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Sensitivity of Pigeon Pea Landraces [*Cajanus cajan* (L.) Millsp.] to Amiprophos Methyl Treatment

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Authors' contributions

This work was carried out in collaboration between all authors. Author OUU designed the study and performed the statistical analysis, interpreted and formatted the final manuscript, author EVI collected the planting materials and wrote the protocol, author EAE wrote the first draft of the manuscript while author MIN collected the data and did the literature search.

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ABSTRACT

Aim: The success of any chemical mutagenesis revolves on the use of plant-specific mutagen(s), optimal concentration(s) and appropriate soaking duration. This paper was aimed at evaluating the effect of amiprophos methyl on morphological and yield traits in pigeon pea [*Cajanus cajan* (L.)Millsp.].
Methods: Thirty seeds each of two varieties of pigeon pea (brown "Fiofio", white "Fiofio") were soaked in 0, 4, 6 and 8 ppm amiprophos methyl (APM) for 24, 48 and 72 hours, respectively. They were planted in a 2 x 4 x 3 factorial layout using randomized complete block design (RCBD) in 10 replications.
Results: Results obtained revealed that there were significant effects (P =.05) of the treatments on the phenological, morphological and yield traits, except on percentage germination, especially when the seeds were soaked for 48 hrs, the variety and mutagen concentrations notwithstanding. Our result revealed that plants raised from white Fiofio seeds soaked in 4 ppm and 6 ppm APM for

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48 hrs produced the highest number of flowers plant^{-1} (227.4±2.95; 212.6±3.57); the highest number of pod plant^{-1} (178.6±5.05; 124.6±4.55) and the seed yield (1016.0±0.79; 935.2±0.37), respectively.
Conclusion: Implicitly though, this could imply that these mutagen concentration and duration of exposure might be promising for pigeon pea productivity.

Keywords: Pigeon pea; mutation breeding; amiprophos methyl; improvement.

1. INTRODUCTION

In the sub-saharan Africa, production of grain legume seeds is estimated at 8 million tonnes from 17.7 million ha [1] accounting for 26.15% of the total global area of production. Nigeria, Burkina Faso, and Niger account for almost 90% of cowpea production with Nigeria ranking the highest. Egypt, Nigeria, South Africa, Uganda and Zimbabwe produce over 90% of the soybean in Africa with Nigeria accounting for 48%. In Ethiopia, pea (*Pisum sativum*) is very important to rural farmers, producing 55% of the total. Dishearteningly, in other countries including Nigeria only about 2% is produced of the total legume which is equivalent with pigeon. Generally in Africa the cultivation of pigeon pea is about 2.81% in 482,882ha of land, yielding 829.1kg/ha [2]. This evidently paints a very bleak picture on the holistic food security pursuit.

Apparently, landraces of crop plants present wide and high variability. Specifically, pigeon pea has been reportedly to have high variability, high adaptability and high nutritive profile [3,4,5]. This notwithstanding, this inherent variability does not result to optimal yield, reduced maturity time and improvement of other important quantitative traits, which could be achieved through mutation breeding. Interestingly, the choice of pigeon pea landraces is that they possess intrinsic capacity to withstand challenging environmental and climatic conditions, which makes them very suitable in the face of the precarious and worsening ecological conditions in the globe, especially in the sub-Saharan African countries [6].

Mutation breeding geared towards further increase of the genetic variability for quantitative traits in various crops have been reported by several researchers [7,8,9,10,11,12,13] and this interestingly has been harnessed for yield improvement [14,15,16,17] breeding disease resistant crops, improved nutritive quality [18] and tolerant to climatic conditions [19]. Comparatively, mutation breeding does not necessarily alter the original genetic makeup of any crop unlike transposon or T-DNA based mutagenesis that generally leads to loss of function as a result of gene disruption [20]. Furthermore, mutation breeding leads to the production of diverse mutant alleles with different degree of trait modifications [21].

Obviously, the success of mutagenesis is fundamentally hinged on the ability of the plant breeder to accurately determine; (a) the specific mutagens for specific crops, (b) the concentration/ dose of the mutagens to be applied and (c) the duration of exposure [16]. We have reported the use of amiprophos methyl, gamma irradiation on cowpea and pigeon pea improvement [6,12,22], oryzalin on Egusi melon improvement [23] while colchicine has been used in polyploidy induction [17] in pigeon pea. The mutagen of interest in this present study is amiprophos methyl (APM).

Amiprophos methyl [0- methyl-0-(4-methyl-6-nitrophenyl)- N- isopropyl – phosphorothioamidate is a herbicide, which has also found application in crop improvement as mutagen. Its action is at the level of microtubules. Microtubules play important role during mitosis, transportation and cell motility [24]. APM action is by binding to the same sites on the a, b-tubulin dimer, which inhibits microtubule polymerization, thus inducing separation of metaphase chromosome [25].

The puzzle of the specific mutagen, optimal concentration and time of exposure for pigeon pea for best result is yet another issue that this paper seeks to evaluate.

2. MATERIALS AND METHODS

2.1 Material Collection and Planting

Seeds of two varieties of pigeon pea (brown “Fiofio”, white “Fiofio”) were obtained from the seed collection of Dr. Udensi, O. Ugorji and the experiment was carried out in the University of Calabar Experimental Farm, Calabar, Nigeria, during the 2010-2011 growing season. Thirty seeds were soaked in 50ml of each of the APM concentration, 0, 4, 6 and 8 ppm for 24, 48 and 72 hours, respectively bringing the final volume to 60 cm^3. Eight beds were made with a spacing of 2 meters between beds. The treated seeds were then sown on a plot of land measuring 12 x 12 meters using randomized complete block design in a 2 x 4 x 3 factorial layout with 10 replications. Three seeds per variety were sown in a hole of 4cm deep according to the method of [26] A spacing of 20 x 75 cm was maintained between stands.

2.2 Data Collection and Analysis

After one month of planting, percentage germination (Number of germinated seeds per plant per treatment divided by total number of seeds planted per plant per treatment multiplied by 100), days to seedling emergence (counting the days for seeds to emerge per plant per treatment), days to 50% flowering (Number of days for 50% of plants per treatment to flower) and days to 50% maturity (Number of days for 50% of plants per treatment to mature) were recorded. Morphological traits such as plant height $plant^{-1}$, number of branches $plant^{-1}$, number of leaves $plant^{-1}$, leaf area $plant^{-1}$, internode length $plant^{-1}$, petiole length $plant^{-1}$, and yield traits including number of flowers $plant^{-1}$, number of pods $plant^{-1}$, pod length, number of seeds pod^{-1}, seed yield $plant^{-1}$, and 100-seed weight were recorded at 6 months. For the estimation of the leaf area, the leaves were laid on a 1cm grid (graph paper) and their outlines were traced. The numbers of square centimeters were calculated, including the partial square and multiplied by 0.1cm^2 [27]. However, all partial squares that are less than half covered were excluded. The seed yield per plant was estimated by multiplying the average number of seeds per pod per plant and the average number of pod per plant [6]. They were subjected to analysis of variance (ANOVA) using Predictive Analytics SoftWare (PASW), version 18.0.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Effect of mutagenic treatment on phenological parameters

Result obtained revealed that there were no significant differences (P =.05) for percentage seed germination between the two varieties of pigeon pea, treatment concentration or soaking duration. However, significant differences were observed for percentage seedling emergence, which was soaking duration dependent. It was observed that at higher soaking duration, percentage seedling emergence declines. Days to seedling emergence showed slight significant differences (P = 0.05) (Table 1). Additionally, days to 50% flowering and maturity were significantly affected (P =.05) by mutagenic treatments concentration, which was concentration and soaking duration dependent.

Generally plants raised from brown fiofio seeds took shorter time to flower than plants raised from white fiofio seeds except those that were soaked in 6ppm at 72 hrs, 8 ppm at 24 and 72 hrs. On the contrary, plants raised from brown fiofio seeds exhibited delayed flowering but however matured earlier than the white, concentration and soaking duration, notwithstanding (Table 1).

3.1.2 Effect of mutagenic treatment on morphological parameters

Result obtained showed that there were significant effects (P =.05) of the mutagenic treatments on all the morphological characters studied variety, mutagen concentration and soaking duration, notwithstanding. It was observed that plant raised from brown fiofio seeds that were soaked in 4 ppm (for 24 and 48 hrs) had tallest plants (288.4±6.74, 289.4±2.47 cm) while those soaked in 8 ppm for 24 hrs gave rise to plants with 281±11.63 cm. They also produced more branches (17.8±1.39), broader leaf area (133.21±5.07 cm^2), increased internode length (5.1±0.49), petiole length (4.4±0.37) while the white fiofio variety plants had the highest number of leaves (462.2±17.02) when the seeds were soaked in 6ppm APM for 48 hrs (Table 2).

3.1.3 Effect of mutagenic treatment on yield of pigeon pea

Treating the seeds of pigeon pea with APM caused significant effects on the yield traits. Our result revealed that plants raised from white Fiofio seeds soaked in 4 ppm and 6 ppm APM for 48 hrs produced the highest number of flowers $plant^{-1}$ (227.4±2.95; 212.6±3.57). This was followed by those soaked in 6 ppm APM for 24hrs and brown variety soaked in 4 ppm for 48 hrs. It was also observed that white Fiofio plants raised from seeds soaked 4 ppm and 6 ppm APM for 48 hrs produced the highest number of pod $plant^{-1}$ (178.6±5.05; 124.6±4.55) and the seed yield (1016.0±0.79; 935.2±0.37), respectively. Generally, plants raised from white Fiofio performed better in their yield traits especially those soaked for 48 hrs, variety and concentration, notwithstanding (Table 3).

3.2 Discussion

Since crop diversification and improvement is a dynamic process, the search for new techniques either singly or in combination that will lead to exponential scale up to match the ever-increasing human demands for food becomes expedient [28]. Importantly, but rather unfortunate, the acute state of food insecurity in the sub-saharan African countries demands urgent strides to mitigating it. The worse scenario in this region is the fact that landraces of crop plants are either allowed to go into extinction or are cultivated on a very low scale on the presumption that they lack the much needed genetic variability to meet the demand for food security [6,11,13]. The implication of this assumption paints a bleak picture on food security and sustainability. Reports by several researchers have revealed the effects of different mutagens, their concentrations and the duration of their exposure on crop improvement programmes [14,15,16,17,23,28,30].

Our result showed that there was no significant effects (P>0.05) of the mutagen, its concentrations and soaking duration on percentage seed germination. This was the position of [17] after treating pigeon pea seeds with colchicine. The implication is that the mutagen did not inhibit physiological and biochemical pathways underlying seed germination but however, seedling emergence declined with increase in soaking duration. The reason underlying delayed seedling emergence is not yet very clear. The percentage of seedlings that emerged from the brown Fiofio APM treated seeds was higher significantly than those of the white. This might possibly suggest that the brown variety might have been able to withstand the inhibitory effect of the mutagenic treatment.

Ironically, the brown Fiofio variety performed better in almost all the morphological traits, except for number of leaves $plant^{-1}$ while the white variety did better in yield traits. Photosynthetically, it should be logical to assume that the more the number of leaves, the higher the seed yield and the broader the leaf, the more surface area that will be exposed to photosynthetic activities [3,4,6,12,30].

This relationship was not observed in the present study as brown Fiofio plants though produced broader leaf surface than plants raised from white Fiofio, white Fiofio plants produced more seeds. One wonders why the variety that showed better morphological traits will performed badly in yield traits. Though the brown variety performed better morphologically, the morphological performance of the white variety was comparable. This suggests that there could have been synergistic interactions of these integral traits including the high number of leaves produced by the white Fiofio. This might be the underlying reason for increase yield in the white variety. There is positive relationship between number of flower per plant, number of pod per plant, number of seeds per pod, pod length and seed yield. This was evident in the yield performance of White Fiofio variety. This position corroborates the earlier report of [6,12,17]. In the report of [4], there was chromosome doubling when seeds of pigeon pea were soaked in 4 ppm APM. This might have favoured the performance of the white Fiofio variety at this concentration.

It should be emphasized succinctly that one of the major aims of crop improvement programmes outside yield increase is the ability to shorten the maturity time that would translate to early harvest such that food supply would be made readily available. From our present report, the mutagenic treatment seems to have significantly reduced flowering time for the white variety and maturity time for the brown variety, while causing delayed maturity for white and flowering time for brown Fiofio, respectively. The days to flowering was reduced for the white Fiofio variety and coincidently produced higher number of flowers at 4 ppm APM and 6 ppm for 48hrs, respectively [27]. However, the time of anthesis initiation might not correlate significantly with the number of flowers produced. It does mean that the above outcome could be by chance. Unfortunately, the white variety that produced higher seed yield had their maturity time delayed slightly. It is worthy to note that one of the goals of genetic manipulation of crops is to reduce the time of maturity. It thus means that any breeding method that fails in this respect should be reconsidered [27]. From our present report, the treatments seem to have delayed the maturity time of white "Fiofio" but had higher seed yield.

Table 1. Phenological response of pigeon pea landraces to amiprophos methyl treatment

Pigeon pea landrace	APM concentration (ppm)	Soaking duration (hr)	% germination	% seedling emergence	Days to seed germination	Days to 50% flowering	Days to 50% maturity
Brown “Fiofio”	0	24	100.0±0.0a	80.02±8.16a	3.6±0.25b	170.7±0.89b	185.3±3.48c
		48	88.70±2.59a	86.68±0.03a	4.4±0.25a	177.0±1.08b	181.3±2.33c
		72	100.0±0.0a	66.68±8.16b	4.2±0.20b	157.3±1.29c	183.7±2.33c
	4	24	100.0±0.0a	80.02±8.16a	3.4±0.25b	211.3±2.84a	183.7±2.33c
		48	100.0±0.0a	100.0±0.0a	4.2±0.37b	197.0±1.05a	187.0±4.0c
		72	88.70±1.09a	86.68±8.16a	4.4±0.25a	195.0±0.29a	189.3±1.67c
	6	24	100.0±0.0a	86.68±8.16a	3.4±0.25b	214.3±0.84a	183.0±4.0c
		48	100.0±0.0a	93.34±6.66a	4.2±0.37b	166.7±2.17b	185.3±3.48c
		72	88.70±2.59a	80.02±8.16a	4.4±0.25a	181.7±1.22b	219.0±1.23ab
	8	24	88.70±2.59a	86.68±0.0a	3.6±0.25b	212.3±2.04a	218.0±13.53b
		48	100.0±0.0a	100.0±0.0a	4.2±0.37b	194.3±1.78a	181.3±2.33c
		72	88.70±2.59a	39.98±6.68c	4.2±0.37b	184.7±17.32b	219.0±1.0ab
White “Fiofio”	0	24	88.70±2.59a	73.34±1.48b	4.4±0.25a	161.0± 0.03c	239.7±3.33a
		48	88.70±2.59a	86.68±2.66a	4.2±0.37b	160.0±1.00c	201.0±16.37b
		72	77.80±1.2a	46.6 ±8.18c	5.2±0.20a	159.0±1.00c	183.0±4.00c
	4	24	100.0±0.0a	93.34±6.66a	4.4±0.25a	157.0±0.77c	236.3±3.33a
		48	88.70±8.59a	86.68±8.16a	4.2±0.37b	162.0± 0.04c	205.0±14.00b
		72	100.0±0.0a	60.02±6.68b	4.8±0.37a	163.0±1.77c	187.0±1.02c
	6	24	88.70±2.59a	86.67±6.66a	4.2±0.20b	161.3±3.76c	232.0±1.00a
		48	88.70±2.59a	86.68±8.16a	4.0±0.45b	157. 7±2.91c	188.7±5.04c
		72	77.80±2.59a	73.34±1.48b	5.0±0.45a	176.0±1.67b	217.3±15.67b
	8	24	77.80±1.2a	60.00±1.48b	4.4±0.25a	191.3±0.67a	231.0±1.02a
		48	100.0±0.0a	100.0±0.02a	4.2±0.37b	153.3±1.40c	191.0±0.04bc
		72	77.80±2.59a	66.68±0.55b	4.8±0.37a	186.0±1.03ab	203.3±1.90b

Means followed with the same case letter along vertical array indicate no significant effect (P > 0.05); n=10; Post-hoc test = Least Significant Difference (LSD)

Table 2. Morphological response of pigeon pea landraces to amiprophos methyl treatment

Pigeon pea landrace	APM concentration (ppm)	Soaking duration (hr)	Plant height plant^{-1} (cm)	Number of leaves plant^{-1}	Number of branches plant^{-1}	Leaf area plant^{-1} (cm^2)	Internode length plant^{-1} (cm)	Petiole length plant^{-1} (cm)
Brown "Fiofio"	0	24	262.6±0.59c	353.6±1.90c	13.8±2.06ab	110.86±4.41b	5.4±0.48 a	4.3±0.56 a
		48	255.4±1.66cd	285.2±0.18d	16.2±1.11a	134.40±8.97a	5.4±0.19 a	4.1±0.40 a
		72	260.2±1.28c	369.0±1.04b	16.0±1.64a	130.72±5.89a	5.4±0.29 a	4.5±0.35 a
	4	24	288.4±2.69a	252.0±0.56e	15.0±2.07a	105.58±6.44b	4.7±0.37 a	3.4±0.62 b
		48	289.4±2.74a	267.4±1.04de	17.8±1.39a	133.21±5.07a	5.1±0.49 a	4.4±0.37 a
		72	265.0±1.96c	380.0±1.14b	17.2±1.56a	135.28±5.55a	5.4±0.49 a	3.2±0.42 b
	6	24	280.4±2.49ab	364.4±1.34b	16.2±1.36a	117.86±4.28b	4.6±0.58 a	4.0±0.47 a
		48	264.0±0.11c	281.2±1.40d	15.8±1.60a	128.59±4.27a	5.0±0.57 a	3.2±0.20 b
		72	251.4±2.55d	402.0±2.67b	16.2±1.82a	137.30±6.77a	5.4±0.29 a	3.6±0.25 ab
	8	24	281.6±1.63a	232.6± 0.34e	15.6±1.57a	124.27±5.32a	4.7±0.20 a	3.3±0.46b
		48	276.0±2.58b	317.4±1.36d	17.6±0.51a	139.85±2.49a	5.3±0.30 a	4.4±0.19a
		72	227.0±3.59g	220.6±0.56ef	12.6±1.44b	113.54± 9.10b	4.6±0.58 a	2.6±0.19c
White "Fiofio"	0	24	199.4±1.71i	232.6±2.53e	12.2±0.92b	103.58±5.24c	4.1±0.19ab	2.6±0.40 c
		48	230.0±2.91g	335.0±1.92c	14.8±0.37a	127.97±10.98a	5.2±0.41 a	3.0±0.27bc
		72	262.6±1.10 c	339.4±1.19c	16.8±1.36a	116.62±9.44 b	5.4±0.19 a	2.8±0.37c
	4	24	217.8±1.20h	457.0±1.21a	14.6±1.54a	117.24±4.78b	3.6±0.29b	2.0±0.27cd
		48	235.8±2.56f	312.8±0.45d	11.0±0.63b	124.03±4.26a	4.8±0.26 a	2.7±0.49c
		72	241.2±1.03ef	267.0±1.86 de	13.6±1.12b	107.95±3.76b	5.0±0.45 a	3.1±0.3 b
	6	24	231.4±0.96fg	462.2±1.02a	16.2±1.74a	115.34±5.18 b	5.0±0.22 a	2.5±0.2 c
		48	247.6±0.53de	306.2±2.96d	13.6±1.17b	138.86±4.43 a	4.7±0.77 a	3.3±0.26b
		72	265.8±1.69c	288.6±1.56d	16.0±1.52a	112.42±4.93 b	5.2±0.25 a	2.7±0.20c
	8	24	230.4±10.67g	317.8±0.81cd	12.6±1.54b	119.11±8.41ab	5.3±0.77 a	3.04±0.16b
		48	249.4±2.98d	281.6±1.45d	14.6±1.47a	136.37±6.34a	4.6±0.43 a	3.0±0.57bc
		72	234.6±1.58f	260.0±1.11e	12.2±1.24b	103.79±7.34bc	4.6±0.40 a	2.7±0.3 c

Means followed with the same case letter along vertical array indicate no significant effect (P > 0.05); n=10; Post-hoc test = Least Significant Difference (LSD)

Table 3. Yield response of pigeon pea landraces to amiprophos methyl treatment

Pigeon pea landrace	APM concentration (ppm)	Soaking duration (hr)	Number of flowers plant^{-1}	Number of pods plant^{-1}	Pod length	Number of seeds pod^{-1}	100 -seed weight	Days to 50% flowering	Days to 50% maturity	Seed yield plant^{-1}
Brown "Fiofio"	0	24	135.8±4.85f	90.0±2.63c	6.6±0.25a	5.4±0.25a	13.98±0.17b	170.7±0.89b	185.3±3.48c	420.4±0.23de
		48	84.2±2.65j	69.4±2.11e	5.9±0.29 d	5.2±0.37a	14.28±0.29b	177.0±1.08b	181.3±2.33c	339.8±0.24ef
		72	88.6±3.49j	62.9±2.69e	6.4±0.17 b	5.0±0.32a	12.08±0.72cd	157.3±1.29c	183.7±2.33c	404.0±0.41e
	4	24	112.0±2.59gh	116.2±3.43b	6.1±0.37c	5.8±0.20 a	14.78±0.38a	211.3±2.84a	183.7±2.33c	438.8±0.43d
		48	193.2±2.63c	66.2±4.47e	5.8±0.18e	5.2±0.20b	14.60±0.73a	197.0±1.05a	187.0±4.0c	387.6±0.26e
		72	128.2±2.22fg	79.6±3.64d	6.5±0.22a	5.4±0.25a	13.28±0.81b	195.0±0.29a	189.3±1.67c	357.8±0.90e
	6	24	114.6±1.91g	60.0±2.74f	6.5±0.16a	5.2±0.20a	15.92±0.40a	214.3±0.84a	183.0±4.0c	309.2±0.40f
		48	176.8±2.52d	181.0±3.86a	5.8±0.30e	5.0±0.32a	12.60±0.54bc	166.7±2.17b	185.3±3.48c	484.8±o.74d
		72	86.2±3.61j	54.6±3.27f	5.4±0.29g	4.8±0.37b	13.48±0.41b	181.7±1.22 b	219.0±1.23ab	334.4±0.45f
	8	24	82.6±2.50j	49.2±3.34fg	6.3±0.30b	5.0±0.63a	13.66±0.36b	212.3±2.04 a	218.0±13.53b	302.2±0.81f
		48	150.8±3.81e	77.8±3.29d	6.2±0.27c	5.8±0.20a	13.22±0.58 b	194.3±1.78a	181.3±2.33c	462.9±0.33d
		72	82.4±3.19j	58.8±2.85f	6.0±0.35d	5.2±0.37a	13.23±0.79b	184.7±17.32b	219.0±1.0ab	321.2±0.83f
White	0	24	80.4±4.01j	81.4±2.16c	5.9±0.16d	5.2±0.20a	11.40± 0.52d	191.3±0.67a	239.7±3.33a	438.8±0.47d
''Fiofio''		48	64.2±3.43k	78.6±4.06d	5.8±0.17e	5.2±0.20a	11.36±0.50d	160.0±1.00c	201.0±16.37b	935.2±0.37b
		72	102.0±3.05i	64.0±2.24 e	4.7±0.58i	4.4±0.25ab	11.98±0.47d	159.0±1.00c	183.0±4.00c	694.8±0.36c
	4	24	122.4±4.20g	90.6±3.47c	6.5±0.42a	5.4±0.5 a	11.20±0.48d	157.0±0.77c	236.3±3.33a	392.8±0.83e
		48	227.4±6.95a	178.6±5.05a	5.9±0.25d	5.2±0.20a	11.26±0.43d	162.0± 0.04c	205.0±14.00b	1016.0±0.79a
		72	136.0±3.30f	56.0±2.24f	5.5±0.16f	5.2±0.20a	11.76±0.24d	163.0±1.77c	187.0±1.02c	502.2±0.49d
	6	24	187.6± 3.86c	43.0±2.81g	5.8±0.19e	5.2±0.37a	9.92±0.45de	161.3±3.76c	232.0±1.00a	229.0±0.05g
		48	212.6± 3.57b	124.6±4.55b	5.6±0.29f	5.0±0.02a	11.80±0.49d	157. 7±2.91c	188.7±5.04c	935.2±0.37b
		72	112.0±2.88gh	42.4±1.75g	5.3±0.34g	5.0±0.32a	11.68±0.41d	176.0±1.67b	217.3±15.67b	711.0±0.99c
	8	24	100.6±2.96i	80.0±4.0d	5.8±0.37e	4.4±0.25ab	13.54±0.32b	161.0±0.03c	231.0±1.00a	344.0±0.21e
		48	115.6±0 .76g	78.4±1.77d	5.9±0.27d	5.0±0.04a	10.92±0.34d	153.3±1.40c	191.0±0.04bc	308.2±0.75f
		72	82.0±2.83j	41.4±1.05g	5.6±0.43f	4.6±0.25b	12.54±0.42c	186.0±1.03ab	203.3±1.90b	196.4±0.92g

Means followed with the same case letter along vertical array indicate no significant effect (P > 0.05); n=10; Post-hoc test = Least Significant Difference (LSD).

4. CONCLUSION

Specifically, plants raised from the two pigeon pea varieties soaked in 4 ppm APM for 48 hrs performed better in the morphological and yield traits. This might imply that this APM concentration and duration of exposure might be promising for optimal pigeon pea breeding and improvement. Suggestively, though not disregarding the reduction in maturity time of this crop, if the delay could lead to increase seed yield, it will be a step in the right direction. It is however, recommended that ploidy analysis be done to give further clue to the actual cause of the reported improvement.

COMPETING INTEREST

This is to affirm that there are no conflicting interest concerning the manuscript as all the authors read and approved the final copy of the manuscript.

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