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Effect of Ethyl Methane Sulphonate (EMS) on the Agronomic Performance of Two Pigeon Pea (*Cajanus cajan* (L.) Millspaugh) Accessions

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Abstract

Background:*Pigeon pea* (*Cajanus cajan L.* Millspaugh) *is an important legume known for its nutritional value. Pigeon pea is a minor crop, but it plays a key role in the subsistence of smallholders in West African countries such as Nigeria and Ghana. Pigeon pea research in terms of mutational breeding in Nigeria is still at a low level compared to other leguminous crops such as cowpea. Despite the numerous uses and nutritional values of pigeon pea, the plant has received little mutagenic research attention, hence, the need for this study.*

Materials and Methods:*Uniform and healthy seeds of the pigeon pea accessions were selected and pre-soaked in distilled water for 6 hours. The pre-soaked seeds were soaked in freshly prepared EMS concentrations (0.0 %, 0.01 %, 0.02 %, 0.03 % and 0.04 %) for 4 hours. A field experiment was set up in a randomized complete block design (RCBD) with three replications. Growth data were collected at 3, 6, 9 and 12 weeks after planting (WAP). The parameters measured include; plant height, number of leaves, number of primary branches, leaf area, stem girth, days to first flowering, pod length, pod diameter, number of pods per plant, number of seeds per pod 100 seed weight, seed yield per plant and seed yield per hectare.*

Results:*The results obtained showed that the treatments significantly improved the vegetative traits of the pigeon pea accessions in both generations. The result of the analysis of variance indicated that there were significant differences ($P<0.05$) between the means of the treated plants when compared to the control plants. Data obtained from the study showed that treatment 0.04 % EMS enhanced vegetative performances in the Brown colour accession whereas in the Cream accession, 0.03 % EMS induced better performance. The yield performances of the pigeon pea accessions were significantly improved by the mutagen treatments. The result of the analysis of variance showed that the plants treated with 0.03 % and 0.04 % EMS produced better yields when compared to the control plants. However, 0.03 % EMS significantly enhanced the yield performances in both Brown colour and Cream colour accessions.*

Conclusion:*The result of the present study has shown that EMS at 0.03 % and 0.04 % could be used by plant breeders to improve the agronomic performance of pigeon pea. It is therefore recommended that plant breeders employ this mutagen in the breeding program of pigeon pea to create beneficial mutation amidst the ever-increasing human population and food insecurity.*

Keywords: *Mutation; ethyl methane sulphonate; EMS; pigeon pea; accessions; growth; yield.*

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I. Introduction

Pigeon pea (*Cajanus cajan* (L.) Millspaugh) is an erect perennial legume growing in tropical and sub-tropical regions having its origin from the northern region of the Indian sub-continent. Pigeon pea belongs to the family Leguminosae currently known as Fabaceae[1]. The crop is available locally in Nigeria, it is affordable and well cultivated in Edo, Enugu, Kogi and Benue states. The "hard-to-cook" phenomenon and the presence of anti-nutrients have limited its utilization[2]. The foremost producers of pigeon pea in Asia are India, Myanmar and Nepal with India leading in the worldwide production at 2,584,007 tons as of 2014[3]. In Africa, Kenya, Malawi, Uganda, Mozambique and Tanzania are the primary producers of pigeon pea. The crop is regarded as a minor crop in West Africa, but it plays a vital role in the subsistence of smallholders in Nigeria, Ghana and Benin[4]. Pigeon pea ranks sixth in the world in dry-land legume production[3]. The crop constitutes the major component of many people's diet in Asia, Africa and South America[5].

The cultivation of different crop varieties has been successfully achieved over the past five decades due to the advent of induced mutation which plays a vital role in the development of crop varieties with desirable traits all over the world. The widespread use of induced mutants in plant breeding programmes across the globe has led to the official release of 3,222 plant mutant varieties from 170 different plant species in more than 60 countries throughout the world[3]. The developed varieties improve biodiversity and serve as a baseline for conventional plant breeding thus directly contributing to the conservation and use of plant genetic resources. The concept of induced mutagenesis for crop improvement dates to the beginning of the 20th century. During the past 89 years, mutation breeding has been successfully used for the improvement of crops and to support the strides made using traditional methods of plant breeding[6].

Chemical mutagens are known to induce point mutations and single-nucleotide polymorphisms (SNPs) rather than chromosomal mutations which characterize the physical mutagens. Among the chemical mutagens, the most used is the alkylating agent called ethyl methane-sulphonate (EMS). EMS alkylates purines especially guanine causing a thymine base over a cytosine residue opposite to the O-6- ethyl guanine during replication, which results in a point mutation at random[7]. Most of the alterations in EMS-mutated populations are G-C to A-T base pair transitions[8]. Amid the current challenges of food insecurity confronting the developing nations, pigeon pea could play an important role in developing new strategic approaches in agricultural productivity in Nigeria. One possible means of achieving this is through induced mutation which could improve the agronomic traits of the plant, hence the need for this study.

II. Materials And Methods

The present study was carried out at the research farm of Michael Okpara University of Agriculture, Umudike. Umudike lies on latitude 05^{o} 291 N and longitude 07^{o} 331 E in the rainforest area of the South-East agricultural zone of Nigeria. The area covers about 100,000 m^2 and lies about 8 to 10 kilometres East of Umuahia, the Abia State capital. It has a humid tropical climate with marked wet and dry seasons. The rainy season spans eight months (from March to October) and the dry season starts from November to February. The average annual rainfall for Umudike ranges from 1568.4 mm to 2601.3 mm within ten (10) years period. The rainy season has its peaks occurring irregularly between June and October[9]. Two land races of pigeon pea were collected from Nsukka, Enugu State. The seeds were identified at the taxonomic unit of the Department of Plant Science and Biotechnology, Michael Okpara University of Agriculture, Umudike.

Raising of the M_1 and M_2 generations: Uniform healthy seeds of each accession were selected from each of the pigeon pea accessions. A total of 8,000 seeds from the two-pigeon accession were selected into different beakers and pre-soaked in distilled water for 6 hours. Thereafter, the seeds were removed from the water and allowed to air dry for 20 minutes. Glass beakers of 500 ml were selected and properly labelled according to the different treatment levels. Different concentrations (0.00 %, 0.01 %, 0.02 %, 0.03 %, 0.04 % w/v) were freshly prepared in buffer 7 according to the method described by Mba*et al.*[10]. After the preparations, the pre-soaked seeds were soaked into the freshly prepared concentrations for 4 hours with intermittent shaking. After the treatment time, the seeds were removed from the solutions and washed thoroughly in running tap water five times to remove the residual chemicals on the seeds. Sowing was done immediately to grow the M_1 generation. The field experiment was set up in a randomized complete block design (RCBD) with replications. The plot size was 3 m × 2 m with 0.5 m apart with a total of 30 plots. The field size was 10 m ×17 m. The planting distance was 90 cm × 50 cm. Planting was done in May 2019 to raise M_1 generation. The matured plants were harvested in November 2019 and seeds from M_1 plants were stored and sown in the field during May 2020 to raise the M_2 generation. Data obtained from the growth and yield parameters were subjected to analysis of variance (ANOVA) for randomized complete block design (RCBD) using Genstat11[1] discovery edition software. Significant differences observed were obtained at a 5 % level of probability.

III. RESULTS

Effect of different concentrations of EMS on the plant height in the M_1 and M_2 generations: The result of the effect of different concentrations of EMS on the plant height of the pigeon pea accession in the M_1 and M_2 generations is presented in Table 1. In M_1 generation, at 3 WAP, the separation of the mean separation showed that the pigeon accessions differed significantly ($P<0.05$). Treatment and interaction effects were not significantly different ($P>0.05$). Among the treatments, the data obtained showed that 0.04 % EMS recorded maximum plant height (16.7 cm) in the Brown colour accession while 0.02 % EMS recorded the minimum plant height (12.9 cm). Plants under the control condition recorded 14.5 cm height. Similarly, data recorded on the Cream colour accession showed maximum plant height in the control (12.1 cm) followed by treatment 0.01 % EMS (11.3 cm) while treatment 0.04 % recorded minimum height of 8.6 cm. At 6 WAP, plant height ranged from 31.7 cm to 44.3 cm under different treatment levels in the Brown colour accession. Maximum plant height was recorded in 0.03 % EMS (44.3 cm) followed by 0.04 % EMS (40.9 cm). The control plant recorded a minimum plant height of 29.4 cm. Also, data recorded on the Cream colour accession indicated that plants treated with 0.03 % EMS produced the tallest plants (37.9 cm) followed by 0.04 % (36.1 cm). Treatment 0.01 % recorded the minimum height (29.4 cm) while the control recorded 31.0 cm height.

The analysis of variance showed that the treatments differed significantly ($P<0.05$), accession and interaction effects were not significantly different. At 9 WAP, the result obtained in the Brown colour accession data obtained range from 70.7 cm to 114.3 cm in the Brown colour accession. Treatment 0.03 % EMS recorded the highest plant height (114.4 cm) while the control recorded the minimum height (70.8 cm). The result obtained in the Cream colour accession showed that ranged from 96.3 cm to 118.7 cm amongst the treatment levels. Maximum plant height was recorded in treatment 0.03 % EMS (118.7 cm). The control plants recorded the minimum height (96.3 cm). At 12 WAP, the result showed that treatment 0.04 % EMS produced the tallest plants (130.2 cm) in the Brown colour accession. The control recorded the minimum height of 104.6 cm. Data obtained on the Cream colour accession indicated that treatment 0.03 % EMS recorded maximum plant height (137.6 cm) followed by 0.04 % (120.8 cm). Minimum plant height was recorded in the control plants (106.3 cm). The result showed that the mutagen treatment differed significantly ($p\geq0.05$). The pigeon accessions and interaction effect were non-significant ($P>0.05$).

In M_2 generation, at 3 WAP, plant height recorded in the Brown colour accession on the treatment ranged from 14.3 cm to 19.1 cm. The control plants recorded the maximum height (19.2 cm) while 0.04 % EMS recorded the minimum height (14.3 cm). Similarly, in the Cream colour, maximum plant height was recorded in the control plants (15.4 cm). Treatment 0.04 % EMS recorded minimum height (11.0 cm). Treatment and interaction effect were not significantly different ($P>0.05$) while accessions differed significantly ($P<0.05$). At 6 WAP, the result of means separation revealed that the pigeon pea accessions differed significantly ($P<0.05$), treatment effect was very significant ($P<0.05$) while interaction effect was not significantly different. Plant treated with 0.04 % EMS in the Brown colour produced the tallest plants (69.3 cm) followed by 0.03 % EMS (63.3 cm). The minimum plant height was however recorded in the control plants (44.1 cm). In the Cream colour, the maximum plant height was recorded in the control (40.4 cm). The treatment 0.04 % EMS recorded the minimum plant height (23.8 cm). At 9 WAP, the result showed that the pigeon pea accessions, treatment and interaction effects were not significantly different ($P>0.05$). The result however showed that in the brown colour, treatment 0.04 % recorded the maximum plant height (120.4 cm). The control recorded plant height of 98.5 cm while the minimum height was recorded in treatment 0.02 % (96.6 cm). Data obtained in the Cream colour accession showed that maximum plant height was observed in treatment 0.03 % (137.4 cm) while treatment 0.01 % recorded the minimum height (114.4 cm). The control plants recorded a height of 134.9 cm. At 12 WAP, the treatment 0.04 % recorded the maximum plant height (141.4 cm) in the brown colour accession. The control recorded minimum height of 119.0 cm. Similarly, in the Cream colour accessions, treatment 0.03 % EMS recorded the maximum plant height (157.2 cm) while treatment 0.01 % recorded a minimum height of 115.6 cm. The control recorded a height of 143.6 cm (Table 1).

Table 1: Effect of different concentrations of EMS on the plant height during M_1 and M_2 generations.

Accession	Conc.	3WAP		6WAP		9WAP		12WAP	
		M_1	M_2	M_1	M_2	M_1	M_2	M_1	M_2
Brown	0.00	14.5	19.2	29.4	44.1	70.8	98.5	104.6	119.0
	0.01	14.8	19.1	31.7	52.7	70.7	101.6	113.7	120.6
	0.02	12.9	17.1	40.8	53.0	85.8	96.6	121.6	123.6
	0.03	15.6	18.1	44.3	63.3	103.9	112.6	123.5	138.4
	0.04	16.7	14.3	40.9	69.5	114.3	120.4	130.2	141.4
	Total	14.9	17.6	37.4	56.3	89.1	105.9	118.7	128.6
Cream	0.00	12.1	15.4	31.0	40.4	96.3	134.9	106.3	143.6
	0.01	11.3	11.8	29.4	37.9	96.6	111.4	111.0	115.6
	0.02	10.0	12.8	32.1	35.6	106.9	124.3	117.1	135.2
	0.03	11.7	13.3	37.9	35.6	118.7	137.4	137.6	157.2
	0.04	8.6	11.0	36.1	23.8	110.9	102.9	120.8	129.4

Total	10.7	12.69	33.3	34.7	105.9	122.2	118.6	136.2
$LSD_{(0.05)}$Acc.	***	***	NS	***	**	NS	NS	NS
$LSD_{(0.05)}$Con.	NS	NS	**	**	**	NS	***	NS
$LSD_{(0.05)}$Inter.	NS	NS	NS	NS	NS	NS	NS	NS

WAP= Weeks after planting, NS= not significant, **=very significant, ***=highly significant

Effect of different concentrations of EMS on the number of leaves during M_1 and M_2 generations: Table 2 shows the result of the effect of different concentrations of EMS on the number of leaves of the pigeon pea accessions during M_1 and M_2 generations. The result obtained showed that EMS concentrations positively affected the number of leaves of the pigeon peas in both generations. In M_1 generation, at 3 WAP, the result showed that the number of leaves recorded a significant effect on the pigeon pea accessions. Treatment and interaction effects were not significantly different (P>0.05). The result obtained on the Brown colour accession showed a maximum number of leaves under the control (12.3). Among the treatment levels, 0.04 % EMS recorded the highest number of leaves (9.0). Similarly, in the Cream colour accession, treatment 0.03 % EMS recorded the maximum number of leaves (12.7) while the minimum number of leaves was seen in the control plants (10.0). At 6 WAP, data showed that there was no significant difference (P>0.05) between the pigeon pea accessions. Mutagen treatments were significantly different whereas interaction effect was not significantly different. The result obtained in the brown colour showed that maximum number of leaves was counted under treatment 0.04 % EMS (50.0). The control plants recorded the minimum number of leaves (24.3). Also, in the Cream colour accession, treatment 0.03 % EMS had the maximum number of leaves (34.7) whereas the control had the minimum number of leaves (23.3).

Data obtained at 9 WAP revealed that the pigeon pea accessions differed significantly (P<0.05). Mutagen treatment effect was significantly different whereas interaction effect was not significantly different. In the Brown colour accession, plants treated with 0.04 % EMS counted the maximum number of leaves (123.0). The control plants counted minimum number of leaves (44.7). Also, at 12 WAP, the effect of the mutagen concentrations on the number of leaves of the pigeon pea accessions was trendy. Data obtained in the brown colour accession revealed that the maximum number of leaves was recorded in 0.04 % EMS (547.0). The minimum number of leaves was observed under the control plants (273.0). Similarly, the result obtained in the Cream colour accession showed that 0.03 % EMS produced the highest number of leaves (260.0). The control plants had 151.0 numbers of leaves (Table 2).

In the M_2 generation, at 3 WAP, data obtained showed that there was a significant difference between the pigeon pea accessions. Mutagen treatment effect was not significantly different whereas interaction effect differed significantly. The result obtained in the Brown colour accession showed that maximum number of leaves (15.0) was counted under treatment 0.04 % EMS whereas the control plants counted the minimum number of leaves (9.7). In the Cream colour accession, the treatment 0.03 % EMS recorded the highest number of leaves (12.7) whereas the control recorded 10.7 numbers of leaves. The data at 6 WAP showed that the highest number of leaves was observed under the treatment 0.04 % EMS (54.7). The control counted 47.7 numbers of leaves. At 9 WAP, in the Brown colour accession, data showed that the treatment 0.04 % EMS recorded highest number of leaves (117.3) whereas the control plants had 113.3 numbers of leaves. Similarly, in the Cream colour accession, plants treated with 0.03 % EMS recorded the highest number of leaves (124.7) whereas the control had 116.7 numbers of leaves. Data obtained at 12 WAP showed that there was no significant difference between the pigeon pea accessions, mutagen treatment and interaction effect. The result from the Brown colour accession showed that the treatment 0.04 % EMS recorded the maximum number of leaves (730.0). The control plants counted 545.3 numbers of leaves. However, in the Cream colour, treatment 0.03 % EMS recorded 916.0 numbers of leaves whereas the untreated plants had 396.1 numbers of leaves (Table 2).

Table 2: Effect of different concentrations of EMS on the number of leaves during M_1 and M_2 generations

Accession	Conc.	3WAP		6WAP		9WAP		12WAP	
		M_1	M_2	M_1	M_2	M_1	M_2	M_1	M_2
Brown	0.00	12.3	9.7	24.3	44.7	72.0	113.3	273.0	545.3
	0.01	10.0	11.7	29.7	42.3	55.3	107.7	327.0	584.0
	0.02	10.0	13.0	32.7	47.0	60.7	110.7	453.7	626.0
	0.03	9.3	12.7	34.0	54.0	123.0	114.3	469.0	633.0
	0.04	9.0	15.0	50.0	54.7	124.0	117.3	547.0	730.0
	Total	10.1	12.4	34.1	48.5	87.0	112.7	413.9	623.7
Cream	0.00	10.7	12.0	23.3	43.3	44.7	116.7	151.0	396.0
	0.01	10.7	10.7	24.3	35.3	66.0	107.7	184.0	361.3
	0.02	10.7	7.3	27.3	28.7	56.3	119.3	184.0	415.7
	0.03	12.7	7.0	34.7	47.7	84.3	140.0	260.0	916.0
	0.04	12.0	6.3	30.7	36.3	70.0	124.7	232.0	530.0
	Total	11.3	8.7	28.1	38.3	64.3	121.7	228.7	523.8

$LSD_{(0.05)}$Acc.	**	***	NS	NS	**	NS	***	NS
$LSD_{(0.05)}$Conc.	NS	NS	**	NS	**	NS	NS	NS
$LSD_{(0.05)}$ inter.	NS	***	NS	NS	NS	NS	NS	NS

Effect of different concentrations of EMS on the leaf area (cm^2) during M_1 and M_2 generations: Table 3 shows the result of the effect of different concentrations of EMS on the leaf area of pigeon accessions in the M_1 and M_2 generations. The result obtained showed that the mutagen concentrations affected the leaf area of the pigeon pea accessions when compared to the control. In the M_1 generation, data obtained at 3 WAP showed that the pigeon pea accessions differed significantly in the mutagen treatment. The treatment and interaction effects were not significantly different (P>0.05). The data obtained from the Brown colour accession revealed that treatment 0.04 % EMS recorded the maximum leaf area (42.2 cm^2) followed by 0.03 % EMS (39.9 cm^2). The minimum leaf area was recorded under the control condition (24.3 cm^2). Similarly, in the Cream colour accession, maximum leaf area was recorded under treatment 0.01 % EMS (23.8 cm^2) followed by 0.04 % EMS (24.0 cm^2). The control measured 22.6 cm^2 leaf area. At 6 WAP, the result showed that the pigeon pea accessions, mutagen treatment and interaction effects were not significantly different (P>0.05). Maximum leaf area was recorded in 0.04 % EMS (56.5 cm^2) followed by 0.03 % (52.2 cm^2). The minimum leaf area was recorded under the control condition (34.9 cm^2). The result obtained in the Cream colour accession indicated that maximum leaf area was recorded in 0.01 %EMS (47.8 cm^2) followed by 0.04 % (32.7 cm). The control recorded the minimum leaf area (21.9 cm^2). Also, at 9 WAP, data showed that the pigeon pea accessions, and mutagen treatments were significantly different (P<0.05) whereas the interaction effect was not significantly different (P>0.05). Data obtained from the Brown colour accession showed that 0.04 % EMS measured maximum leaf area (127.3 cm^2) whereas the control measured the minimum leaf area (51.0 cm^2). Also, the result obtained from the cream colour accession showed that the leaf area was maximum under treatment 0.03 % EMS (67.6 cm^2) followed by 0.04 % EMS (61.9 cm^2). The control recorded the minimum leaf area (32.9 cm^2). Data obtained at 12 WAP indicated that the pigeon pea accessions, mutagen treatments and interaction effect was not significantly different (P>0.05). In the Brown colour, treatment 0.04 % EMS measured the maximum leaf area (131.8 cm^2) followed by 0.03 % (103.3 cm^2) whereas the control recorded the minimum leaf area (88.2 cm^2). Similarly, in the Cream colour accession, the result showed that maximum leaf area was measured in treatment 0.03 % EMS (97.5 cm^2) whereas in the control, the minimum leaf area was 78.1 cm^2.

In the M_2 generation, data recorded at 3 WAP showed that there was significant difference (P<0.05) between the pigeon pea accessions. The treatments and interaction effects were not significantly different (P>0.05). Among the treatment levels, the treatment 0.04 % EMS recorded the maximum leaf area (35.0 cm^2) in the Brown colour accession. The control however recorded the minimum leaf area (19.7 cm^2). Also, the result obtained in the Cream colour accession showed that treatment 0.03 % EMS recorded maximum leaf area (20.7 cm^2) whereas treatment 0.01 % recorded the minimum leaf area (9.8 cm^2). The control measured 16.4 cm^2. At 6 WAP and 9 WAP, the mutagen treatment maintained an upward trend as the Brown colour accession had the maximum leaf area as recorded in treatment 0.04 % EMS (Table 3).

Table 3: Effect of different concentrations of EMS on the leaf area (cm^2) during M_1 and M_2 generations.

Accession	Conc.(%	3 WAP		6 WAP		9 WAP		12 WAP	
		M_1	M_2	M_1	M_2	M_1	M_2	M_1	M_2
Brown	0.00	24.3	19.7	34.9	38.6	51.0	99.1	87.6	112.3
	0.01	27.1	20.1	35.8	42.9	66.4	103.7	88.2	113.2
	0.02	28.8	30.4	49.1	44.8	68.2	108.9	99.8	118.7
	0.03	39.9	31.1	52.2	55.6	87.3	114.9	103.3	126.6
	0.04	42.2	35.0	56.5	64.7	127.3	121.3	131.8	128.8
	Total	32.5	16.0	45.7	49.3	80.0	109.6	101.1	119.9
Cream	0.00	22.6	16.4	21.9	25.9	32.9	52.8	78.1	102.9
	0.01	23.8	9.8	47.8	28.2	60.4	73.1	82.8	105.3
	0.02	22.0	17.0	24.5	26.8	53.1	89.9	81.9	119.9
	0.03	20.0	20.7	29.7	39.3	67.6	101.7	97.5	127.8
	0.04	23.0	16.0	32.7	34.0	61.9	96.0	91.7	125.1
	Total	22.3	27.3	31.3	30.9	55.2	82.7	86.4	116.2
$LSD_{(0.05)}$Acc.		**	***	NS	***	**	**	NS	**
$LSD_{(0.05)}$Conc		NS	NS	NS	**	**	NS	NS	NS
$LSD_{(0.05)}$inter.		NS	NS	NS	NS	NS	NS	NS	NS

Effect of different concentrations of EMS on the number of primary branches during M_1 and M_2 generations: Table 4 presents the result of the effect of different concentrations of EMS on the number of branches in M_1 and M_2 generations of the pigeon pea accessions. Primary branching was observed from 6 weeks after planting in both pigeon pea accessions. In the M_1 generation, data obtained showed that there was a

significant difference (P<0.05) between the pigeon pea accessions. The mutagen treatments and interaction effects also differed significantly (P<0.05). The result obtained from the Brown colour showed that treatment 0.04 % EMS had the highest number of branches (10.3) whereas the treatment 0.01 % EMS recorded the minimum number of branches (7.0). Also, in the Cream colour, 0.032 % EMS recorded the maximum number of branches (9.0) whereas the control had the minimum (6.3). At 9 WAP, data also showed that the pigeon pea accessions differed significantly (P<0.05). Mutagen treatments differed significantly (P<0.05) whereas interaction effect was not significantly different (P>0.05). The result shows that treatment 0.04 % EMS had the maximum number of branches (17.70) in the Brown colour. The control plants counted 15.0 numbers of branches. Similarly, in the Cream colour, treatment 0.03 % EMS recorded the maximum number of branches (14.8) whereas the control recorded 10.0 numbers of branches. At 12 WAP, data showed that there was no significant difference (P>0.05) between the pigeon pea accessions, mutagen treatments and interaction effects. The result showed that treatment 0.04 % EMS counted the highest number of branches (24.70 in the Brown colour accession. The control however counted 18.3 as the minimum number of branches. Similarly, in the Cream colour, the maximum number of branches (23.0) was observed under treatment 0.03 % EMS. The control plants had the minimum number of branches (16.0).

In the M_2 generation, data obtained at 3 WAP showed that the pigeon pea accessions differed significantly (P<0.05). The mutagen treatments and interaction effects were not significantly different (P>0.05). Result obtained from the Brown colour accession show that the 0.04 % EMS recorded the maximum number of branches (13.7). The control plants recorded 8.7 numbers of branches. Similarly, at 9 WAP, data obtained showed that the pigeon pea accessions differed significantly (P<0.05). Treatment and interaction effects were not significantly different (P>0.05). In the Brown colour, the result showed that treatment 0.04 % EMS recorded the maximum number of branches (18.0) whereas the control recorded minimum number of branches (14.7). However, in the Cream colour accession, treatment 0.03 % EMS recorded maximum number of branches (18.0) whereas the control plants recorded 12.0 numbers of branches. At 12 WAP, data showed that there was no significant difference (P>0.05) between the pigeon pea accessions, mutagen treatments and interaction effects. In the Brown colour, 0.04 % EMS counted maximum number of branches (22.7) the control had 20.3 numbers of branches. Also, in the Cream colour, 0.03 % EMS recorded maximum number of branches (22.7) whereas the control counted 19.0 (Table 4).

Table 4: Effect of different concentrations of EMS on the number of primary branches during M_1 and M_2 generations.

Accession	Conc.	6 WAP		9 WAP		12 WAP	
		M_1	M_2	M_1	M_2	M_1	M_2
Brown	0.00	8.0	11.0	15.0	14.7	18.3	20.3
	0.01	7.0	12.7	10.7	16.3	21.0	21.3
	0.02	8.0	13.7	11.3	16.3	19.3	22.3
	0.03	8.0	12.7	15.0	18.0	21.0	22.7
	0.04	10.3	10.7	17.7	17.3	24.7	21.7
	Total	8.3	12.1	13.9	16.5	20.9	21.7
Cream	0.00	6.3	8.7	10.0	12.0	16.0	19.3
	0.01	7.3	9.0	8.3	14.3	17.3	20.7
	0.02	7.3	8.3	10.3	13.0	20.3	19.0
	0.03	9.0	9.7	11.7	18.0	23.0	22.7
	0.04	8.0	6.7	11.7	13.0	21.0	19.0
	Total	7.6	8.5	10.4	14.1	19.5	20.1
$LSD_{0.05}$Acc.		**	***	***	**	NS	NS
$LSD_{0.05}$ Conc.		***	NS	**	**	NS	NS
$LSD_{0.05}$ inter.		**	NS	NS	*	NS	NS

Effect of different concentrations of EMS on the stem girth of the pigeon pea accessions during M_1 and M_2 generations.

Table 4.8 shows the result of the effect of different concentrations of EMS on the stem girth of the pigeon pea accessions during the M_1 and M_2 generations at different week intervals. In M_1 generation, data obtained at 3 WAP showed that there was no significant difference (P>0.05) between the pigeon pea accessions. Mutagen treatment and interaction effects were also not significantly different. In the Brown colour accession, treatment 0.03 % EMS and 0.04 % EMS measured 0.3cm stem girth whereas 0.01 % EMS and 0.02 % EMS measured 0.2 cm stem girth. The control however measured 0.3 cm stem girth. Similarly, in the Cream colour accession, treatment 0.04 % EMS measured the lowest stem girth (0.2 cm) whereas the control measured 0.3 cm stem girth. Also, at 6 WAP, data obtained showed that there was significant difference (P<0.05) between the pigeon pea accessions, treatment effect also differed significantly whereas interaction effect was not significantly different. The result obtained in the Brown colour accession showed that treatment 0.03 % EMS increased the stem (0.5 cm) compared to the other treatment levels while the control measure 0.4 cm stem girth. Also, in the Cream colour accession, the result showed that treatment 0.03 % EMS measures the highest stem

girth (0.5 cm). The control plants measured 0.4 cm stem girth. At 9 WAP and 12 WAP, the result obtained in the Brown colour accession showed that 0.03 % EMS significantly increased the stem girth (1.8 and 2.0 cm) at both weeks. Similar result was obtained in the Cream colour accession with increased stem girth recorded under treatment 0.03 % EMS (2.0 and 2.2 cm) respectively.

In the M_2 generation, the result obtained at 3 WAP revealed that there was no significant difference ($P>0.05$) between the pigeon pea accessions. Mutagen treatment and interaction effect also did not differ. The result obtained in the Brown colour accession showed that treatment 0.03 % EMS increased the stem girth (0.3 cm) when compared to the other treatments and the control. In the Cream colour accession, 0.03 % EMS also measured the highest stem girth (0.3 cm). At 6 WAP, the result obtained also showed that the pigeon pea accessions differed significantly. Mutagen treatment effect also differed significantly whereas interaction effect was not significantly different. Also, at 9 WAP and 12 WAP, data result showed that there was no significant difference between the pigeon pea accessions ($P>0.05$). Mutagen treatment and interaction effects were not significant different. In the Brown colour accession, the result showed that the plants treated with 0.03 % EMS measured the highest stem girth (2.2 and 2.5 cm) respectively. Similarly, in the Cream colour accession, treatment 0.03 % EMS also measured the highest stem girth (2.1 and 2.4 cm) respectively when compared to the other treatment levels and the control (Table 4).

Table 4: Effect of different concentrations of EMS on the stem girth (cm) during M_1 and M_2 generations.

Accession	Conc. (%)	3WAP		6WAP		9WAP		12WAP	
		M_1	M_2	M_1	M_2	M_1	M_2	M_1	M_2
Brown	0.00	0.3	0.2	0.4	0.5	1.1	1.6	1.3	2.0
	0.01	0.2	0.2	0.3	0.5	1.6	1.9	1.8	2.2
	0.02	0.2	0.2	0.4	0.5	1.4	2.0	1.9	2.3
	0.03	0.3	0.3	0.5	0.4	1.8	2.2	2.0	2.5
	0.04	0.3	0.2	0.4	0.5	1.1	1.9	1.5	2.2
	Total	0.3	0.2	0.4	0.5	1.4	1.9	1.7	2.3
Cream	0.00	0.3	0.2	0.4	0.4	1.2	1.3	1.5	1.8
	0.01	0.3	0.2	0.4	0.4	1.1	1.3	1.8	1.8
	0.02	0.3	0.2	0.4	0.4	1.6	1.8	1.8	2.2
	0.03	0.3	0.3	0.5	0.5	2.0	2.1	2.2	2.4
	0.04	0.2	0.2	0.4	0.4	1.7	1.6	1.8	2.0
	Total	0.3	0.2	0.4	0.4	1.5	1.6	1.8	2.0
$LSD_{(0.05)}$Acc.		NS	NS	**	**	NS	NS	NS	NS
$LSD_{(0.05)}$Conc.		NS	NS	**	**	NS	NS	***	NS
$LSD_{(0.05)}$inter.		NS	NS	NS	NS	NS	NS	NS	NS

Effect of different concentrations of EMS on days to first flowering in the pigeon pea accessions during M_1 and M_2 generations: Table 5 presents the result of the effect of different concentrations of EMS on days to first flowering in the pigeon pea accessions during the M_1 and M_2 generations. The result obtained on the pigeon pea accessions in both generations revealed that the mutagen treatment enhanced early flowering when compared to the control plants. Observations revealed that the lower concentrations of the mutagen induced early flowering in the pigeon pea accessions during the M_1 and M_2 generations. A trend was observed in flowering time as increase in the concentration of the mutagen caused a gradual delay in flowering time of the plants. Data obtained in the M_1 generation showed that days to first flowering among the pigeon pea accessions were highly significantly ($P\leq0.01$). Mutagen treatment and interaction effects showed highly significant difference. The result obtained in the Brown colour accession showed that early flowering was induced by treatment 0.01 % EMS (109.3) followed by 0.02 % EMS (115.0) the control plants flowered under 120.7 days. Similarly, in the Cream colour accession, the result followed the same trend. The result also showed that plants treated with 0.01 % EMS flowered earlier than the other treatment levels (103.3 days). The control plants flowered in 111.3 days.

In the M_2 generation, data showed that there was a highly significant difference between the pigeon pea accessions. Mutagen treatments and interaction effects showed a highly significant difference. The result obtained in the Brown colour accession revealed that treatment 0.01 % EMS induced early flowering (111.3 days) among the other treatment levels. However, the control plants flowered under 117.7 days. Also, in the Cream colour accession, the result showed that the plants treated with 0.01 % EMS flowered first (100.7 days). The control plants however flowered in 111.7 days (Table 5).

Table 5: Effect of different concentrations of EMS on days to first flowering in the pigeon pea accessions

Accession	Conc. (%)	M_1	M_2
Brown	0.00	120.7	117.7
	0.01	109.3	106.3
	0.02	115.0	111.3
	0.03	118.7	115.0
	0.04	123.0	118.7

	Total	117.3	113.8
Cream	0.00	111.3	111.7
	0.01	103.3	100.7
	0.02	106.3	102.7
	0.03	108.7	105.0
	0.04	110.0	108.7
	Total	107.9	105.7
$LSD_{(0.05)}$Acc.		***	***
$LSD_{(0.05)}$Conc.		***	***
$LSD_{(0.05)}$inter.		***	**

** =very significant, ***=highly significant

Effect of different concentrations of EMS on the yield parameters of the two pigeon pea accessions during M_1 and M_2 generations; Table 6 and 7 show the result of the effect of different concentrations of EMS on yield parameters of the pigeon pea accessions during M_1 and M_2 generations. The result recorded on the pod length in the M_1 generation revealed that the pigeon pea accessions were very significantly different (P<0.05). The mutagenic treatments and interaction effects were not significantly different (P>0.05). In the Brown colour accession, treatment 0.01 % EMS significantly increased the pod length (7.0 cm) whereas the other treatment levels measured 6.9 cm pod length respectively. The control measured 6.4 cm pod length. Also, in the Cream colour accessions, treatment 0.03 % EMS increased the pod length with mean value of 6.5 cm. the control plants measured 6.0 cm pod length. In M_2 generation, data revealed that there was no significant difference between the mutagenic treatments and interaction effects whereas the pigeon pea accessions differed significantly. The result obtained in the Brown colour accession showed maximum pod length under treatment 0.01 % EMS (7.6 cm) followed by treatment 0.02 % EMS (7.3 cm). The control plants measured 6.9 cm pod length. Similarly, in the Cream colour accession, treatment 0.03 % EMS and 0.04 % EMS recorded maximum pod length (6.9 cm) whereas the control measured pod length off 6.0 cm (Table 6).

In M_1 generation, data obtained on the number of seeds per pod revealed that the pigeon pea accessions were not significantly different (P>0.05). Mutagen treatment and interaction effect differed significantly (P>0.05). In the Brown colour accession, the number of seeds per pod was counted the same number in both treatment levels and control (5.0) respectively. Similarly, in the Cream colour, treatment 0.03 % counted the highest number of seeds per pod (5.7) followed by other treatment levels (5.0). The control plants counted the least number (4.3). In the M_2 generation, data revealed that the pigeon pea accessions were not significantly different (P<0.05). Treatment effect differed significantly (P>0.05) whereas interaction effects were not significantly different (P<0.05). The result showed that 0.03 % EMS counted the highest number of seeds per pod (5.7) in the Brown colour whereas, the control counted the least number (5.0). Also, in the Cream colour, treatment 0.03 % EMS counted the highest number of seeds per pod (6.0). The control had the least (5.0).

Observations on the number of pods per plant in the M_1 generation showed that the pigeon pea accessions differed very significantly (P>0.05). Treatment effect and interaction effects also differed significantly (P>0.05). The result obtained from the Brown colour showed that maximum number of pods per plant was recorded under treatment 0.04 % EMS (101.0). The maximum number of pods per plant was counted in control plants (9.07). In the Cream colour, treatment 0.03% EMS counted the maximum number of pods per plant (104.7) whereas, the control counted 48.3. Similarly, in the M_2 generation, the result also showed that the pigeon pea accession differed significantly (P>0.05). Mutagen treatment effect differed significantly (P>0.05) whereas, interaction effect was not significantly different (P<0.05). The result obtained from the Brown colour Pigeon pea showed that the 0.04% EMS recorded the highest number of pods per plant (107.7) whereas, the control plants recorded 93.7. Similarly, in the Cream colour, 0.03 % NaN_3 counted the highest number of pods per plant (108.0). The control plants counted 57.7 (Table 6).

` In the M_1 generation, data obtained from 100 seed weight showed that the pigeon pea accessions were highly significantly different (P>0.05) whereas, interaction effect was significantly different (P>0.05). However, in the Brown colour, plants treated with 0.04% EMS measured the maximum seed weight (12.3 g). Similarly, in the Cream colour, 0.03 % EMS measured maximum weight (10.7 g). In the M_2 generation, data obtained showed a highly significant difference (P>0.05) between the pigeon pea accessions. Mutagen treatments and interaction effects were significantly different (P>0.05). In the Brown colour, the result obtained showed that 0.04% EMS had the maximum seed weight (13.5 g) whereas, the control measured 12.7 g seed weight. In the Cream colour, 0.03% EMS recorded a maximum weight of 10.5g.

Data obtained from seed yield per plant in the M_1 generation revealed that the pigeon pea accessions showed highly significantly difference ($P \leq 0.01$). Mutagen treatments differed significantly whereas, interaction effect was not significantly different (P<0.05). The result obtained in the Brown colour revealed that treatment 0.03 % EMS measured the highest seed yield per plant (578.1 g). Similarly, the result obtained in the cream colour also revealed that 0.03% EMS recorded the highest seed yield per plant (447.2g) whereas the control plants recorded the last seed yielded per plant (413.5g). In the M_2 generation, data recorded showed that there

was a highly significant difference (P≤0.01) between the pigeon pea accessions. Treatment and interaction effects were highly significantly different (P≤0.01). The result obtained in the Brown colour showed that 0.03 % EMS measured maximum seed yield per plants (596.4g). The control measured the minimum seed yield per plant (585.8 g). Similarly, in the cream colour, 0.03 % EMS measured maximum seed yield per plant (478.9 g) whereas the control plants measured minimum seed yield per plant (421.9 g).

The effect of the mutagen on the seed yield per plot was highly significant (P≤0.01) whereas, interaction effect was not significantly different (P>0.05). In the Brown colour accession, the result showed that treatment 0.03 % EMS recorded the highest seed yield per plot (1284.54 g) followed by 0.01 % EMS (1249.44 g). The control plants recorded the least seed yield per plot (1100.27 g). Similarly, in the Cream colour, the result also showed that 0.03% EMS recorded the highest seed yield per plot (993.63 g). The control plants recorded the least (810.77 g). The M_2 generation, data obtained showed that there was highly significant difference between the pigeon pea accessions. Treatment and interaction effects were also highly significant (P≤0.01) in the Brown colour treatment 0.03 % EMS recorded the highest seed yield per plot (1312.12 g). The control plants recorded the least (1178.48 g). Also, in the Cream colour, the result followed the same trend. Treatment 0.03% EMS recorded the highest seed yield (1053.58g) whereas the control recorded 843.72 g seed yield per plot.

Table 4.10 presents the result of the effect of different concentration of EMS on the yield per hectare in M_1 and M_2 generations of the pigeon pea accessions. The result obtained showed that the mutagen treatment increased the yield per hectare during both generations of the pigeon pea accessions. Data obtained in M_1 generation showed that there was highly significant difference between the pigeon pea accessions. Mutagen treatment effect was also highly significantly different (P≤0.01). In the Brown colour, yield per hectare was significantly increased by treatment 0.03 % EMS (2055.29 kg) followed by 0.04 % EMS (1999.11 kg). The control measured 1760.44 kg yield per hectare. Also, in the Cream colour, 0.03 % EMSalso increased the yield per hectare with mean value of 1589.81kg followed by 0.04% EMS (1524.01 kg). The control plants however measured 1297.23 kg yield per hectare. In M_2 generation, data obtained showed that there was highly significant difference (P≤0.01) between the pigeon pea accessions. Treatment and interaction effects were highly significantly different (P<0.05). The result obtained in the Brown colour accession showed that treatment 0.03 % EMS recorded the highest yield per hectare (2099.40 kg) followed by 0.04 % EMS (1930.23 kg). Similarly, in the cream colour, treatment 0.03 % EMS recorded the highest yield per hectare (1685.73 kg) followed by 0.04 % EMS (1412.16 kg).

Table 6:Effect of different concentrations of Ems on the yield of the pigeon pea accessions during M_1 and M_2 generations.

Accession		PL		NSPP		NPPP		100SW		Sy/plt	
	Conc.	M_1	M_2	M_1	M_2	M_1	M_2	M_1	M_2	M_1	M_2
Brown	0.00	6.4	6.9	5.0	5.0	90.7	95.7	11.2	12.9	561.1	589.2
	0.01	7.0	7.6	5.0	5.3	86.7	93.7	11.8	12.7	556.1	585.8
	0.02	6.9	7.3	5.0	5.0	96.3	100.7	11.7	13.2	570.0	589.1
	0.03	6.9	7.0	5.0	5.7	97.3	104.0	10.7	11.7	578.1	596.4
	0.04	6.9	7.2	5.0	5.3	101.0	107.7	12.3	13.5	573.5	594.7
	Total	6.8	7.2	5.0	5.3	94.4	100.3	11.5	12.8	567.8	591.1
Cream	0.00	6.0	6.1	4.3	5.0	48.3	57.7	10.2	11.5	413.5	421.9
	0.01	6.0	6.7	5.0	5.7	60.0	69.7	9.6	11.5	414.8	421.9
	0.02	6.4	6.8	5.0	5.7	67.3	74.3	9.9	11.4	425.2	428.2
	0.03	6.5	6.9	5.7	6.0	104.7	108.0	10.7	11.3	447.2	478.9
	0.04	6.4	6.9	5.0	5.3	94.7	93.0	10.3	10.9	437.2	441.3
	Total	6.3	6.7	5.0	5.5	75.0	80.5	10.1	11.3	427.6	438.4
$LSD_{(0.05)}$Acc.		**	**	NS	NS	**	**	***	***	***	***
$LSD_{(0.05)}$Conc.		NS	NS	**	**	**	**	NS	**	**	***
$LSD_{(0.05)}$inter.		NS	NS	**	NS	**	NS	**	**	NS	***

Table 7:Effect of different concentrations of Ems on the seed yield per plant (g) and yield per hectare (kg) yield of the pigeon pea accessions during M_1 and M_2 generations.

Accession	Conc. (%)	Sy/plot(g)		Yield per hectare (kg)	
		M_1	M_2	M_1	M_2
Brown colour	0.00	1100.27	1178.48	1760.44	1885.57
	0.01	1199.52	1195.11	1919.23	1912.18
	0.02	1240.63	1206.39	1985.01	1930.23
	0.03	1284.54	1312.12	2055.26	2099.40
	0.04	1249.44	1189.44	1999.11	1903.10
	Total	1214.88	1216.31	1943.81	1946.10
Cream colour	0.00	810.77	843.72	1297.23	1349.95
	0.01	894.57	860.59	1431.31	1376.95
	0.02	925.44	876.87	1480.71	1402.99
	0.03	993.63	1053.58	1589.81	1685.73

	0.04	952.50	882.60	1524.01	1412.16
	Total	915.38	903.47	1464.61	1445.56
$LSD_{(0.05)}$Acc.		***	***	***	***
$LSD_{(0.05)}$Conc.		***	***	***	***
$LSD_{(0.05)}$inter.		NS	***	NS	***

IV. Discussion

Effect of different concentrations of EMS on the growth and yield parameters of the pigeon pea accessions during M_1 and M_2 generations: Mutation induction in crop plants using physical or chemical means generally allows plant breeders to screen and select mutants with desirable or improved traits. The result obtained from this study showed that all the vegetative and yield traits were significantly enhanced by the mutagen concentrations when compared to the control plants. The study revealed that plants treated with 0.04 % EMS recorded a better performance as observed in the Brown colour whereas 0.03 % EMS performed better in the Cream colour in the M_1 and M_2 generations.

The result of the study showed that plant height increased gradually at the various stages of development with maximum height recorded in 0.04 % EMS and 0.03 % EMS respectively in the M_1 and M_2 generations. The increase in plant height by the mutagen concentration could be attributed to many factors resulting from increased concentration. The mean increase in plant height might be due to the attraction of their genome integrated by environment signals which probably lead to increased rate of cellular respiration and expansion of their meristematic region. The result of this study is in conformity with the report of Gunasekaran and Pavadai[12], who observed an increase in plant height and other growth variables in M_2 generation of ground seeds treated with different concentrations of EMS and DES. Similarly, observation was made by Animasaun*et al.*[13] on groundnut varieties treated with different concentrations of sodium azide. Breeding for improved plant height for pigeon pea would result improvement in number of leaves and other vegetative traits as evident in this study. Plants with increased number of leaves were induced by 0.04 % and 0.03 % respectively in both pigeon peas during the M_1 and M_2 generations. The increased average leaf area per plant recorded in this study during the M_1 and M_2 generations would be expected to enhance the rate and efficiency of photosynthesis which leads to a marked increase in plant biomass and consequently would be associated with improved productivity[14].

Number of branches per plant was increased by higher concentrations of EMS in the pigeon pea accessions. This increase however showed that EMS at higher concentrations (0.03 % and 0.04 %) induced stimulatory effect on the number of branches per plant. This observation conforms to the report of Chandirakala and Subbaraman[15], who reported higher magnitude of primary branches in pigeon pea. The study also showed that plants treated with higher concentrations of EMS increased the plant stem girth during M_1 and M_2generations.The increase in the morphological characters of the pigeon pea accessions might be due to chromosomal aberrations induced and activation of growth hormones by the mutagen that tends to produce an increase in the morphological traits. However, many researchers have reported a negative effect of mutagens on the vegetative characters of many crop plants. The findings of this study are at variance with the report of Laskar*et al.*[16]. Findings from the study during M_1 and M_2 generations revealed significant difference in most of the traits which indicated the existence of variation in the pigeon pea accessions. This observation is in accordance with the report of Urmila *et al.*[17] on three Sesame genotypes treated with different concentrations of EMS during M_1 and M_2 generations. From the result of this present study, plants in M_2 generation showed better performances than the M_1 plants. This is because selection of mutants can only begin in M_2 generation as the mutant gene mostly are in heterozygous state and requires many generations of selfing to achieve homozygousity.

Yield is an indispensable parameter is mutation breeding because ultimately the plant breeder wants to improve yield along with other beneficial traits. The result obtained from the present study indicated that EMS could be utilized to improve the yield characters of the pigeon pea accessions studied. The study revealed that the effect of the mutagen concentrations on the yield parameters varied among the pigeon pea accessions. Pods with increased lengths were obtained in plants treated with EMS when compared to the control plants during M_1 and M_2 generations. Increase in pod lengths could possibly result to increase in number of seeds per pod which in turn could increase yield per plant. The increase in pod length observed in this study contradicts the finding of Bolbhat*et al.*[18] who posited a decrease in the pod length of horsegram treated with EMS and gamma ray singly and in combination. Observation on the number of seeds per pod revealed that all the treatments showed significant increase which indicates that EMS has promoter effect on seed production in the pigeon peas studied. This effect may be due to an increase in the metabolic status of the seedlings or an increase in the activity of growth promoters' effects on seed production. Number of pods per plant is one of the most vital yield contributing traits which closely and constantly correlated with yield per plant. This attribute is also regarded as a measure of fertility in plants. From the result obtained, it was observed that higher concentrations of EMS (0.03 % and 0.04 %) significantly improved the number of pods per plant in the pigeon pea accessions. This observation conforms to the report of Bolbhat*et al.*[18] in horsegram who reported an increase in number of pods

per plant at 0.2 %, 0.3 % and 0.4 % EMS. The increase in number of pods per plant counted under the treated plants at 0.03 % and 0.04 % EMS showed that the mutagen could enhance physiological and biological processes necessary for pod formation which includes enzymatic activities. Observation on 100-seed weight showed an increase by the higher concentrations of EMS during M_1 and M_2 generations. This result agreed with the report of Hegazi and Hamideldrin[19] in okra seeds treated with different doses of gamma radiation. Similarly, Bolbhat *et al*.[18] also reported an increase in 100-seed weight of horsegram treated with gamma ray and EMS when compared to the control plants in M_1 generation. This observation also conforms to the findings of Aledare[20,] who reported an increase in 100-seed weight of pigeon pea treated with gamma radiation and sodium azide. The result recorded on the seed yield per plant showed that there was an improvement in plants treated with EMS when compared to the control plants in both generations. EMS at 0.03 % induced a significant increase in seed yield per plant in the pigeon pea accessions. The result of this study also showed that the mutagen treatments induced a beneficial effect on seed yield per plot. This increase/effect could be attributed to the stimulatory effect of EMS at higher concentrations. The increase in seed yield per plot observed in the present study agreed with the findings of Bolbhat*et al*.[18] in M_1 generation of horsegram.

V. Conclusion

Crops generated through induced mutation breeding are greatly contributing to the global food production and nutritional security in both developed and developing countries. Therefore, creating genetic diversity is needful for effective plant breeding programs. The results obtained from this study have further proved the potency of EMS in inducing mutation in crops. Observations from the present study showed that the treatments enhanced the vegetative and yield characters of the pigeon pea accessions during M_1 and M_2 generations. Beneficial agronomic traits were recorded in plants treated with 0.03 % EMS and 0.04 % EMS respectively. Hence, for agronomic improvement of the pigeon pea accessions, 0.03 % and 0.04 % EMS are suitable for beneficial mutation inducement.

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