagen (Table 2). The shortest shoots (14.27 cm) were produced from the jamun seeds treated with sodium azide 0.1 %which also showed a reduction (8.42 cm) with the increased dosage of sodium azide 0.5 %. The decrease in shoot length with an increase in mutagenic concentration might be due to an abnormality in chromosome framework (Adamu and Aliya 2007), reduced level of auxins, inhibition of aux in synthesis (Aruna *et al*., 2010), failure of assimilation mechanism and chromosomal damage cum mitotic inhibition (Murali *et al*., 2013). The hampered protein synthesis in the embryonic cells could also have prevented the passage of cell from G1 onwards thereby retarding the shoot emergence (Manjaya and Nandanwar 2007).

Shoot dry weight. Maximum (1.88 g) shoot dry weight was measured in the seeds treated with colchicine 0.1% which decreased to 1.61 g with the increased dosage of colchicine 0.2 % (Table -3). Untreated seeds escalated weighing 1.27g than sodium azide treatments with1.23g in sodium azide 0.1% reducing to 0.46 g with concentration of 0.5 per cent respectively which was the least of all the treatments. The improvement in shoot weight and biomassin colchicine-treated plants can be attributed to an increased cell division and activation of growth hormone auxin (Zaka *et al.,* 2004). Colchicine treatment resulted in shoot and root weight increment (Kumar *et al*., 2019; Barman *et al*., 2015).

Vigour Index. Decreased vigour index with the increasing dosage of the chemical mutagens used was noticed with colchicine to be the superior than EMS and sodium azide (Table 3). The untreated seeds even bagged out than sodium azide. Examination of the data revealed that the highest vigour index-I (1471.36 cm) and vigour index-II (151.92 g) was found in colchicine - 0.1%. On contrary, the lowest (972.22 cm and 84.04 g) at concentration of 0.1 % which reduced to 25.57 g in (sodium azide 0.5%) was calculated in sodium azide 0.1% which reduced to 460.80 cm in sodium azide 0.5%. Vigour index I is mainly calculated from the shoot length and germination percentage. The decrease in shoot length with an increase in mutagenic concentration might have caused variation in the vigour index I of jamun seedlings (Manjaya and Nandanwar 2007). The highest seedling vigour index II depends on the higher metabolic and physiological cell activity, better utilization of assimilates and enzyme activity (Verma *et al*., 2019). Cell activation and quicker seedling emergence in colchicines treated seeds can be attributed to the highest seedling vigour II (Amiri *et al*., 2010).

Number of leaves. Maximum leaves (15.15) were counted in the seedlings raised from the seeds treated with colchicine 0.1 per cent. The untreated seeds were superior to sodium azide treatment with 13.23 leaves per seedling. Minimum leaves in the range of 7-12 were produced in the seedlings raised from the seeds treated with varying concentrations of sodium azide to the tune of 12.08 in (sodium azide 0.1%) which reduced to 7.82 in (sodium azide 0.5%). The increased leaf production due to the lower dose of colchicine might be due to its stimulatory influence on plant morphogenesis. Due to the active division of the cells colchicine enhanced auxin action (Bennici *et al.,* 2006). Proper availability of photosynthates and more protein availability in the genes led to increase in vegetative growth and leaf production (Raufe *et al.,* 2006). The research findings of Barman *et al*. (2015) indicative of more leaves with colchicine in jamun and Essel *et al*. (2015) in cowpea are in agreement with the present results. Rosmaina *et al.* (2021) concluded in their study that colchicine significantly increased the number of leaves in plants.

Total carbohydrate estimation. The photo-assimilate substances in the form of carbohydrates were revealed in the present investigation which are the very important parameters for the explanation of the physiological activity of the treated plants (Table 4). The outcome of the data declared that total carbohydrate content was analyzed to be the highest by 35-39 percent in colchicine treated plants. It was 39.57 per cent in the seeds treated with the concentration of colchicine 0.1 % which reduced to 35.49 per cent with the higher dose (0.5%). Sodium azide treated seeds had lesser amount than untreated plants. Seeds enriched with carbohydrate content with colchicine might be due to increased leaf dimensions with more number of photosynthetic cells per unit area of the leaves (Warner and Gerald 1993). According to Bernard *et al*. (2012) there is correlation of DNA content with the photosynthetic rate per cell. Thus the increase of it in colchicine treated plants is the possible reason for the carbohydrate content (Barman *et al*., 2015).

Total phenol estimation. Phenols are considered as the defense components of the plant genetic framework as they prevent the production of free radicals and save the plants from infection and viral diseases (Shoresh and Harman 2008). The present investigation inTable-4 showed higher (32.76mg/g GAE) phenol content extracted from the leaves of the seedlings whose seeds were treated with colchicine 0.1 %. EMS treated seeds contained phenols in the range of 26- 30 mg/g GAE with 30.96 mg/g GAE the highest phenolic content in the treatment of EMS 0.1% which decreased to 26.71 with mg/g GAE with the application of EMS 0.5 %. The least count of phenols (19.65mg/g GAE) was generated from the highest concentration of sodium azide (0.5%) but the untreated plants contained more phenols (22.38 mg/g GAE) than sodium azide concentrations. According to various research aspects phenols act as a defensive agents which protect the plants from harmful radiations. Plants synthesize them and that forms the screening mechanism in the epidermal layer (Carletti *et al*., 2003). Colchicine mutagen affect the DNA of the cell and also the protein metabolism due to which the metabolic profile gets changed and reactive oxygen species in the colchicine treated plants (Barman *et al*., 2015). Thus, it alters the mechanism of the biosynthesis of several compounds (Bernard *et al*., 2012).

Table 1: Effect of chemical mutagens on germination and polyembrony in jamun.

Treatment	Commencement of germination (days)	Completion of germination (days)	Germination (%)	Polyembryony (%)
T_1 = EMS 0.1%	$14.23^{fg} \pm 2.07$	$26.98^{i} \pm 0.20$	$78.39^{abc} \pm 1.03$	$32.59^{e} \pm 0.47$
T_2 = EMS 0.2%	$15.50^{efg} \pm 3.77$	$28.40^{gh} \pm 0.14$	$77.86^{abc} \pm 4.43$	$25.91^{gh} \pm 0.87$
T_3 = EMS 0.3%	$15.57^{efg} \pm 3.46$	$29.17^{f} \pm 0.06$	$76.11^{cd} \pm 0.03$	$23.18^{ij} \pm 0.26$
T_4 = EMS 0.4%	$17.60^{def} \pm 3.14$	$29.36^{f} \pm 0.15$	$75.35^{cd} \pm 3.07$	$19.82^{kl} \pm 2.05$
T_5 = EMS 0.5%	$19.00^{cde} \pm 1.00$	$30.49^{e} \pm 0.40$	$65.52^{ef} \pm 2.79$	$17.15^{h} \pm 0.51$
T_6 = Colchicine 0.1%	$13.03^{g} \pm 1.87$	$26.62^{i} \pm 1.13$	$80.67^{a} \pm 0.03$	$44.59^{a} \pm 0.62$
T_7 = Colchicine 0.2%	$14.33^{fg} \pm 2.55$	$27.88^{h} \pm 0.10$	$80.48^{ab} \pm 1.52$	$42.25^{b} \pm 0.38$
T_8 = Colchicine 0.3%	$15.35^{efg} \pm 0.12$	$28.32^{gh} \pm 0.95$	$76.27^{bcd} \pm 0.03$	$38.55^{c} \pm 0.18$
T_9 = Colchicine 0.4%	$15.95^{efg} \pm 2.18$	$28.45^{gh} \pm 0.11$	$74.97^{cd} \pm 3.13$	$36.46^{cd} \pm 0.08$
T_{10} = Colchicine 0.5%	$17.63^{def} \pm 4.05$	$28.70^{fg} \pm 0.07$	$73.31^{d} \pm 2.61$	$34.81^{de} \pm 0.24$
T_{11} = Sodium azide 0.1%	$20.45^{cd} \pm 0.11$	$32.28^{d} \pm 0.13$	$68.13^{e} \pm 4.01$	$28.71^{f} \pm 0.09$
T_{12} = Sodium azide 0.2%	$23.00^{bc} \pm 2.00$	$34.15^{c} \pm 0.03$	$62.14^{fg} \pm 3.65$	$27.42^{fg} \pm 0.87$
T_{13} = Sodium azide 0.3%	$25.80^{ab} \pm 0.10$	$34.63^{bc} \pm 0.07$	$59.67^{gh} \pm 3.06$	$24.28^{hi} \pm 0.04$
T_{14} = Sodium azide 0.4%	$26.76^{ab} \pm 0.35$	$35.24^{ab} \pm 0.12$	$56.59^{hi} \pm 2.45$	$21.17^{jk} \pm 2.31$
T_{15} = Sodium azide 0.5%	$29.20^{a} \pm 1.55$	$35.55^{a} \pm 0.35$	$54.73^{i} \pm 4.46$	$18.70^{lm} \pm 1.86$
T_{16} = Control	$18.67^{de} \pm 4.04$	$29.18^{f} \pm 0.025$	$81.89^{a} \pm 1.46$	$42.49^{ab} \pm 1.72$
Mean	**18.88**	**30.34**	**71.38**	**29.88**
CD (p≤0.05)	**4.04**	**0.68**	**4.29**	**2.25**
SE(m).±	**12.85**	**1.33**	**2.1**	**1.1**
	1.98	**0.33**		

Mean values followed by same superscript within a column are significantly at par (p≤0.05)

Table 2: Effect of chemical mutagens on shoot traits in jamun.

Treatment	Shoot length (cm)	Shoot dry weight (g)	Vigour index- I(cm)	Vigour index- II (g)
T_1 = EMS 0.1%	$17.51^{ab} \pm 0.01$	$1.60^{b} \pm 0.13$	$1372.28^{ab} \pm 16.87$	$125.65^{b} \pm 7.8$
T_2 = EMS 0.2%	$16.98^{b} \pm 0.00$	$1.35^{c} \pm 0.15$	$1322.05^{b} \pm 69.39$	$105.79^{c} \pm 16.66$
T_3 = EMS 0.3%	$15.24^{c} \pm 0.03$	$0.83^{ef} \pm 0.04$	$1160.22^{cd} \pm 2.21$	$62.92^{ef} \pm 5.04$
T_4 = EMS 0.4%	$11.75^{e} \pm 0.02$	$0.75^{f} \pm 0.03$	$885.40^{ef} \pm 36.11$	$56.23^{f} \pm 3.8$
T_5 = EMS 0.5%	$10.42^{f} \pm 0.00$	$0.59^{g} \pm 0.16$	$682.68^{gh} \pm 29.02$	$38.85^{g} \pm 26.72$
T_6 = Colchicine 0.1%	$18.24^{a} \pm 0.02$	$1.88^{a} \pm 0.09$	$1471.36^{a} \pm 1.14$	$151.92^{a} \pm 4.85$
T_7 = Colchicine 0.2%	$18.10^{ab} \pm 0.02$	$1.61^{b} \pm 0.04$	$1456.88^{a} \pm 26.43$	$129.33^{b} \pm 4.06$
T_8 = Colchicine 0.3%	$15.27^{c} \pm 0.01$	$1.30^{c} \pm 0.08$	$1164.69^{cd} \pm 1.12$	$99.15^{c} \pm 6.11$
T_9 = Colchicine 0.4%	$14.84^{c} \pm 0.05$	$0.97^{de} \pm 0.04$	$1112.38^{cd} \pm 49.35$	$73.04^{de} \pm 8.05$
T_{10} = Colchicine 0.5%	$14.76^{c} \pm 0.01$	$0.94^{de} \pm 0.08$	$1081.33^{d} \pm 38.89$	$68.94^{ef} \pm 6.96$
T_{11} = Sodium azide0.1%	$14.27^{cd} \pm 0.00$	$1.23^{c} \pm 0.04$	$972.22^{e} \pm 205.53$	$84.04^{d} \pm 13.17$
T_{12} = Sodium azide0.2%	$13.28^{d} \pm 0.03$	$1.01^{d} \pm 0.05$	$825.26^{f} \pm 48.33$	$63.05^{ef} \pm 8.82$
T_{13} = Sodium azide0.3%	$13.12^{d} \pm 0.00$	$0.96^{de} \pm 0.09$	$782.65^{fg} \pm 40.72$	$57.09^{f} \pm 5.16$
T_{14} = Sodium azide 0.4%	$10.81^{ef} \pm 0.03$	$0.57^{g} \pm 0.03$	$611.77^{h} \pm 26.43$	$32.23^{gh} \pm 11.91$
T_{15} = Sodium azide 0.5%	$8.42^{g} \pm 0.01$	$0.46^{g} \pm 0.1$	$460.80^{i} \pm 37.52$	$25.57^{h} \pm 27.55$
T_{16} = Control	$14.55^{c} \pm 2.83$	$1.27^{c} \pm 0.05$	$1191.58^{c} \pm 23.61$	$103.72^{c} \pm 4.08$
Mean	**14.22**	**1.08**	**1034.6**	**79.85**
CD (p≤0.05)	**1.18**	**0.15**	**104.03**	**12.97**
SE(m).±	**0.58**	**0.07**	**50.94**	**6.35**

Values in the same column not followed by the same letter are significantly different at the 5% level of probability

Root length. The root length decreased progressively with increasing doses of all the chemical mutagens under study (Table 3). Out of all the mutagens tried colchicine and EMS had a more pronounced effect on root length. The higher reduction in root length (11.03 cm) was observed in sodium azide 0.5 %. In comparison with sodium azide, chemical mutagens (colchicine and EMS) had a more pronounced effect on root length. Maximum (34.20 cm) root length was measured in (colchicine 0.1%). Mutagenic dosages and the reduction rate of root length exhibited an inverse relationship. It might be due to many factors that may be imputed to a chromosomal abnormality with reduction in height, reduction, auxin levels, inhibition of auxin synthesis, failure of assimilation mechanism and chromosomal damage cum mitotic inhibition. The hampered protein synthesis in the embryonic cells could also prevent the passage of cell from G1 onwards thereby retarding the root emergence Manjaya and Nandanwar (2007). The decrease in root length due to mutagenic treatment observed in the present study was akin to earlier reports of Adamu and Aliya (2007) in tomato, Aruna *et al.* (2010) in brinjal and Murali *et al*. (2013) in sorghum. The effect of chemical mutagens on root diameter exhibited significant variations. It decreased with an increase in the concentration of chemical mutagens. Maximum (3.59 mm) root diameter was measured in colchicine 0.1% as compared to EMS and sodium azide. This might be due to the stimulatory action of colchicine which seemed to be favourable for exploiting the variation resulting from mutation for this quantitative root character (Tiwari and Mishra 2012).

Table 3: Effect of chemical mutagens on total carbohydrates and phenols in jamun.

Treatments	No. of leaves	Total carbohydrate (% equivalent D-glucose)	Total phenols (GA equivalents $100g^{-1}$ fw)	Root length (cm)
T_1= EMS 0.1%	$13.86^{ab} \pm 0.025$	$28.14^{e} \pm 0.19$	$30.96^{c} \pm 1$	$26.70^{b} \pm 1.61$
T_2= EMS 0.2%	$12.59^{bcde} \pm 0.030$	$27.37^{e} \pm 1.03$	$28.45^{e} \pm 5$	$23.56^{c} \pm 1.80$
T_3= EMS 0.3%	$10.81^{cdefg} \pm 0.047$	$26.85^{ef} \pm 0.29$	$28.17^{e} \pm 0.03$	$19.20^{de} \pm 1.18$
T_4= EMS 0.4%	$9.34^{fgh} \pm 0.031$	$25.05^{g} \pm 0.37$	$27.25^{f} \pm 0.04$	$16.90^{efg} \pm 1.25$
T_5= EMS 0.5%	$8.76^{gh} \pm 0.025$	$24.27^{g} \pm 0.47$	$26.71^{g} \pm 0.05$	$12.10^{hi} \pm 0.62$
T_6= Colchicine 0.1%	$15.15^{a} \pm 0.032$	$39.57^{a} \pm 0.70$	$32.76^{a} \pm 0.01$	$34.20^{a} \pm 1.02$
T_7= Colchicine 0.2%	$14.23^{ab} \pm 0.035$	$38.54^{ab} \pm 1.04$	$32.21^{b} \pm 0.05$	$33.70^{a} \pm 1.20$
T_8= Colchicine 0.3%	$12.84^{abcd} \pm 0.021$	$37.60^{bc} \pm 1.10$	$31.19^{c} \pm 1.73$	$23.47^{c} \pm 1.36$
T_9= Colchicine 0.4%	$10.18^{efgh} \pm 0.026$	$36.98^{cd} \pm 1.63$	$30.27^{d} \pm 0.04$	$18.73^{def} \pm 0.80$
T_{10}= Colchicine 0.5%	$9.48^{fgh} \pm 0.035$	$35.49^{d} \pm 1.17$	$30.15^{d} \pm 10$	$14.30^{gh} \pm 1.23$
T_{11}= Sodium azide 0.1%	$12.08^{bcde} \pm 1.13$	$20.40^{h} \pm 1.29$	$22.24^{hi} \pm 2$	$23.10^{c} \pm 1.51$
T_{12}= Sodium azide 0.2%	$11.25^{cdef} \pm 3.99$	$18.79^{i} \pm 0.99$	$21.90^{i} \pm 6.51$	$21.07^{cd} \pm 1.32$
T_{13}= Sodium azide 0.3%	$10.47^{defg} \pm 3.77$	$17.54^{ij} \pm 0.52$	$21.42^{j} \pm 0.03$	$16.27^{fg} \pm 1.35$
T_{14}= Sodium azide o.4%	$8.81^{fgh} \pm 0.56$	$16.61^{jk} \pm 0.68$	$20.23^{k} \pm 3$	$13.36^{hi} \pm 3.36$
T_{15}= Sodium azide 0.5%	$7.82^{h} \pm 0.023$	$15.56^{k} \pm 0.85$	$19.65^{l} \pm 4$	$11.03^{i} \pm 2.05$
T_{16}= Control	$13.23^{abc} \pm 1.98$	$25.41^{fg} \pm 0.97$	$22.38^{h} \pm 2$	$29.20^{b} \pm 1.77$
Mean	**11.31**	**27.13**	**26.62**	**21.06**
CD ($p \leq 0.05$)	**2.45**	**1.54**	**0.47**	**2.72**
SE(m).±	**13.14**	**0.75**	**0.23**	**1.33**

Mean values followed by same superscript within a column are significantly at par ($p \leq 0.05$)

CONCLUSIONS

As an outcome of the research study out of the chemical mutagens used for seed treatment colchicine @ 0.1 % proved to be the best with significant effects on initiation of seed germination, shoot biomass production, shoot length and diameter, leaf production, root length and diameter and leaf biochemical compounds such as phenols and carbohydrates. For raising superior quality planting material seeds of jamun treated with 0.1 % colchicine can produce healthy and vigorous seedlings on commercial basis.

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