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Mutagenic effect of ethyl methane sulfonate in M2 generation of three genotypes of tomato (*Solanum lycopersicum*)

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Abstract

In this study, three genotypes of tomato (Cobra, Roma vf, and Tropimech) were subjected to induced mutation with ethyl methane sulfonate (EMS). The result in the M2 generation was analyzed and traits assessed showed significant different ($P < 0.05$) among the variants of genotypes of tomato species studied. Cobra and Roma vf genotypes produced lots of mutants of interest. Cobra variant 2 (CV2) had the highest fruit weight of 2.796kg with a total of 36.7 number of harvested fruits per plant. Variant 3 had a fruit weight per plant of 2.178kg and it produced the highest number of harvested fruits per plant of 43. Other relatively performed variants of cobra include, variant 7 with the fruit weight of 1.7131kg and 28.3 number of harvested fruits. Variant 8 recorded a fruit weight per plant of 1.474kg with 30.3 number of harvested fruits. Variants 5 and 4 equally performed well with their fruit weights of 1.254kg and 1.232kg and number of harvested fruits of 29 and 19.7 respectively. In Roma vf, the highest fruit weight per plant of 1.2094kg was recorded by variant 8 with 69 harvested fruits per plant. This variant produced lots of fruits with a creeping growth habit that makes it behave like the indeterminate variety. Variant 2 recorded 1.11613kg with 25.33 of harvested fruits giving an average fruit weight of 44.06g. The M2 generation of Tropimech variety (TV) varied significantly in values recorded for the variants with TV3 recording highest fruit weight per plant of 368.47g.

Keywords: Breeding; Induced mutation; Mutant; Tomato; Variant

1 Introduction

Tomato (*solanum lycopersicon*) is one of the most widely grown vegetable crops in the tropical and sub-tropical regions of the world. This is so basically because of the importance of its fruit which is either used in its fresh form to make soup and stew or processed into paste. The fruits are rich in essential amino acids, vitamins, minerals and lycopene. The antioxidant (Lycopene) found in tomato is responsible for the red colour of the fruit and is very effective for the heart health. Heart diseases like heart attack and stroke are reduced with more intake of lycopene. Lycopene also helps to treat high blood pressure and diabetes. It has been suggested that in terms of heart health, it is more effective to eat tomatoes and tomato products than take lycopene supplements. There is a strong relation between tomato intake and blood concentrations of lycopene (Ganji 1994). Growing tomatoes in Nigeria is faced with a lot of challenges, ranging from lack of improved seeds to challenges of weather, diseases, pests and post-harvest losses due to lack of good storage facilities. Induced mutation in tomato is important for tomato breeding and for crop improvement. Induced mutation breeding is an alternative to traditional method of breeding especially in crops and has been extensively used by researchers to improve crops across nations. Crop improvement through induced mutation for example has resulted in the development and release of about 3222 mutant varieties worldwide, India alone account for over 330 mutant varieties (Rafiul et al., 2016). Induced mutation is aimed at creating variations from the existing genotype and

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subsequently selecting the mutants with beneficial horticultural traits. Traits such as earliness to maturity, fruit yield, fruit size, fruit colour and quality, adaptation to some biotic and abiotic stresses are the attributes of interest.

Mutation increases biodiversity and aids plant breeders by creating variants that do not occur in nature. This is achieved by the use of either physical irradiation or with use of chemical alkylating agents, nitrous acid, base analogs etc. With the continuous decline in genetic diversity, mutation breeding has become more popular and inevitable. Also with the obvious risk posed by global climate change to crop yield and the ever increasing demand for food and other agricultural products, crop improvement techniques must be more precise in developing improved crop varieties. Mutation breeding however has been proven to be a successful tool used by breeders. Induced mutation has been used to enhance yield, better nutritional quality and wider adaptability of most important crops such as wheat, rice, pulses, millets and oil seeds worldwide (Raina et al., 2016). Foliage diseases are rampant at high temperature and high relative humidity and often increase losses in terms of yield (Uguru and Igili, 2002). But induced mutation has proved to produce plants that can resist some diseases attacking tomato (Yudhvir,1995). Induced mutation can rapidly create variability in quantitatively and qualitatively inherited traits in crop (Bhat et al., 2006; Raina, et al., 2018*).* The objective of this study therefore, is to develop mutants that will be high yielding and tolerant to biotic and abiotic stress in the M2 generation which when recommended to the farmers would help to solve the problem of tomato scarcity occasioned by low yield.

2 Material and methods

2.1 Plant Materials

Three varieties of tomato used in this experiment are, Cobra, Roma vf and Tropimech

2.2 Experimental materials

Mutagenic agent used was ethyl methane sulfonate (EMS)

Non chemicals include petri-dishes, filter papers, masking tape, beakers, syringe, sieve, used water sachets for the nursery, compost manure, phyto-feeds, wooden stakes, and ropes.

2.3 Experimental procedure

A stock solution of EMS was prepared using distilled water. The stock solution was then used to prepare, 0.01%, 0.1%, 0.25% and 0.5% EMS solutions using 0.1 M phosphate buffer (pH7.2). These concentrations of ethyl methane sulfonate (EMS), (0.01%, 0.1%, 0.25% and 0.5%) was used to induce mutation on the three tomato varieties.

2.3.1 Experiment 1

Field evaluation of M0 plants of three varieties of tomato soaked in ethyl methane sulfonate

Soaking of the seeds in the mutagen

One hundred seeds each of the three varieties were soaked in water and in 0, 0.01, 0.1, 0.25 and 0.5% concentrations of ethyl methane sulfonate (EMS) for 3hrs, 6 hrs and 12 hrs respectively. At the end of each duration of soaking the seeds were washed five times with distilled water and air dried before planting in the petri dishes. Treated seeds were planted in petri dishes to enhance germination. The sprouted seeds were planted in plastic bags in the nursery. Seedlings were raised in the nursery growth medium of compost in plastic bags. Three seedlings were planted in a bag and later thinned to two per bag. Watering was done when necessary until they mature for transplanting. The seedlings spent three weeks after planting before transplanting them to the field. The experimental field was ploughed, harrowed and ridged. The experiment was laid out in a 3x3x5 factorial in a randomized complete block design (RCBD) with three replications. The factors are; A=3 varieties, B=3 durations of soaking and C= 5 concentrations of EMS. Seedlings were planted at a spacing of 1m between ridges and 0.45m within ridges. Poultry manure was applied evenly to the ridges to enhance the nutrient capacity of the soil. Phyto-feed was applied in a ring form two weeks after transplanting to the plants to boast the nutrients of the soil. Weeding was carried out manually using hoes at a regular interval to ensure a weed free field. Harvesting was done when the fruits were fully ripped, that is when the fruits turn fully red. These fruits were harvested according to treatment and the seeds processed for use in the next experiment.

2.3.2 Experiment 2

Field evaluation of M1 seeds of the three genotypes

100 seeds from plants harvested from each treatment in experiment 1 were presoaked in water and then planted in petri dishes to enhance germination. The experiment was laid in a 3x5 factorial in a randomized complete block design with 3 replications.

Factor A is the duration of soaking (3hrs, 6hrs and 12 hrs.) and Factor B is the concentrations of EMS (0, 0.01, 0.1, 0.25, and 0.5%). The matured fruits were harvested according to treatments. Selection were done based on the desired agronomic traits for further evaluation in the M2. Agronomic traits such as earliness to maturity, fruit yield and quality, fruit size etc. were some of the traits based for the selection. The selected fruits were processed and seeds planted in the next experiment for evaluation as M2 plants.

2.3.3 Experiment 3

Field Evaluation of selected M2 variants of Cobra.

Ten selected variants of cobra were selected based on their performance in the field. The parameter studied include, days to 50% flowering, days to maturity, fruit weight per plant, number of branches, number of fruits harvested, number of flowers per truss, number of fruits per truss, number of truss per plant, number affected by blossom end rot, leaf length, leaf width, number of leaves, number of branched, number of branches at maturity, plant height and plant height at maturity.

2.3.4 Experiment 4

Field evaluation of M2 variants of Roma vf

Eleven selected variants of Roma vf were selected based on their performance in the field. The same parameters studied in experiment 3 were equally studied in this experiment.

2.3.5 Experiment 5

Field evaluation of selected M2 variants of Tropimech

Five selected variants of Tropimech were evaluated in the field and the same experimental procedure as in experiment 3 above was also followed in this experiment. The same parameters were also studied in this experiment.

2.4 Statistical Analysis

The analysis of variance (ANOVA) as outlined in the design was carried out using Genstat software version 12.1 (VSN International Ltd., 2009) to assess the differences in the treatment while treatment means were separated using least significant difference (LSD) as outlined in Obi (2002).

3 Results

3.1 Observations of M2 variants of Cobra

There is a significant difference ($P < 0.05$) on the number of days to 50% flowering among the variants. The shortest number of days to 50% flowering was recorded by variants 7 and 10 (54.33days) as shown in Table 1. The longest was recorded by variant 4 (65days). The number of days to 50% flowering for variants 2, 4, and 1 are statistically the same ($P < 0.05$). The shortest number of days to maturity was significantly shown by variant 7, (91 days), followed closely by variant 10, (92days), while variant 1 recorded the longest number of days to maturity. Fruit weight had a significant ($P < 0.05$) effect among the variants studied. The highest fruit weight and yield was recorded by variant 2, (2.796kg), while variant 1 (control), had the least (0.615kg). Variant 3 had the next highest fruit yield of 2.178kg, variants 7, 8, and 5 are statistically ($P < 0.05$) the same with 1.713kg, 1.714kg and 1.254kg respectively. There is a significant difference ($P < 0.05$) on the number of branches among the variants studied. The highest number of branches was recorded by variant 4 while variant 1 recorded the least. Variants 9, 7, 5 and 10 are statistically the same ($P < 0.05$). Variant 3 recorded significantly the highest number of fruits harvested while variant 1 recorded the least. Variant 2 had the second highest number of fruits harvested which is statistically the same ($P < 0.05$) with variants 8, 7 and 4. The number of truss per plant had a significant difference ($P < 0.05$) on the variants. The highest number of flowers per truss was recorded by variant 2 while the least was recorded by variant 4. Variant 2 had significantly the highest number of fruits per truss while the least was recorded by variant 5. Variant 3, variant4, variant 7 and variant 8 are statistically the same. (P< 0.05). The mean number of truss per plant show a significant (P < 0.05) effect among the variants studied. The highest number of truss per plant was recorded by variant 2 while variant 10 had the least. The highest number of plants affected by blossom end rot was recorded by variant 1 (control) which is significantly (P < 0.05) different from the rest of the variants studied. Variants 5 and 6 are statistically the same.

Table 1 Effect of mutagenic on yield components of M2 variants of Cobra

Mutants	D50%F	DM	FW/P	NFH	NFL/T	NFR/P	NFR/T	NBER
CV1	63.67	102.0	651	15.0	7.33	34.3	3.67	7.33
CV2	64.33	98.33	2796	36.7	7.33	44.7	5.0	0.0
CV3	57.67	95.67	2178	43.0	6.0	45.0	4.0	0.67
CV4	65.67	100.33	1232	19.7	4.67	33.3	3.67	1.33
CV5	63.67	99.67	1254	28.0	5.67	28.0	2.67	4.33
CV6	60.67	97.0	1031	19.3	6.33	23.7	3.0	3.67
CV7	54.33	91.0	1731	28.3	6.0	34.3	4.33	0.33
CV8	55.33	91.33	1474	30.3	7.0	26.7	4.33	1.33
CV9	57.67	95.33	885	20.3	6.67	22.7	3.33	4.67
CV10	54.33	92.0	1075	23.0	5.67	22.7	3.67	2.0
LSD(P < 0.05)	2.309	3.013	626.2	9.88	1.744	11.24	1.158	2.157

D50%F = Days to 50% flowering, DM = Days to maturity, FW/P = Fruit weight per plant, NFH = Number of fruits harvested per plant, NFL/T = Number of flowers per truss, NFR/P = Number of fruits per plant, NFR/T= Number of fruits per truss, NBER = Number of fruits affected by blossom end rot per plant.

Table 2 Effect of mutagenic on growth parameters of M2 variants of Cobra

Mutants	LL	LW	NB	NBM	NL	NT/P	PG	PHM	PH
CV1	16.67	13.7	3.33	6.67	21.6	18.0	4.6	75.2	33.72
CV2	15.3	12.7	4.0	11.33	21.0	23.33	5.933	63.6	33.97
CV3	19.53	14.8	4.67	13.67	20.3	21.0	4.9	66.0	30.63
CV4	16.2	13.5	6.67	10.67	19.0	16.67	4.8	61.6	23.8
CV5	19.13	15.03	5.0	12.33	26.3	15.0	5.367	69.6	28.63
CV6	23.1	17.5	4.33	9.33	27.0	12.0	4.767	66.2	28.87
CV7	15.87	13.13	6.33	13.33	22.3	15.33	5.4	52.7	27.47
CV8	20.4	13.37	4.33	9.0	19.3	12.33	4.533	57.9	33.7
CV9	14.97	9.9	6.67	10.0	33.0	18.67	4.867	56.9	32.63
CV10	18.83	12.23	5.0	9.33	34.7	11.0	4.267	62.2	30.33
LSD(P < 0.05)	3.101	2.387	1.718	3.316	10.13	8.119	0.7377	14.01	4.502

LL = Leaf length, LW = Leaf width, NB = Number of branches, NBM = Number of branches at maturity, NL = Number of leaves, NT/P = Number of truss per plant, PG = Plant girth, PHM = Plant height at maturity, PH = Plant height.

Both the mean leaf length and width had a significant effect (P < 0.05) on the variants (Table 2). The longest leaf length and width was recorded by variant 6. And the shortest was recorded by variant 9. The number of branches had a significant effect (P < 0.05) on the variants. The highest number of branches was recorded by variants 4 and 9 while variant 1 recorded the least. At maturity, variant 1 in Table 2 equally recorded the least number of branches while variant 3 had the highest. There is no significant difference (P < 0.05) recorded among the variants in respect to the number of leaves. There is a significant difference among the variants with respect to the number of truss per plant. The highest number was recorded by variant 2 while the least was recorded by variant 10. Plant girth had a significant difference on the variants. Variant 2 had the highest while the least was recorded by variant 1. The plant height at both flower bud initiation and at maturity had a significant difference on the variants. At flower bud initiation, the highest plant height was recorded by variant 2 followed closely by variant 1 while the least plant height was recorded by variant 4. At maturity the highest plant height was recorded by variant 1 while variant 7 recorded the least (Table 2).

3.2 Observations of M2 variants of Roma VF

The number of days to 50% flowering had a significant ($P < 0.05$) effect among the variants in Table 3, the least number of days to 50% flowering was recorded by variant 3 while variant 11 recorded the highest. Variants 5, 7 and 8 are statistically the same ($P < 0.05$). The number of days to maturity also had a significant difference ($P < 0.05$) on the variants. The least number of days to maturity was recorded by variant 3 while variant 11 recorded the longest number of days to maturity. The mean fruit weight per plant had a significant ($P < 0.05$) effect among the variants studied. The highest fruit weight was recorded by variant 8 (1.2094kg) followed closely by variant 4 (1.1714kg) and variant 2 (1.1161kg). The least was recorded by variant 11. The other variants are statistically the same ($P < 0.05$). There is a significant ($P < 0.05$) effect among the variants studied. The highest number of fruits harvested was recorded by variant 8 while the least was recorded by variant 1 (control). The mean number of truss per plant had a significant effect on the variants. The highest number of flowers was recorded by variant 9 while the least was recorded by variant 1. The mean number of fruits per truss had a significant ($P < 0.05$) difference among the variants. The highest number of fruits per plant was recorded by variant 8 (75.67), followed by variant 3 (56) and variant 7 (52). The least number was however recorded by variant 11. The number of fruits per truss had a significant effect among the variants. The highest number was recorded by variant 7 while variant 11 recorded the least. Variants 4, 5 and 6 are statistically the same ($P < 0.05$). The mean number of fruits affected by blossom end rot recorded a significant ($P < 0.05$) effect among the variants. The least number was recorded by variants 4 and 7 while the highest was recorded by variant 11.

Table 3 Effect of mutagenic on yield components of M2 variants of Roma VF

Mutants	D50%F	DM	FW/P	NFH	NFL/T	NFR/P	NFR/T	NBER
RV1	44.0	82.67	709.33	14.67	5.67	22.33	4.33	0.67
RV2	41.67	81.67	1116.13	25.33	6.33	29.0	5.0	0.67
RV3	39.67	72.33	798.07	40.33	7.67	56.0	6.67	0.67
RV4	40.67	78.67	1171.47	43.33	6.33	37.67	4.67	0.0
RV5	42.33	80.0	745.8	16.33	5.67	22.33	4.33	0.67
RV6	40.33	78.67	747.8	15.67	6.0	19.33	4.33	0.67
RV7	43.33	82.67	845.17	39.33	7.33	52.0	7.0	0.0
RV8	43.33	82.33	1209.4	69.0	8.0	75.67	6.0	0.67
RV9	45.33	84.33	665.8	33.67	8.33	40.0	6.67	1.0
RV10	51.0	85.67	728.77	17.0	6.33	20.33	3.67	0.33
RV11	52.0	85.67	528.67	18.67	6.33	20.0	2.67	1.67
LSD(P < 0.05)	1.719	1.729	412.107	14.825	1.299	13.834	1.16	0.988

D50%F = Days to 50% flowering, DM = Days to maturity, FW/P = Fruit weight per plant, NFH = Number of fruits harvested per plant, NFL/T = Number of flowers per truss, NFR/P = Number of fruits per plant, NFR/T = Number of fruits per truss, NBER= Number of fruits affected by blossom end rot per plant.

The result in Table 4 show the longest leaf length was recorded by variant 11 while variant 7 had the shortest and closely followed by variant 3. Variants 2, 5, 6, 8, 9 and 10 are statistically the same ($P < 0.05$). The number of branches per plant also had a significant ($P < 0.05$) effect on the variants. The highest number of branches was recorded by variants 4 and 9 followed by variant 3. The least number was recorded by variant 1, 5 and 6 of which recorded the same value. At maturity the number of branches equally had a significant ($P < 0.05$) effect on the variants. The highest number at maturity was recorded by variant 8 while the least was recorded by variant11. The number of leaves per plant had a significant ($P < 0.05$) difference. The highest number of leaves was recorded by variant 4 while the least was recorded by variant 1. Variants 2, 3, 8 and 9 are statistically the same ($P < 0.05$). There is equally a significant ($P < 0.05$) effect shown among the variants on number of truss per plant. The highest number was recorded by variant 8 while variant 1 recorded the least. The highest plant girth was recorded by variant 2 which had a significant difference (P < 0.05). The least was recorded by variant 1. The plant height had a significant difference (P < 0.05) on the variants studied. The tallest plant was recorded by variant 1 while variant 5 had the shortest plant. Plant height at maturity equally had a significant (P < 0.05) difference among the variants. The tallest plant at maturity was recorded by variant 8 while variant 2 recorded the shortest. Variants 1, 4, 5, 6 and 10 are statistically the same (P < 0.05).

Table 4 Effect of mutagenic on growth parameters of M2 variants of Roma VF

Mutants	**LL**	**LW**	**NB**	**NBM**	**NL**	**NT/P**	**PG**	**PHM**	**PH**
RV1	22.27	15.37	2.67	9.33	12.67	10.33	5.27	78.83	37.3
RV2	19.9	14.83	4.67	10.0	24.33	14.0	5.27	58.0	30.87
RV3	16.6	11.37	5.0	11.0	25.67	15.67	4.27	106.43	33.93
RV4	20.13	14.03	6.0	10.67	31.67	14.33	5.33	64.73	30.37
RV5	17.43	12.03	2.67	6.67	15.67	10.67	4.4	64.6	26.0
RV6	17.33	12.1	2.67	8.67	15.33	11.0	4.13	63.1	27.87
RV7	14.4	10.4	3.0	12.0	16.67	15.33	4.07	103.97	28.67
RV8	17.5	13.77	5.67	15.67	25.0	24.67	4.97	154	37.17
RV9	18.7	15.03	6.0	8.33	28.0	14.33	4.37	86.93	35.4
RV10	18.93	14.97	3.67	8.33	19.33	17.67	4.63	63.27	29.97
RV11	23.53	18.37	4.33	6.67	22.0	13.0	3.83	55.17	32.03
LSD(P < 0.05)	5.092	3.896	1.882	2.353	6.676	4.122	0.832	18.138	3.342

LL = Leaf length, LW = Leaf width, NB = Number of branches, NBM = Number of branches at maturity, NL = Number of leaves, NT/P = Number of truss per plant, PG = Plant girth, PHM = Plant height at maturity, PH = Plant height.

3.2.1 Experiment 5

Field evaluation of selected M2 variants of Tropimech

The number of days to 50% flowering in Table 5 had a significant (P < 0.05) difference among the variants. The least number was recorded by variant 2 while the longest was recorded by variant 5 (control). The rest of the variants are statistically the same (P < 0.05). The number of days to maturity equally had a significant effect (P < 0.05) on the variants. Variant 3 had the least number of days to maturity while variant 5 recorded the longest number of days to maturity. The fruit weight per plant had a significant effect (P < 0.05) on the variant. The highest number of fruit weight was recorded by variant 1 (624.67g) and the least was recorded by variant 5 (205.43). Variants 2 and 4 are statistically the same (P < 0.05). The highest number of fruits harvested was recorded by variant 1 which had a significant difference (P < 0.05) among the variants. The least number of fruits harvested was recorded by variant 5. Variants 2, 3 and 4 are statistically the same (P < 0.05). The number of fruits per plant had a significant difference on the variants with the highest number being recorded by variant 2 (15) followed closely by variant 1 (11.67). The least number was recorded by variant 5. The mean number of flowers per truss had a significant difference (P < 0.05) on the variants. The highest number was recorded by variant 2 while variant 5 recorded the least. The other variants are statistically the same (P < 0.05). The number of truss per plant equally had a significant (P < 0.05) effect on the variants studied. Variants 2 and 4 had the highest number while variants 5 and 1 recorded the least number. The number of fruits affected by blossom end rot had a significant effect (P < 0.05) on the variants. The highest number was recorded by variant 1 while the least was recorded by variant 4.

Table 5 Effect of mutagenic on yield components of M2 variants of Tropimech

Mutants	D50%F	DM	FW/P	NFH	NFL/T	NFR/P	NFR/T	NBER
TV1	53.33	87.33	624.63	19.33	5.67	11.67	3.0	1.67
TV2	51.67	86.67	263.1	11.0	6.33	15.0	3.33	1.33
TV3	53.0	85.33	368.47	10.33	5.0	7.67	2.33	0.0
TV4	53.33	93.33	283.37	11.33	5.0	9.33	3.33	0.0
TV5	54.67	91.33	205.43	7.33	5.0	3.0	3.0	1.0
LSD (P < 0.05)	2.75	4.402	152.474	3.403	0.876	3.979	0.842	1.14

D50%F = Days to 50% flowering, DM = Days to maturity, FW/P = Fruit weight per plant, NFH = number of fruits harvested per plant, NFL/T = Number of flowers per truss, NFR/P = Number of fruits per plant, NFR/T = Number of fruits per truss, NBER = Number of fruits affected by blossom end rot per plant.

In Table 6 the leaf length and width had a significant difference ($P < 0.05$) on the variants. Variant 1 recorded the highest of those parameters while variant 3 recorded the least. The number of branches had a significant effect ($P < 0.05$) on the variants. Variant 1 recorded the least number of branches at flower bud initiation and at maturity. At flower bud initiation the highest was recorded by variant 2 while variant 4 recorded the highest at maturity. The number of leaves per plant had a significant effect ($P < 0.05$) the highest number was recorded by variant 5 while variant 1 recorded the least number of branches per plant (Table 6). Variants 2, 3 and 4 are statistically the same ($P < 0.05$). The number of truss per plant equally had a significant difference ($P < 0.05$) on the variants. The highest number was recorded by variant 2 while variant 5 recorded the least. The mean plant girth equally recorded a significant effect ($P < 0.05$) on the variants. The least plant girth was recorded by variant 5 while variant 4 had the highest. The mean plant height both at flower bud initiation and at maturity had a significant effect ($P < 0.05$) on the variants. At flower bud initiation and at maturity, the least height was recorded by variant 5. At flower bud initiation the highest was recorded by variant 2 while variant 1 recorded the highest plant height at maturity.

Table 6 Effect of mutagenic on growth parameters of M2 variants of Tropimech

Mutants	LL	LW	NB	NBM	NL	NT/P	PG	PHM	PH
TV1	20.83	16.5	2.0	6.67	10.67	10.0	3.33	86.9	37.67
TV2	17.93	13.57	3.33	9.33	15.67	11.33	3.0	78.33	40.73
TV3	12.4	9.57	2.33	5.33	14.0	6.67	2.93	58.47	28.07
TV4	16.3	13.3	2.33	12.67	16.33	7.67	3.47	56.33	32.7
TV5	17.3	14.4	3.0	8.33	16.67	6.33	2.8	47.97	25.63
LSD(P < 0.05)	3.643	4.346	1.031	4.631	4.56	2.048	0.512	12.257	5.719

LL = Leaf length, LW = Leaf width, NB = Number of branches, NBM = Number of branches at maturity, NL = Number of leaves, NT/P = Number of truss per plant, PG = Plant girth, PHM = Plant height at maturity, PH = Plant height.

4 Discussion

The main aim of plant breeding is to create variations from the existing genotypes for crop improvement. Crop improvement in the area of yield, quality, earliness to maturity and adaptation to biotic and abiotic stresses. Mutation breeding has proved to be one of the best tools used by breeders in the recent years to achieve such goal. The present study has proved such claims of mutation breeding in creating lots of variations. From the result presented, we have variants that yield more than 2kg of fresh tomato fruits per plant with some fruit weighing close to 80g per fruit. Though, yield is an outcome of various other processes which are subject to changes with the environment. We had variants weighing less than 20g per fruit supporting submissions by Yudhvir, (1995) that induced mutation using EMS reduced fruit size in tomato. In Roma Vf a variant with creeping growth habit producing lots of fruits with dark green colour around the calyx region was developed. The observed significant variation in the parameters of the variants of Cobra, Roma vf and Tropimech studied is an indication of the differences among the possible genetic divergence in the tomato plant. Similar observation was made by Nweke et al. (2020) in castor plant. Cobra variant 2 (CV2), Roma vf variant 8 (RV8) and Tropimech variant 1 (TV1) had the highest fruit weight and number of harvested fruit per plant among the variants in Cobra, Roma vf and Tropimech respectively. The differences in yield among the variants could be attributed to the physiology of the variants and environment. Many changes in crop physiology that determine yield in crop productivity is influenced greatly by the environment the crop thrives. Also differences in root distribution and morphology of the variants within the soil environment may have equally contributed in the differences recorded in the fruit yield and other parameters assessed. Crop root distribution is associated with water and nutrient uptake as root water extraction pattern in soil moisture changes varies with crop specie. Furthermore, fruit weight is determinant of how effectively the products of photosynthesis were translocated to the fruits of which the ability varies with the variants. Days to flowering varies with the variants, in cobra, the range is 54.33-65.67days, Roma vf, 39.87-52days and Tropimech, 51.67-54.67days respectively. Days to maturity range 91-102days (Cobra), 78.67-85.67days (Roma vf) and 85.33-93.33days (Tropimech). The delay in flowering witnessed in some variants may be attributed to reduction in photosynthetic activities probably due to reduced light intensity as well as reduced air temperature. There was an efficient and effective branching, leaf length and width and number of leaves recorded among the variants studied. However, it should be noted that long vegetative growth could mean higher potential for biomass production which may or may not translate to higher yield as observed in some variants. Tomato vines are typically covered with fine short hairs that turn into roots when in contact with soil and moisture, especially if the vines connection to its original root is damaged or severed (Peet, 2009). Phonological traits are more influenced by environmental factors according to Ilo et al. (2020) when they found environment to have influenced greatly characters like number of days to germinate and length of staminate region of castor accessions in Enugu southeast, Nigeria. Variant 8 of Roma vf produced lots of fruits with creeping growth habit, this an ideal character in agriculture because it will help to prevent lodging. Also it should be noted that so survive a plant may reduce the number of fruits generated by producing a smaller quantity of fruits and this reproductive adjustment are differential among crop as found among the variants studied in their fruit sizes and weight. It was observed that the variants of the tomato species studied are resistant to blossom end rot disease as effect of the disease was very minimal on the variants and some variants did not record the disease at all.

The divergence in the recorded results of the 3 varieties of tomato probably might be due to changes in the genetic sequence induced by the EMS. The changes according to Loewe (2008) occur at many different levels and they can have widely differing consequences. Mutation breeding is a short cut method to improve genetic variability and is primarily aimed at improving yield and yield attributing traits (Kozgar et al., 2014).

5 Conclusion

The result of the present study has been able to prove the efficacy and efficiency of EMS in inducing mutation and that the dose and duration of treatment is adequate in increasing genetic variability in the tomato crop. The study has been able to produce heritable variants or mutant varieties that are the basis for plant breeding and crop improvement among the genotypes studied. The consistent in performance of the variants indicated the existence of genotype x environmental (G x E) interaction. From the existing genotypes studied variants or mutants that do not occur in nature with beneficial horticultural traits have been created in tomato for further use in the crop improvement. Tomato growers can lay hold on the already certified variants like the V2, V4, V7 and V3 in Cobra and V8, V4 and V2 in Roma VF for better yield. It is interesting to note that these variants gave relatively the overall best performance in all the agronomic attributes and subsequently the highest fruit yield. There was high genetic plasticity for fruit yield/plant due to genetic differences of the variants. The performance of the variants was consistent. The study showed that there are changes in the variants of tomato studied for all the traits evaluated.

Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest regarding the publication of this article as the authors agreed to publish the work on this journal.

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