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Genetic and correlation analyses of the variation in yield traits in x - ray irradiated groundnut mutants

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ABSTRACT:

The experiment analyzed the genetic variation in morphological traits in x - ray irradiated groundnut (*Arachis hypogaea* L.) to assess adaptation to humid environment. Seeds of four soybean varieties; MS – 54 – 76, ICGV – SM – 42, RMP – 12 and SAMNUT 21, were exposed to six levels of x - ray irradiation; 0, 40, 60, 80, 100 and 120 KV at the rate of 28 mili Ampere per seconds. The experiment was laid out in split plot design, in three replicates. There were increases in the 100 seed weight, number of pods per plant, weight of pods per plant, weight of seeds per plant and shelling percentage in M_2 than in the M_1 implying that x – ray created beneficial variation in the cultivars. The x – rays also reduced the number of days to maturity and number of days to flowering in M_2. Phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) in all traits. Moderate to high heritability and genetic advance estimates were obtained for most traits. Number of branches per plant, seed weight per pod and number of pods per plant were significantly and positively associated with grain yield per hectare. The high range of the genetic components among the traits and positive

correlation coefficient indicates that pedigree selection should be used to improve on the traits. By virtue of performance in the humid environment, MS54-76 and RMP 12 were best adapted to the humid ecology.

Keywords: Mutation breeding, Mutant varieties, Mutagenesis, *Arachis hypogaea* L., x – ray irradiation

INTRODUCTION

Groundnut or peanut (Arachis hypogaea L.) is a legume in the family Fabaceae. It has high protein (26 - 28%), fats and edible oil (50%) content, more than 6 essential vitamins and minerals (Nigam et al., 1991). The crop is a major oil seed, mainly of the monounsaturated fatty acids, considered as healthy oil with nutritional benefits for man and livestock (Olatunde et al. 2014). China is the world's leading producer of groundnut with 16.05 MM tonnes, followed by India with 15.5 MM tonnes and USA with 1.66 MM tonnes (China Agriculture, 2013). According to FAO (2008), 34.8 MM tonnes of groundnut was produced globally in 2008, of which Nigeria contributed 3.8 MM tonnes. Before 1966, Nigeria was a major exporter of groundnut, but production had declined steadily because the Sahara desert had encroached areas where groundnut was cultivated, followed by a switch from agrarian to oil economy, such that groundnut farmers are engaged in other sectors (Alobi et al. 2013).

An estimated 200 million people in Africa are under – nourished (Benson, 2004), and the number of people in this category is increasing. Food production to combat the under nourishment is impaired by decline in the land area available for agricultural purposes caused by expanding poorer soil conditions, desert encroachment, urban population growth and phenomena of global climatic changes associated with erratic weather. To boost the nutrition status, all the available land, either in the rainforest region or savannah should be utilised in food production to add credence to the nutrition and food security efforts in the continent. Groundnut has immense health benefits because of its nutrient content and it creates income for many smallholder farmers but it has the limitation in the areas where it can grow commercially. In Nigeria, groundnut production is concentrated in the Guinea and Sudan savannah (Taphee and Jongur, 2014), because the genotypes are adapted to the weather condition. Also, groundnut has low variability and this affects its production (Showemimo et al. 2012).

The yield in crop plants can be improved by selection and by combining traits that contribute to the physiological efficiency to enhance the economic yield of the crop. Successful breeding programme depends on the degree of genetic variation that can be created in the plant population. The estimate of the heritability and other genetic parameters are essential to indicate the direction to focus in the improvement of traits in crop plants and lay down the guidance for selection programme. Mutation induction is an important tool used to create variability in plants. Over the years, superior plant varieties have been developed with the use of induced mutation (Kharkwal and Shu, 2009), because mutagenesis procedures are much simpler and faster than the conventional hybridization. Ionising radiation, such as alpha particles, gamma and x – rays have the advantage of effective penetration, and the treatment of seeds with these agents is the most convenient and practical means to directly change the genetic makeup of the plants.

Groundnut seeds contain protein, fat and carbohydrate and that is what makes them sensitive to radiation induced stress, but low doses of radiation have beneficial effects (Faraq and Zahran, 2014). The objectives of this study were to evaluate the variation in some yield traits created with x – ray irradiation in four groundnut varieties to evaluate adaptation to humid environment, and then to estimate the genetic variances and the relationship between the yield traits in the mutant varieties.

MATERIALS AND METHODS

The experiment was conducted in the Department of Crop Science, University of Calabar, Calabar (latitude 4.50 N; longitude 8.00 E), in Nigeria. Two hundred seeds each of four Groundnut varieties: MS 54-76, ICGV-SM-42, RMP 12 and SAMNUT 21 were irradiated with 40, 60, 80, 100 and 120 KV of x – ray at the rate of 28 mili-amperes per second (mA/s) for 20 minutes each, the beams were placed 30 cm above the platform; seeds set aside as control (0KV) were not irradiated.

The experiment was laid out in split plot design with three replications. X – ray dosages were the main - plot treatments and varieties were the sub - plot treatments. The seeds were sown at a spacing of 0.45 m x 0.25 m and each sub - plot was made up of four rows; three seeds were sown per hole and later thinned to one seedling per hole giving a plant population of 88, 889.00 plants per hectare, at one week after establishment. Three generations of planting was carried out in this study; from irradiated (M0) to first (M1), then to second (M2) mutant generation.

Six plants in the middle – rows (2nd and 3rd) of each sub - plot in the M1 and M2 generations were tagged for data collection. Some of the characters measured were: number of days to 50 % seedling emergence, plant height (cm), number of branches per plant, Number of days to 50 % flowering, number of days to pods maturity, number of pods per plant, number of empty pods per plant, number of seeds per pod, weight of pods per plant (g), weight of seeds per plant (g), weight of seeds/hectare, length of pod per plant (cm), shelling percentage and 100 seed weight.

The data collected were analysed using GENSTAT (2005) Software for Analysis of Variance (ANOVA) and significant means were compared using Duncan's New Multiple Range Test (DNMRT). The linear additive model used for the analysis of variance was stated as Yijk = μ + rk + ai + δik + bj + (ab)ij + eijk

Where: Yijk = observation in the kth replicate of the ith dosage of the x – ray and the jth variety; μ = the general mean of the population; rk = the block effect for the kth block; ai = effect of the ith main plot treatment; δik = the random error associated with the main plot; bj = the effect of the jth sub – plot or variety treatment; (ab)ij = the effect of the interaction between the main plot and the sub plot treatment and eijk = the random error associated with the sub plot.

The broad sense heritability was computed from the expected mean squares of variance components from ANOVA using the formulae below (Steel and Torrie, 1982), presented in Table 1. Components of genotypic (σ2g), phenotypic (σ2P) and environmental or error (σ2e) variances were

$$\sigma^2 g = \frac{MSg - MSaxg}{ra}; \quad \sigma^2 e = MSe \quad \text{and} \quad \sigma^2 p = \sigma^2 g + \sigma^2 e$$

Where: MSg = mean square of genotypes, MSaxg = mean square of the interaction between x – ray dosages and varieties, MSe = mean square of error, a = number of x – ray dosages and r = number of replications.

Genetic analyses were determined by the phenotypic coefficient of variance (PCV) and the genotypic coefficient of variance (GCV).

$$\text{PCV (\%)} = \frac{\sqrt{\sigma^2 p} \times 100}{x} \quad \text{and} \quad \text{GCV (\%)} = \frac{\sqrt{\sigma^2 g} \times 100}{x}$$

Where: x = sample mean

The expected genetic advance (GA) and genetic advance percentage (GA %) were calculated as

$$\text{Expected genetic advance (GA)} = i\sigma pH, \text{ and } GA\,\% = \frac{GA}{x} \times 100$$

Where: i = Standardized selection difference constant at 5 % = 2.06, σp = phenotypic standard deviation and x = grand mean of the population.

Broad sense heritability estimate (H) = ratio of the genetic variance to the phenotypic variance in per cent

$$\text{Heritability (H)} = \frac{\sigma^2 g}{\sigma^2 p} \times 100$$

Simple correlation coefficient (r) was calculated for the association between yield and yield related traits;

$$r = \frac{\text{cov}(X, Y)}{s_X s_Y}$$

RESULTS AND DISCUSSION

The growth curve of the number of branches per plant in the second mutant (M_2) generation of the x –ray irradiated groundnut cultivars is shown in Figure 1. RMP 12 had significantly the most number of branches per plant at physiological maturity, at 11 weeks after planting (WAP), then, ICGV-SM -42 had more branches than MS 54-76 and SAMNUT 21. The growth curve in respect of the plant height in the M_2 generation is shown in Figure 2, ICGV-SM-42 had the tallest plants, while SAMNUT 21 had the shortest plants at maturity.

Growth and yield traits in the first (M1) and second (M2) mutant generations of the x – ray irradiated groundnut cultivars are presented in Table 2. There was no significant difference in the number of days from planting to 50 % seedling emergence in the irradiated cultivars in M1 generation. In the M2 generation, MS 54 – 76 and RMP – 12 had the least number of days to 50 % seedling emergence. In the number of days to physiological maturity, MS54-76 matured fastest in 91 and 90 days in M1 and M2 respectively, Samnut 21 matured in 126 days in both the M1 and M2, the 126 days was the longest. The number of days to maturity is an important character in humid environment because crops like groundnut, which are generally adapted to semi – arid and arid weather conditions can be cultivated in the humid environments, utilising the relatively short dry season (Shiyam, 2010).

MS54-76 had the highest 100 seeds weight in the M2 generation (61.4 g), the weight was heavier than 40 g in M1. Nadaf et al. (2009) and Channayya et al. (2010) also noted an increase in the 100 seed weight in M2 generation, more than in the M1. ICGV – SM – 42, RMP – 12 and SAMNUT 21 also had higher seed weight per plant in the M2 generation than the M1 parents. Increased shelling percentage was observed in the second (M2) mutant generation for MS 54 – 76, ICGV – SM – 42 and RMP – 12 compared to their respective parents (M1). The earliness of flowering observed in both M1 and M2 showed that MS 54 – 76 had the lowest number of days from planting to 50 % flowering in M2. Grain yield per hectare recorded by ICGV – SM – 42 and SAMNUT 21 in the second (M2) mutant generation were higher compared to the yield per hectare in the first (M1) mutant generation. Yield is the result of the cumulative effect of the increase in seed weight per plant and increased in the number of seeds per pod, which had impacted on the grain yield/ha in the varieties in the M2 generation. All the phenotypic variations between M1 and M2, are directed towards increase in characters in the M2 are indicators that x – ray radiation was beneficial to the plants.

The coefficients of variation and heritability estimates of the traits are shown in Table 3. The phenotypic coefficient of variation (PCV) and the genotypic coefficients of variation (GCV) were positive for all the traits. High PCV and GCV were observed in the number of branches (79.3 and 68.7), number of pods per plant (101.5 and 100), weight of pods per plant (144.8 and 141.6), weight of seeds per plant (82.8 and 74.3) number of empty seeds per pod (155 and 143.5), shelling per cent (71 and 67.8) and grain yield per hectare (79.8 and 70.5) indicating the presence of high variability in the characters and the potentials for their improvement through selection. This study corroborates the works of Rajib and Jagatpati (2011) and Mousmi et al. (2013).

Low phenotypic (PCV) and genotypic (GCV) coefficient of variations were observed in plant height (25.8 and 22.8), number of days to 50 % seedling emergence (19.2 and 13), number of days to 50 % flowering (10 and 9.9), number of days to maturity (32.2 and 31.6), weight of 100 seeds (54 and 34.6) and pod length per plant (24 and 22) indicated the unstable nature of the traits and are indicative of low likelihood for improvement of the traits through selection (Okoye and Eneobong, 1992; Rajib and Jagatpati, 2011).

Traits with high heritability estimates were number of branches per plant (75%), plant height (78%), number of days to 50 % flowering (96%), number of pods per plant (97%), weight of pods per plant (95%), number of days to maturity (96%), weight of seeds per plant (80.6%), shelling per cent (91%), pod length per plant (84%) and grain yield per hectare (78%). The heritability ranging from 75 % to 97 % indicated that non – genetic components or environment had minor affect on the phenotypic expression of traits (Mousim et al., 2013); and equally showed high response to selection in these trait (Shadakshari et al., 1995). Also, high genetic advance was observed for the number of branches at 11 WAP (122.6), weight of seeds per plant (137.5), shelling percentage (133), number of filled pods per plant (95) and grain yield per hectare (123.5) showing the influence of additive gene action, as such direct selection can be carried out on these traits (Idahosa et al., 2010; Rajib and Jagatpati, 2011).

High heritability with low genetic advance was observed in the number of days to 50 per cent flowering, indicating non - additive genes were in control of the characters, the low genetic coefficient of variation and heritability obtained for grain yield was not particularly surprising since yield is a product of many complex characters. Therefore, direct selection to improve grain yield may not be possible, except through indirect selection of related secondary traits (Rajib and Jagatpati, 2011).

The correlation matrix showing the association between pairs of traits in the x – ray irradiated groundnuts is presented in Table 4. The number of seeds per pod correlated positively and significantly with weight of seed per plant and grain yield per hectare indicating that improving the grain yield in the cultivares can be achieved through selection of plants with higher number of seeds per pod or plants with heavier seeds. Also, positive and significant association existed between the number of days from planting to 50 % flowering with the number of days from planting to maturity, number of seeds per pod and weight of seed per plant implying that selection can be used for improvement of these traits. Positive association was observed between the number of days to 50 % seedling emergence and shelling percentage, and with grain yield per hectare. The significant positive correlation between the characters suggests that the characters can be improved simultaneously in a breeding programme (Idahosa et al., 2010).

In this study, the early maturing variety; MS54-76 and RMP 12 yielded higher than the other varieties because they avoided the period of intensive rainfall in the study area; Calabar. Calabar is an humid environment, rains are highest from April to October. Similar stress avoidance mechanism has been reported in groundnut in response to drought and cold conditions (Pasupuleti et al., 2013). The traits with high genotypic and phenotypic coefficient of variability, high heritability, high genetic advance and positive correlation coefficient between the pairs of characters, can be used for improving the x – ray irradiated groundnut by selection in the humid environment. The traits, such as number of branches per plant, number of pods per plant, weight of pods per plant, weight of seeds per plant, shelling percentage and grain yield per hectare can be reliably and efficiently improved by selection.

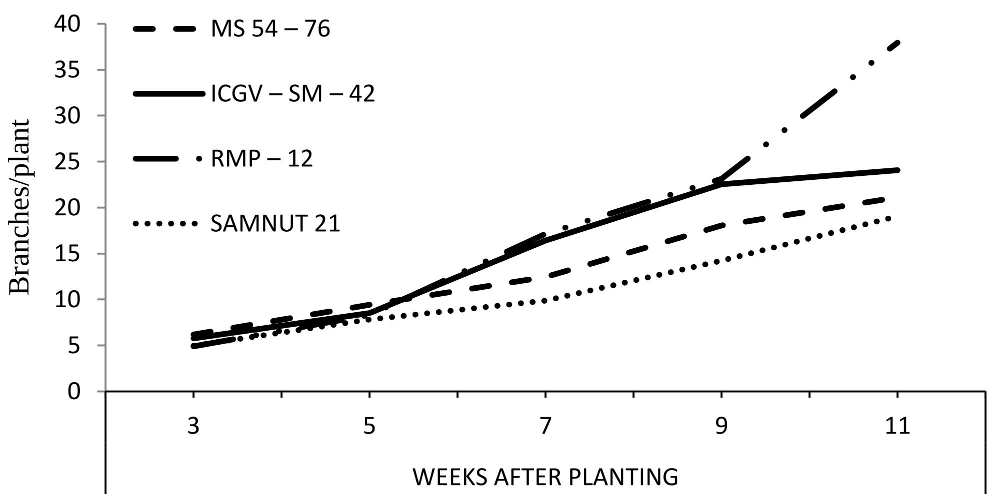

Figure 1. Number of branches per plant in M_2 generation of x - ray irradiated groundnut cultivars

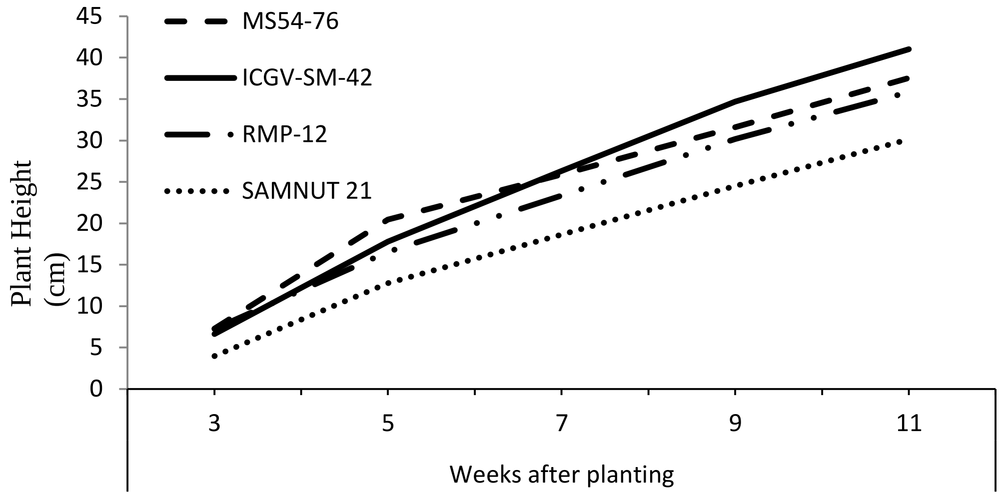

Figure 2. Plant height in M_2 generation of x - ray irradiated groundnut cultivars

Table 1. Analysis of variance and expected mean squares for the x –ray and varieties model

Source of variation	DF	Mean square	Expected mean square
Replication	r – 1	MSr	$\sigma^2e + g\sigma^2\gamma + ag\sigma^2r$
X – ray dosage	a – 1	MSa	$\sigma^2e + g\sigma^2\gamma + r\sigma^2ag + r\sigma^2a$
Replication x X – ray	(r – 1)(a – 1)	MSrxa	$\sigma^2e + g\sigma^2\gamma$
Variety	g – 1	MSg	$\sigma^2e + r\sigma^2ag + ra\sigma^2g$
X – ray x Variety	(a – 1)(g – 1)	MSaxg	$\sigma^2e + r\sigma^2ag$
Error	a(a – 1)(g – 1)	MSe	σ^2e
Total	**rag - 1**		

Table 2. Growth and yield traits of x - ray irradiated M_1 and M_2 mutant groundnut in the humid environment

	D50% SE	DMat	100SW	EPP	NSPP	D50%Fl	NPP	PWtP	SWtP	SP%	YLDHA
M_1 generation											
MS54-76	5.44^{a}	91.39^{c}	50.41^{a}	9.30^{a}	1.25^{a}	26.22^{c}	54.70^{a}	43.70^{a}	14.34^{a}	23.80^{b}	2210^{a}
ICGV-SM-42	5.67^{a}	109.67^{b}	35.59^{b}	9.50^{b}	1.24^{a}	28.61^{a}	28.00^{bc}	28.10^{bc}	8.13^{b}	29.80^{b}	1279^{b}
RMP-12	5.33^{a}	110.44^{b}	47.53^{a}	9.89^{b}	1.29^{a}	28.61^{a}	32.40^{b}	34.00^{b}	10.07^{ab}	29.80^{b}	1591^{ab}
SAMNUT21	6.33^{a}	126.67^{a}	31.37^{c}	7.58^{b}	1.22^{a}	27.50^{b}	22.20^{c}	14.50^{c}	6.71^{b}	45.60^{a}	1060^{b}
M_2 generation											
MS54-76	3.83^{c}	90.33^{c}	61.40^{a}	7.00^{a}	1.58^{a}	25.67^{b}	22.14^{a}	21.30^{a}	12.86^{a}	62.74^{a}	2032.0^{a}
ICGV-SM-42	5.78^{ab}	114.61^{b}	44.20^{b}	8.89^{a}	1.33^{a}	28.22^{a}	25.00^{a}	23.40^{a}	9.22^{b}	$46.01b^{c}$	1458.0^{ab}
RMP-12	4.94^{b}	114.94^{b}	42.40^{b}	8.78^{a}	1.34^{a}	28.39^{a}	21.45^{a}	19.90^{a}	10.10^{ab}	54.60^{ab}	1524.0^{ab}
SAMNUT21	6.50^{a}	126.56^{a}	37.90^{b}	7.61^{a}	1.26^{a}	28.50^{a}	16.05^{a}	23.80^{a}	7.68^{b}	36.60^{c}	1214.0^{b}

Key: Means with different letters in each column in the M_1 and M_2 generations for a particular trait were significantly different at 5% probability. D50% SE = Days to 50% Seedling Emergence; DMat = Days to Maturity; 100SW = 100 Seed Weight; EPP = Empty pods per plant; NSPP = Number of seeds per pod; D50% Fl = Days to 50% Flowering; NPP = Number of Pods per Plant; PWtP = Pod Weight Per Plant (g); SWtP = Seed Weight per Plant (g); SP%= Shelling Percentage.

Table 3. Components of variation in the X - ray irradiated groundnut

Morphological trait	σ^2g	σ^2p	GCV	PCV	GA	H
No Branches at 11WAP	699.41	931.65	68.69	79.28	122.61	75.07
Plant height at 11WAP	88.16	112.98	22.80	25.82	41.52	78.05
Days of 50% emergence	0.56	1.20	13.10	19.24	18.38	46.33
Days of 50% flowering	7.52	7.76	9.89	10.04	20.05	96.91
No of pods/plant	1179.20	1211.7	100.12	101.49	203.45	97.32
Weight of pods/plant	2472.00	2586.83	141.65	144.88	285.25	95.56
Days of maturity	1196.89	1247.24	31.58	32.24	63.73	95.96
No of seeds/pods	-0.02	0.01	-10.59	5.92	-32.96	-200
Weight of seed/plant	53.19	65.98	74.34	82.80	137.51	80.62
Empty pods/plant	494.53	578.2	143.5	155.13	262.41	85.53
Shelling percentage	479.03	526.5	67.76	71.04	133.00	90.98
100 seed weight	259.00	634.00	34.61	54.00	45.57	40.85
Pod length/plant	0.27	0.32	22.35	24.33	42.20	84.38
No of filled pod/plant	119.87	161.78	53.67	62.35	95.17	74.09
Grain yield / ha	1171540	1500710	70.50	79.81	123.54	78.10

Key: σ^2g = variance of the genetic component; σ^2p = variance of the phenotypic component; GCV = genotypic coefficient of variation; PCV = phenotypic coefficient of variation; GA% = genetic advance per cent and H = broad sense heritability.

Table 4. Correlation coefficient among the traits of X-ray irradiated M_2 mutant groundnut varieties in humid environment.

	D50%Fl	PDPT	WPD	DYMT	SDPD	WSD	EPPD	SH%	100SD	LTPD	FDPD	YLDHA
D50%SE	0.845	-0.452	0.734	0.942	-0.931	-0.911	0.366	0.991**	-0.573	-0.901	-0.585	0.968*
D50%Fl		-0.255	0.288	0.953*	0.979*	0.990**	0.728	-0.777	-0.070	-0.582	-0.466	-0.940
PDPT			-0.249	-0.496	0.387	0.292	0.452	0.531	0.215	0.252	0.973*	0.475
WPD				0.466	-0.445	-0.419	-0.084	-0.782	-0.975*	-0.945	-0.244	-0.540
DYMT					0.992**	0.975*	0.493	-0.911	-0.270	-0.706	-0.667	0.996**
SDPD						0. 99**	-0.593	0.886	0.239	0.702	0.574	0.990**
WSD							-0.670	0.854	0.209	0.689	0.490	0.973*
EPPD								-0.241	0.264	-0.205	0.233	-0.480
SH%									0.639	0.914	0.638	0.940
100SD										0.849	0.160	0.349
LTPD											0.322	0.766
FDPD												0.640

Key: * and ** Differ significantly at 5 % and 1 % probability level respectively. D50%SE = Days to 50 % seedling emergence; D50%Fl = Days to 50 % lowering (50%F); PDPT = Number of pods per plant; WPD = Weight of pods per plant; DYMT = Days to maturity; SDPD = Number of seeds per pod; WSD = Weight of seeds per plant; EPPD = Number of empty pods; SH% = Shelling percentage; 100SD = 100 seed weight; LTPD = Length of pod; FDPD = Number of filled pods; YLDHA = Grain yield per hectare.

REFERENCES

[1] Alobi, O. F. Owonibi, B., Olafemi, S. O. and Olagunju, S. (2013) Production analysis of groundnut in Birni Gwari Lcal Government Area, Kaduna. Production and Technology Journal (PAT) 9: 102 - 113

[2] Benson, T. (2004) Africa's food and nutrition security situation: Where are we and how did we get here? 202 Discussion paper No 37. Washington, DC: International Food Policy Research Institute

[3] Channayya H., Nadaf H. L., Ganapathi M. and Praveenkumar B. (2010). Induced mutations in groundnut (Arachis hypogaea L.) Karanataka Journal of Agricultural Science, 23, 327-329.

[4] China Agriculture (2013). World peanut production 2012. www.cnagric.com.

[5] FAO (2008) Economic and Social Department. The Statistical Division of the Food and Agriculture Organization of the United Nation

[6] Farag, I.A. A. and Zahran, A. A. (2014) Groundnut (Arachis hypogaea L) growth and yield responses to seed irradiation and mineral fertilization. IOSR Journal of Agriculture and Veterinary Science 7: 63-70

[7] GENSTAT (2005) GenStat Release 8.1 (PC/Windows) Lawes Agricultural Trust (Rothamsted Experimental Station)

[8] Idahosa D. O, Alika J.E and Omoregie A. U. (2010) Genetic variability heritability and expected genetic advance as indices for yield and yield components selection in cowpea (Vigna unquiculata L) Walp. www.sceincepub.net/academia

[9] Kharkwal, M. C and Shu, Q. Y. (2009). The role of induced Mutations in World Food Security (pp. 33-38). FAO, Rome.

[10] Mousmi S., Gupta, V. K. and Pendey H. C. (2013) Studies of phenotypic and genetic variation in various growth characters in neem (Azadirachata indica. A. Juss) gemplasm. Journals of Agricultural Science Research, 3, 72-78

[11] Nadaf, H. L., Kaven S. B., Madhusudan K. and Motagi B. N. (2009). Induced genetic variability for yield and yield components in peanut (Arachis hypogaea L.). In Shu, Q. Y. (Ed.), Induced plant mutation in the genomics era (pp. 346-348). FAO, Rome.

[12] Nigam, S. N., Dwivedis S. L. and Gibbons, R. W. (1991). Groundnut breeding, constraints achievement and future possibilities. Plant Breeding Abstract, 61, 1127-1136.

[13] Okoye, F. I. and Eneobong, E. E. (1992). Genetic variability and correlation studies in African yam bean (Sphenostylis stenocarpa). Nigerian Journal of Botany. 5, 75-83.

[14] Olatunde, O. B, Ajav E. A and Fatukasi S.O (2014) Design and fabrication of groundnut (Arachis hypogaea) roaster cum expeller. International Journal of Science and Technology 3: 177 – 184.

[15] Pasupuleti, J., Nigam, S. N., Manishh, K. P., Nagesh, P. and Rajeev, K. V. (2013). Groundunt improvement: Use of genetic and genomic tools. Front Plant Science, 4, 23-26.

[16] Rajib R. and Jagatpati, T. (2011). Evaluaion of genetic parameters for agro-metrical characters in carnation genotype. Journal of African Crop Science, 19, 183 - 188.

[17] Shadakshari, Y. G., Virupahshappa, K . and Shivasharikar (1995). Genetic variability studies in the gemplasm collections of sesamum (Sesamum indicum L.). Mysore Journal of Agricultural Science, 29, 133 – 137.

[18] Shiyam, J. O . (2010). Growth and yield response of groundnut (Arachis hypogaea L.) to plant densities and phosphorus on ultisol in southern Nigeria. Libyan Agricultural Research Center Journal International, 4, 211-214.

[19] Showemimo, F. A., Asare - Bediako, E. A., Abdulai, I., Adewusi, K. M. and Aderinola, A. P. (2012), Genotypic expression of some groundnut varieties to gamma radiation. In: proceedings of 36th annual conference genetics in quest for sustainable agricultural transformation (pp. 140-143). University of Calabar, 15th-18th October 2012.

[20] Shukla, S., Bhavgava, A., Chatterjee, A., Siirivastava, J., Singh, N. and Singh, S. P. (2006). Mineral profile and variability in vegetable amaranth (Amaranthus tricolor). Plant Food and Human Nurition. 61, 23—28

[21] Steel, R. G. D and Torrie, J. H. (1982) Principles and procedures of statistics. A biometrical approach 2nd ed. London McGraw – Hill International Book Co.

[22] Taphee, G.B. and Jongur, A. A. U. (2014) Productivity and efficiency of groundnut farming in Northern Taraba State, Nigeria. Journal of Agricultuer and Sustainability 5: 45 – 56.