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Sodium azide and hydroxyl ammonium hydrochloride show affinity for different *Oryza sativa* varieties in mutation studies.

La azida de sodio y el clorhidrato de hidroxilamonio muestran afinidad por diferentes variedades de *Oryza sativa* en estudios de mutación.

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ABSTRACT

The comparative effects of sodium azide (NaN_3) and hydroxyl ammonium hydrochloride ($NH_2OH.HCl$) on the growth and yield parameters of therice varieties; FARO 44, FARO 52 and FARO 57 were investigated. The planting materials obtained from the National Cereal Research Institute, Badeggi, Bida, Niger State were treated with 0.004 % sodium azide and 0.25 % hydroxyl ammonium hydrochloride at pH 3. Control seeds were treated with distilled water at neutral pH. Growth parameters recorded include percentage germination and length of plumule and radicle. Yield parameters include number of tillers per plant, number of panicles per plant, one hundred grain weight. Results obtained include percentage germination with sodium azide having the highest percentage germination in FARO 44 and FARO 52 while hydroxyl ammonium hydrochloride had the highest percentage germination in FARO 57. For number of panicles per plant at harvest, sodium azide treated grains had the highest number of panicles harvested in FARO 44 and FARO 52 while hydroxyl ammonium hydrochloride had the highest number of panicles harvested per plant at harvest in FARO 57.The observations from this research showed that sodium azide had more affinity for FARO 44 and FARO 52 while hydroxyl ammonium hydrochloride had an affinity FARO 57.

Keywords: sodium azide, hydroxyl ammonium hydrochloride, FARO 44, FARO 52, mutagenesis, rice.

RESUMEN

Los efectos comparativos de la azida de sodio (NaN_3) y el clorhidrato de hidroxilamonio ($NH_2OH.HCl$) en los parámetros de crecimiento y rendimiento de las variedades de arroz; Se investigaron FARO 44, FARO 52 y FARO

57. Los materiales de siembra obtenidos del Instituto Nacional de Investigación de Cereales, Badeggi, Bida, Estado de Níger, se trataron con azida de sodio al 0,004 % y clorhidrato de hidroxilamonio al 0,25 % a pH 3. Las semillas de control se trataron con agua destilada a pH neutro. Los parámetros de crecimiento registrados incluyen el porcentaje de germinación y la longitud de la plúmula y la radícula. Los parámetros de rendimiento incluyen el número de macollos por planta, número de panículas por planta, peso de cien granos. Los resultados obtenidos incluyen el porcentaje de germinación con azida de sodio que tiene el mayor porcentaje de germinación en FARO 44 y FARO 52, mientras que el clorhidrato de hidroxilamonio tuvo el mayor porcentaje de germinación en FARO 57. Para el número de panículas por planta en la cosecha, los granos tratados con azida de sodio tuvieron el mayor número de panículas cosechadas en FARO 44 y FARO 52, mientras que el clorhidrato de hidroxilamonio tuvo el mayor número de panículas cosechadas por planta en FARO 57. Las observaciones de esta investigación mostraron que la azida de sodio tenía más afinidad por FARO 44 y FARO 52, mientras que el clorhidrato de hidroxilamonio una afinidad FARO 57.

Palabras clave: azida de sodio, clorhidrato de hidroxilamonio, FARO 44, FARO 52, mutagénesis, arroz

INTRODUCTION

Rice (*Oryza sativa*) is the world's most important staple food crop consumed by more than half of the world population as represented by over 4.8 billion people in 176 countries with over 2.89 billion people in Asia, over 150.3 million people in America and over 40 million people in Africa (IRRI, 2004). It is the second most cultivated cereal after maize. The demand for rice in Sub-Saharan Africa is growing much faster than for any grain with both the rich and poor relying on it as a major source of calories (Kormawa and Akande, 2004). It provides 20 % of the per capita energy and 13 % of the protein consumed worldwide.

The Nigerian rice sector has witnessed some remarkable developments particularly in the last 10 years. Both rice production and consumption in Nigeria have vastly increased during the aforementioned period (Ojehomon *et al.,* 2009). However the demand for rice has continued to outstrip production given shift in consumption preference for rice especially by urban dwellers. Bamidele *et al.* (2010) reported that households preferred imported rice to local rice, because the imported rice is of higher quality and grade (it has a better taste, it is polished, not broken, free of stones and other debris). Kassali *et al.* (2010) noted that the main reason imported rice is preferred is as a result of its good quality as presumed by consumers. Also, Bamba *et al*. (2010) noted that consumers in large urban centres have a marked preference for high quality imported rice. Increasing the production of higher quality rice will reduce imports and strengthen food security (Bamba *et al.,* 2010).

Mutation is a tool used by geneticist to study the nature and function of genes which are the building blocks and basis of plant growth and development, thereby producing raw materials for genetic improvement of economic crops (Adams and Aliyu, 2007). It is the ultimate source of variation that involves the production of new alleles. It can occur as gene (or point) mutations, where only a single base is modified or one or a relatively few bases are inserted or deleted. Mutations are also achievedvia large deletions or rearrangements of DNA. Chromosome breaks or rearrangements, orgain or loss of whole chromosome have all been reported as possible measures (Kristien and Errol, 2000). Mutations canbe induced using physical or chemical mutagens including sodium azide and hydroxyl ammonium hydrochloride, which have both been previously reported to improve the yield of a variety of crops such as cowpea (Mensah and Akomeah, 1992), rice (Mensah et al*.,* 2003), soya bean (Mensah et al*.,* 2013), and sesame (Birara *et al.,* 2014). The aim of the experiment was therefore to compare the effects of sodium azide (NaN_3) and hydroxyl ammonium hydrochloride ($NH_2OH.HCl$) on the growth and yield parameters of the three rice varieties; FARO 44, FARO 52 and FARO 57.

MATERIALS AND METHODS

Collection of grains: Three improved high yielding rice varieties; FARO 44, FARO 52 and FARO 57 were obtained from the National Cereals Research Institute, Badeggi, Bida, Niger State.

Preparation of treatment solution: The stock solution of 1 % hydroxyl ammonium hydrochloride was prepared by dissolving 5 g of hydroxyl ammonium hydrochloride salt in 500 ml of ortho-phosphoric acid regulated water (pH 3). The lethal dose 50 (LD_{50}); the dose at which at least 50 % of grains will germinate was determined by treating grains pre-soaked in water for 14 hours with 1 %, 0.5 %, 0.25 %, 0.125 % and 0.0625 % of the stock solution. The lethal dose was determined as 0.25 %.

After the lethal dose was determined, 0.25 % of hydroxyl ammonium hydrochloride was prepared by measuring 25 ml of stock solution and making up to 100 ml with ortho-phosphoric acid regulated water (pH 3) and used to treat the grains. Control was only distilled water at neutral pH.

Preparation of sodium azide (NaN_3) solution: The stock solution of sodium azide was prepared by dissolving 1 g of sodium azide salt in 100 ml of ortho-phosphoric acid regulated water (pH 3). Measured 0.004 % $NaN_3$was choice concentration according to earlier research by Omoregie, 2014. It was prepared by mixing 0.4 ml of stock solution in 96.6 ml of ortho-phosphoric acid regulated water (pH 3) and used to treat grains. Control was only distilled water at neutral pH.

Grain treatment: Rice grains free from insect attack were selected by hand picking and pre-soaked in tap water for 14 hours and then transferred to hydroxyl ammonium hydrochloride and sodium azide solutions respectively; both at pH 3 for 6 hours with continuous stirring to ensure proper penetration. At the end of exposure to hydroxyl ammonium hydrochloride and sodium azide treatment, grains were properly rinsed with water to prevent the further action of the mutagenic agents before transferring to petri dishes.

Experimental layout: Treated and control seeds were respectively placed in twenty-seven (27), 9 cm sterile petri dishes lined with one sterile Whatman filter paper and arranged on a laboratory table. The petri dishes were thereafter covered with a 60 cm × 45 cm meshed net to prevent it from rodent attack.

The field work was carried out at the Department of Plant Biology and Biotechnology Screen House, located beside the Faculty of Life Sciences, University of Benin. Top soil (0-10 cm) depth was collected from the fallow site opposite the former Botanic garden of the Department of Plant Biology and Biotechnology, University of Benin. Two and half kilogram of soil was then weighed into twenty-seven (27) perforated experimental bowls.

Experimental design: The experimental design was a completely randomized design with three blocks. Each block was a replicate of the three rice varieties comprising of the two treatments and control levels. There were nine (9) perforated bowls per block and a total of twenty-seven (27) bowls for the experiment.

Germination studies: For percentage germination, 10 treated and untreated seeds were sown in 9 cm sterile petri dishes lined with one sterile Whatman No.1 filter paper containing 5 ml of distilled water. Number of grain from which radicle or plumule emerged were counted daily up to the fourteenth (14^{th}) day after sowing. Distilled water was added to the petri dishes daily to maintain the moisture in the petri dishes.

Percentage germination was then calculated by the formula:

$$\frac{Number of germinated grains x\ 100}{Total number of grains in Petridish}$$

The lengths of radicle and plumule of a particular selected grain were measured daily up to the sixth (6^{th}) day after sowing with a meter rule and a mathematical set divider

Field Experiment: Ten (10) grains were sown per bowl. The plants were watered daily to avoid dehydration using tap water since the experiment was conducted in a screen house. Inorganic fertilizer (N.P.K. 15:15:15), was applied at the twelfth week after planting at the rate of 4 g/kg (Ikhajiagbe *et al.,* 2009). The fertilizer was applied by first dissolving it in water and applied at 5 cm perimeter away from the plant to avoid scotching of the plants.

Yield parameters: For the determination of yield parameters, number of tillers as well as panicles per plant, including 100-grain weight was determined. Number of tillers per plant was counted after more than 50 % of all the varieties have flowered. Number of panicles per plant were counted at the time of harvest. Panicles were harvested when they turned straw colour. One hundred grains per plant were weighed from the harvested grains.

Statistical analysis: Means and standard errors were calculated from data obtained. Data were analyzed following two-way analysis of variance using GENSTAT (8th edition). Means were separated using Duncan's multiple range. Data were presented as mean ± SE

RESULTS

Percentage germination of FARO 44, FARO 52 and FARO 57 rice varieties: The result of the percentage germination observed in the three rice varieties is presented in Table 1. At day 2, theNaN_3-treated grains (SAtG) of FARO 52 had the highest percentage germination of 41.87 mm while the control of FARO 57 had the least with a percentage germination of 6.67 mm. At day 3, theSAtGof FARO 44 had the highest percentage germination of 53.33 %, followed by the SAtGof FARO 52 having a percentage germination of 50 %. The least percentage germination was observed in the $NH_2OH.HCl$ treated grains of FARO 44 and control of FARO 57 both having a percentage germination of 26.67 mm. At day 4, the SAtGof FARO 57 had the highest percentage germination of 60 %, followed by the control and SAtG of FARO 44 both having a percentage germination of 53.33 % with the least germination observed in the $NH_2OH.HCl$ treated grains of FARO 44 having a percentage germination of 26.67 %. At day 5, the control of FARO 44 had the highest percentage germination of 63.33 % while the $NH_2OH.HCl$ treated grains of FARO 52 had the least with a percentage germination of 36.67 %. The highest percentage germination was observed in the control of FARO 44 having a percentage germination of 63.33 % and the least was observed in the $NH_2OH.HCl$ treated grains of FARO 44 with germination percentage of 36.67 % at day 6 and 12. At day 14, the control of FARO 44 had the highest percentage germination of 66.67 % followed by the $NH_2OH.HCl$ treated grains of FARO 57 having a percentage germination of 63.33 %. The least percentage germination was observed in the $NH_2OH.HCl$ treated grains of FARO 44 with a percentage germination of 40 %.

Table 1. Percentage germination of the three rice varieties

VARIETIES TREATMENT	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 12	DAY 14
FARO 44 Control	33.33 ± 3.33^{ab}	46.67 ± 3.33^{a}	53.33 ± 3.33^{ab}	63.33 ± 3.33^{a}	63.33 ± 3.33 ^{a}	63.33 ± 8.82 ^{a}	66.67 ± 6.67 ^{a}
FARO 44 $NH_2OH.HCl$	23.33 ± 12.01^{ab}	26.67 ± 12.02^{a}	26.67 ± 10.00^{a}	36.67 ± 8.82^{a}	36.67 ± 8.82^{a}	36.67 ± 8.82^{a}	40.00 ± 10.00^{a}
FARO 44 NaN3	33.33 ± 3.33^{ab}	53.33 ± 8.82^{a}	53.33 ± 8.82^{ab}	56.67 ± 12.01^{a}	56.67 ± 12.0 ^{a}	56.67 ± 12.02^{a}	56.67 ± 12.02^{a}
FARO 52 Control	41.87 ± 11.05^{a}	41.87 ± 11.05^{a}	48.89 ± 10.60^{ab}	48.89 ± 12.22^{a}	58.89 ± 4.84^{a}	58.89 ± 4.84^{a}	58.89 ± 4.84^{a}
FARO 52 NH2OH.HCl	32.20 ± 6.50^{ab}	32.20 ± 6.50^{a}	35.92 ± 10.07^{ab}	39.25 ± 9.64^{a}	42.22 ± 15.61^{a}	42.59 ± 10.32^{a}	42.59 ± 10.32^{a}
FARO 52 NaN_3	46.67 ± 17.64^{a}	50.00 ± 17.32^{a}	50.00 ± 11.55^{ab}	53.00 ± 11.55^{a}	53.00 ± 11.55^{a}	53.00 ± 11.55^{a}	53.00 ± 11.55^{a}
FARO 57 Control	6.67 ± 6.67^{b}	26.67 ± 3.33^{a}	30.00 ± 10.00 ^{b}	40.00 ± 3.33^{a}	43.33 ± 3.33^{a}	53.33 ± 3.33^{a}	53.00 ± 5.77^{a}
FARO 57 $NH_2OH.HCl$	36.67 ± 8.82^{ab}	36.67 ± 8.82^{a}	43.33 ± 8.82^{ab}	46.67 ± 12.02^{a}	46.67 ± 12.02^{a}	56.67 ± 12.01^{a}	63.33 ± 12.02^{a}
FARO 57 NaN_3	36.37 ± 8.82^{ab}	46.67 ± 3.33^{a}	56.00 ± 5.77 ^{a}	56.67 ± 3.33 ^{a}	60.00 ± 3.33^{a}	60.00 ± 3.33 ^{a}	60.00 ± 1.55^{a}

Mean ± standard error. Mean of three replicates.

Different alphabets in columns indicate significant differences at 5 % level of probability

Length of plumule of FARO 44, FARO 52 and FARO 57 rice varieties: Table 2 shows the length of plumule of the three rice varieties. At day 2, the longest plumule was observed in theSAtGof FARO 44 having a length of 1.67 mm. The grains of FARO 44 control, FARO 52 $NH_2OH.HCl$ and NaN_3 as well as FARO 57 control and $NH_2OH.HCl$ did not show noticeable plumule. At day 3, the longest plumule length of 6.33 mm was observed in $NH_2OH.HCl$ treated grains of FARO 57 while the least of 4 mm was observed in $NH_2OH.HCl$ treated grains of FARO 44. At day 4, the longest plumule length was observed in the control of FARO 44 as well as the $NH_2OH.HCl$ treated grains of FARO 57 both having a length of 14.33 mm each. The least was observed in the SAtG of FARO 52 with a length of 9 mm. At day 5, the longest length of plumule was seen in the NaN_3 treated seeds of FARO 57 with a length of 27.33 mm. At day 6, the SAtG of FARO 57 had the longest plumule length of 40 mm with control of FARO 52 having the least length of 26.67 mm.

Length of radicle of FARO 44, FARO 52 and FARO 57 rice varieties: Table 3 shows the length of radicle of the three rice varieties. The longest radicle length was observed in the $NH_2OH.HCl$ treated grains of FARO 44 and 57 both having a length of 3.67 mm each on day 2 while the SAtG of FARO 52 had no radicle. At day 3, $NH_2OH.HCl$ treated grains of FARO 57 still had the longest radicle of length 18 mm with the least radicle length coming from the $NH_2OH.HCl$ treated grains of FARO 52 having a length of 3 mm. At day 4, the longest radicle length was observed in the $NH_2OH.HCl$ treated grains of FARO 44 having a length 26.67 mm while the SAtG of FARO 57 had the shortest radicle of length of 13 mm. At day 5, the $NH_2OH.HCl$ treated grains of FARO 44 still had the longest radicle length of 41 mm while the least radicle length was observed in the SAtG of FARO 52 having a length of 20.67 mm. At day 6, the $NH_2OH.HCl$ treated grains of FARO 57 had the longest radicle length of 50 mm while the SAtG of FARO 52 had the shortest length of 20.67 mm.

Table 2. Length of plumule of the three rice varieties (mm)

	FARO 44 Control	FARO 44 $NH_2OH.HCl$	FARO 44 NaN3	FARO 52 Control	FARO 52 NH2OH.HCl	FARO 52 NaN_3	FARO 57 Control	FARO 57 $NH_2OH.HCl$	FARO 57 NaN_3
Day 2	0.00^{b}	0.33 ± 0.27^{b}	1.67 ± 0.97^{a}	0.33 ± 0.27^{b}	0.00^{b}	0.00^{b}	0.00^{b}	0.00^{b}	0.67 ± 0.54^{ab}
Day 3	5.33 ± 0.88^{a}	4.00 ± 0.91^{a}	5.33 ± 1.65^{a}	5.33 ± 0.88^{a}	5.67 ± 0.67^{a}	4.33 ± 0.88^{a}	4.67 ± 0.67^{a}	6.33 ± 0.88^{a}	6.00 ± 1.00^{a}
Day 4	14.33 ± 2.19^{a}	12.33 ± 4.06^{a}	10.33 ± 3.19^{a}	13.67 ± 1.67^{a}	13.33 ± 1.20^{a}	9.00 ± 3.51^{a}	13.33 ± 2.19^{a}	14.33 ± 2.40^{a}	12.00 ± 0.58^{a}
Day 5	22.00 ± 1.20^{a}	21.33 ± 5.81^{a}	18.00 ± 4.04^{a}	20.33 ± 1.86^{a}	19.67 ± 1.45^{a}	18.00 ± 5.69^{a}	19.67 ± 2.60^{a}	21.33 ± 3.85^{a}	27.33 ± 0.88^{a}
Day 6	32.00 ± 3.79^{a}	30.33 ± 2.03^{a}	31.67 ± 7.36^{a}	26.67 ± 1.67^{a}	31.67 ± 4.67^{a}	30.00 ± 7.21^{a}	28.33 ± 5.49^{a}	29.33 ± 4.91^{a}	34.00 ± 1.15^{a}

Mean ± standard error. Mean of three replicates.

Different alphabets in rows indicate significant differences at 5 % level of probability.

Table 3. Length of radicle of the three rice varieties (mm)

	FARO 44 Control	FARO 44 $NH_2OH.HCl$	FARO 44 NaN3	FARO 52 Control	FARO 52 NH2OH.HCl	FARO 52 NaN_3	FARO 57 Control	FARO 57 $NH_2OH.HCl$	FARO 57 NaN_3
DAY 2	1.00 ± 0.00^{a}	3.67 ± 1.20^{a}	3.33 ± 1.13^{a}	1.67 ± 0.56^{a}	1.33 ± 1.09^{a}	0.00^{a}	2.67 ± 2.18^{a}	1.00 ± 0.00^{a}	3.67 ± 1.37^{a}
DAY 3	13.67 ± 2.91^{ab}	13.00 ± 3.76^{ab}	12.33 ± 2.33^{ab}	13.33 ± 0.88^{ab}	3.00 ± 0.00^{b}	8.00 ± 1.53^{ab}	12.67 ± 3.71^{ab}	7.00 ± 3.79^{ab}	18.00 ± 2.52^{a}
DAY 4	21.67 ± 3.38^{a}	26.67 ± 4.48^{a}	16.33 ± 3.76^{a}	19.33 ± 1.86^{a}	13.33 ± 3.18^{a}	15.67 ± 4.50a	22.00 ± 4.51^{a}	13.00 ± 7.23^{a}	25.33 ± 3.29^{a}
DAY 5	35.00 ± 3.51^{ab}	41.00 ± 4.73^{a}	29.00 ± 5.51^{ab}	25.00 ± 2.52^{b}	23.33 ± 5.70^{b}	20.67 ± 6.36^{b}	33.33 ± 3.93^{ab}	26.33 ± 3.48^{ab}	35.33 ± 4.70^{ab}
DAY 6	43.67 ± 2.73^{ab}	48.33 ± 3.71^{a}	39.67 ± 6.36^{ab}	32.00 ± 4.16^{abc}	27.33 ± 4.18^{bc}	20.67 ± 6.77^{c}	39.67 ± 5.67^{ab}	35.67 ± 2.03^{abc}	50.00 ± 16.46^{a}

Mean ± standard error. Mean of three replicates.

Different alphabets in rows indicate significant differences at 5 % level of probability

Yield parameters of FARO 44, FARO 52 and FARO 57 rice varieties: Table 4 shows the yield parameters of the three rice varieties. For number of tillers per plant at 20 weeks after planting (WAP), the $NH_2OH.HCl$ treated grains of FARO 52 and 57 had the highest number of tillers per plant. They both had 4 tillers. For FARO 44, the highest number of tillers was observed in its SAtG having about 3.67 tillers. The least number of tillers was observed in the control of FARO 52 with 2.33 tillers. For number of panicles at harvest, the NaN_3 treated seeds of FARO 44 had the highest number of panicle, with about 5 panicles. For FARO 52, the control and SAtG had the highest number of 2 panicles each. For FARO 57, the highest number of panicles was observed in its $NH_2OH.HCl$ treated grains with 3.33 panicles. The least number of panicle was observed in the $NH_2OH.HCl$ treated grains of FARO 52.

Table 4. Yield parameters of the three rice varieties

Varieties	No. of tillers per plant at 20 weeks	No. of panicles per plant at harvest	100-grain weight (g)
FARO44Control	3.33 ± 0.67^{a}	4.00 ± 0.00^{ab}	3.24 ± 0.14^{a}
FARO44NH2OH.HCl	3.00 ± 0.58^{a}	3.67 ± 0.33^{ab}	3.58 ± 0.00^{a}
FARO44NaN3	3.67 ± 1.20^{a}	5.00 ± 1.00^{a}	3.39 ± 0.39^{a}
FARO52Control	2.33 ± 0.58^{a}	2.00 ± 0.00^{b}	0.92 ± 0.00^{b}
FARO52NH2OH.HCl	4.00 ± 2.00^{a}	1.67 ± 1.67^{b}	0.90 ± 0.00^{b}
FARO52NaN3	3.00 ± 2.08^{a}	2.00 ± 0.00^{b}	1.00 ± 0.02^{b}
FARO57Control	2.67 ± 0.67^{a}	2.67 ± 1.33^{b}	1.10 ± 0.28^{b}
FARO57NH2OH.HCl	4.00 ± 0.00^{a}	3.33 ± 1.45^{ab}	1.31 ± 0.41^{b}
FARO57NaN3	3.33 ± 0.88^{a}	3.00 ± 1.00^{ab}	1.21 ± 0.16^{b}

Mean ± standard error. Mean of three replicates.
Different alphabets in columns indicate significant differences at 5 % level of probability.

For 100-grain weight, the highest was observed in the $NH_2OH.HCl$ treated grains of FARO 44 having a weight of 3.58 g followed by its SAtG having a weight of 3.39 g. For FARO 52, the highest was observed in its SAtG having a weight of 1.00 g. For FARO 57, the highest was observed in its $NH_2OH.HCl$ treated grains with a weight of 1.31 g. The least was observed in the $NH_2OH.HCl$ treated grains of FARO 52 with a weight of 0.9 g.

DISCUSSION

Percentage germination was highest, though not significant in the sodium azide treated grains of FARO 44 and 52 while the Hydroxyl ammonium hydrochloride treated grains had high germination percentage in FARO 57 (Table 1). The percentage germination of FARO 57 treated with sodium azide was low compared to that treated with Hydroxyl ammonium hydrochloride. Cheng and Gao (1988) treated barley seeds with sodium azide and recorded significant decrease in percentage germination. Their study supports sodium azide effect in germination of FARO 57. Aliero (2006) treated the seeds of *Sesamum indicum* with hydroxylamine and reported an increase in germination and seedling development. The effect of Hydroxyl ammonium hydrochloride on FARO 57 supports their findings. Previous studies showed that sodium azide decreased percentage germination. Khan *et al*. (2004, 2005) reported decrease in germination in chicken pea and mung bean. Omoregie (2014) also reported a delay in percentage germination in rice treated with sodium azide.

Length of plumule was relatively long, however not significantly different in the sodium azide treated varieties of FARO 44 as at day 2 (Table 2). Al-Qurainy and Khan (2009) reported that sodium azide is a strong mutagen in plant that affects the different parts of the plants and their growth developmental phenomena by disturbing the metabolic activities. At day 6, the longest plumule was observed in the control of FARO 44 followed by its sodium azide treated grains. In FARO 52, the longest plumule was observed in the Hydroxyl ammonium hydrochloride treated grains. In FARO 57, the longest plumule was observed in the sodium azide treated grains. These differences were statistically insignificant.

Length of radicle was significantly different in the Hydroxyl ammonium hydrochloride treated grains of the three rice varieties at day 6 (Table 3). At day 6, all the Hydroxyl ammonium hydrochloride treated grains of the three rice varieties had the longest radicle length. The least length was observed in all the sodium azide treated grains of the three rice varieties. Similar results were obtained by Al-Qurainy and Khan (2009). They observed the lowest root length on day 14 for the group of barley exposed to 2.5 mM sodium azide for 3 hours.

For yield parameters (Table 4), the highest number of tillers per plant was highest in the Hydroxyl ammonium hydrochloride treated grains of FARO 52 and 57. In FARO 44, the highest was observed in its sodium azide treated grains. Although these differences were not significant.Ikhajiagbe *et al*. (2013) observed an enhancement in the number of tillers by sodium azide on FARO 57.

For number of panicles per plant at harvest, the sodium azide treated grains of FARO 44 had the highest number of panicle at harvest followed by its control. For FARO 52, both the control and sodium azide treated grains had the highest number of panicle harvested. Khan *et al*. (2004) reported that the number of pods in mung bean increased with sodium azide treatment. For FARO 57, its Hydroxyl ammonium hydrochloride treated grains had the highest number of panicle harvested.

For hundred-grain weight, no significant difference was observed. The Hydroxyl ammonium hydrochloride treated seeds of FARO 44 had the highest grain weight followed by its sodium azide treated grains. For FARO 52, the highest grain weight was observed in its sodium azide treated grains. For FARO 57, the highest grain weight was observed in its Hydroxyl ammonium hydrochloride treated grains.

As conclusion, the observations from this research indicate that both sodium azide and Hydroxyl ammonium hydrochloride are potent mutagens. Sodium azide was found to be more effective on FARO 44 and 52 while Hydroxyl ammonium hydrochloride was more effective on FARO 57. This research has also shown that the level of muatagenic activity of a mutagen can vary among varieties of a particular species. More research into this variability should be researched into.

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