J. Appl. Environ. Biol. Sci., 6(8)54-60, 2016
© 2016, TextRoad Publication

ISSN: 2090-4274
Journal of Applied Environmental and Biological Sciences
www.textroad.com

Variability, Correlations, Heritability and Genetic Advance of Rhizome Yield and Yield Related Traits in Ginger (*Zingiberofficinale* Rosc.) Landraces from Burkina Faso

Hervé NANDKANGRE*[1], Mahama OUEDRAOGO[1], Romaric K. NANEMA[2], Souleymane BADO[3], Nobila OUEDRAOGO[1], Mahamadou SAWADOGO[2]

[1]Institut de l'Environnement et de Recherches Agricoles (INERA), Département de Productions Végétales, Laboratoire de Génétique et de Biotechnologies Végétales, 04 BP 8645 Ouagadougou, Burkina Faso
[2] Université de Ouagadougou, UFR-SVT, Département de Biologie et Ecologie Végétales, Equipe de Recherche en Génétique et Amélioration des Plantes, Laboratoire Biosciences, 03 BP 7021 Ouagadougou 03, Burkina Faso
[3] Plant Breeding and Genetics Laboratory, Department of Nuclear Sciences and Application, International Atomic Energy Agency (IAEA), Vienna International Centre, PO Box 100, 1400 Vienna, Austria

Received: April 13, 2016
Accepted: June 5, 2016

ABSTRACT

Ginger (*Zingiberofficina* leRosc.) is an economically important plant, valued all over the world. Ginger was introduced in Burkina Faso several decades ago, and is commonly called « *Gnamankou* ». Identification and characterization of germplasm is an important link between the conservation and utilization of plant genetic resources. A total of 56 ginger ecotypes collected from three provinces (Léraba, Comoé and Kénédougou) in Burkina Faso were assessed in Bérégadougou, based of 13 morph-metric and agronomic traits. Four replications were used in randomized complete block design during the rainy season 2015. This study aimed to assess the extent of genetic variability existing in ginger landraces grown in Burkina Faso through the study of variance components, heritability and genetic advance to select best genotypes for further breeding program. Significant differences were observed ($p < 0.01$) among all the genotypes for all the characters studied, except tillers number per plant. Rhizome yield and rhizome weight per plant showed high phenotypic and genotypic coefficients of variability, while leaf width, rate of emerged shoots, plant height, rhizome width and thickness were relatively moderate. Rhizome weight per plant had significant correlation with rhizome thickness, plant height and leaf width. These traits are most important selection indices of rhizome yield. High heritability estimates associated with high genetic advance were obtained for rhizome weight per plant, rhizome yield, plant height and rhizome length indicating the presence of additive gene action on these characters. Selection based on rhizome weight per plant, plant height, rhizome length and rate of emerged shoots will be rewarding for yield improvement. The study reveals existence of genetic variability among cultivated ginger from Burkina Faso for further yield improvement.

KEYWORDS: Burkina Faso, characterization, selection, *Zingiberofficinale.*

INTRODUCTION

Ginger, the rhizome of *Zingiberofficinale*Rosc.is valued all over the world as a spice in culinary preparations, for its medicinal properties [1, 2, 3], for its horticultural significance [4]and also for the ritual and religious purposes [5]. Ginger is native to India and South-east Asia [6, 7, 8]. India is a leading producer of ginger [9]and contributes for 30% of world's production [10]. In Africa, Nigeria is ranked first, however, yields are comparatively low. That is due to various factors such as poor agronomic practices, unimproved varieties, laborious farming, operations amongst other [11]. Ginger is normally propagated by its rhizome and yield has reached 30 t ha^{-1} of fresh ginger rhizome [12]. Since it is vegetatively propagated, the genetic variability is very limited [13].

Ginger was introduced in Burkina Faso several decades ago, and is commonly called «*Gnamankou*». According to [14], in Burkina Faso, ginger production is limited to small land area (generally less than 1 ha) in spite of its many virtues. It is mainly grown by men in the South-west area and is economically important for the producers and the traders because source instant incomes. In view of the great demand country wide, there is a basic need to develop high yielding varieties with better quality to increase the production and productivity of ginger in Burkina Faso. Genetic variability study and selection for important traits are crucial activities that any plant breeder should apply to achieve better yield and other desirable agronomic traits [15].While plant breeding relies on the availability of the genetic diversity in the species to develop elite cultivar and to preserve that genetic diversity through conservation. The current work aims to assess the extent of genetic variability existing

***Corresponding Author:** Hervé NANDKANGRE, Institut de l'Environnement et de Recherches Agricoles (INERA), Département de Productions Végétales, Laboratoire de Génétique et de Biotechnologies Végétales, 04 BP 8645 Ouagadougou, Burkina Faso. Email: hervenankangre@yahoo.fr Telephone: +226 72 04 30 62 / +226 76 50 90 86 Fax: +226 25300271

in ginger landraces grown in Sudanian agro-ecological zone of Burkina Faso through the study of variance components, heritability and genetic advance to select best genotypes for further breeding program.

MATERIAL AND METHODS

Plant material and study site

The study was carried out in Bérégadougou locates at the South-west of Burkina Faso (10°43'23.7'' N latitude and 004°44'47.1'' W longitude) during the rainy season 2015. Fifty-six ginger ecotypes were collected from three provinces in the Sudanianphyto-geographical zone of Burkina Faso. Three accessions were acquired from Comoé, 16 from Léraba and 37 from Kénédougou (Table1). The minimum and maximum monthly means of temperature of site during the study were respectively 26.4°C (August) and 31.7°C (April) and 935 mm were recorded as total rainfall.

Table 1. Origin and number of ginger accessions collected

Accession N°	Origin
ZoC01; ZoC02; ZoC03	Comoé
ZoL04; ZoL05; ZoL06; ZoL07; ZoL08; ZoL09; ZoL10; ZoL11; ZoL12; ZoL13; ZoL14; ZoL15; ZoL16; ZoL17; ZoL58; ZoL60	Léraba
ZoK18; ZoK19; ZoK20; ZoK21; ZoK22; ZoK23; ZoK24; ZoK25; ZoK26; ZoK27; ZoK28; ZoK29; ZoK30; ZoK31; ZoK32; ZoK33; ZoK35; ZoK36; ZoK37; ZoK38; ZoK39; ZoK40; ZoK41; ZoK42; ZoK43; ZoK44; ZoK45; ZoK46; ZoK48; ZoK49; ZoK50; ZoK53; ZoK54; ZoK55; ZoK56; ZoK57	Kénédougou

Experimental design and agronomic practices

Randomized Complete Blocks (RCB) design was used with four replications. Each block was divided into four sub-blocks, on which 14 accessions were planted per sub-block that corresponds to 56accessions per replication. The spacings between rows and plants were 30 and 20 cm respectively, 50 cm between sub-blocks in size of 4.8 x 1.4 m and 1 m between blocks in size of 10.1 x 3.3 m. eight pieces of rhizome seed of 3 to 5 cm length each, with two to three active buds were planted per accession. Organic manure (dung of cow) was applied after ploughing by spreading 4000 Kg ha^{-1} and also mineral fertilizers, NPK and urea at 150 and 100 Kg ha^{-1} respectively four and six weeks after planting. Regular weeding was performed as needed.

Data collection and analysis

For data collection, three plants were randomly selected per row. The accession ZoK51 was not considered during analyses because it had less than three plants for some rows. A total of 13 parameters were recorded during the different stages of plant development. Four weeks after planting (WAP), the rate of emerged shoots (Emg) was recorded. At the maximum vegetative growth stage and the maturity, seven parameters were recorded. Those included the number of leaves per tiller (NL/T), leaf length (LLen), leaf width (LWid), plant height (PlH), tiller thickness (TilTh), tillers number per plant (Til/P) and days taken to maturity (Dm). After harvest, the rhizomes were washed with tap water and any impurity was removed carefully and five parameters were measured as rhizome length (RhL), width (RhW) and thickness (RhTh), rhizome weight per plant (RhW/P) and yield (YLD).

Analysis of variance was performed with GENSTAT V4.10.3at 1% of probability level. Genotypic and phenotypic correlations were performed using the formula of [16]:

$$\mathbf{rx,y} = \frac{\mathrm{COV(x,y)}}{\sqrt{(\delta^2 x)(\delta^2 y)}}$$

Where rx,y is either genotypic or phenotypic correlation between variables x and y. COV(x,y) is the genotypic or phenotypic covariance between two variables, δ^2x is the genotypic or phenotypic variance of the variable x, δ^2y is the genotypic or phenotypic variance of the yield y.

The mean squares of the genotype and error for each character were used to calculate the genotypic variance (**δ^2g**), phenotypic variance (**δ^2ph**), Heritability (Broad sens) (H^2), Genotypic Coefficient of Variability (GCV), Phenotypic Coefficient of Variability (PCV) and Genetic Advance (GA) (Table 2) according to[15]:

Table 2. Formulas of the genetic parameters estimated

Parameter	Formula	Significance of the terms
Genotypic variance (δ^2g)	$\delta^2g = (MSG - MSE)/r$	MSG: Mean Square of Genotype
Phenotypic variance (δ^2ph)	$\delta^2ph = \delta^2g + (MSE/r) = MSG/r$	MSE: Mean Square of error
Heritability (Broad sense) (H^2)	$H^2 (\%) = (\delta^2g / \delta^2ph)*100$	r: Number of replications
Genotypic Coefficient of Variability (GCV)	$GCV (\%) = (\delta g/X)*100$	δg: Genotypic standard deviations δph: Phenotypic standard deviations
Phenotypic Coefficient of Variability (PCV)	$PCV (\%) = (\delta ph/X)*100$	X: Mean of the character
Genetic Advance (GA)	$GA = H^2 * \delta ph * K$	δph: Phenotypic standard deviations K = 2,06 (Selection coefficient)

RESULTS AND DISCUSSION

Analysis of variance

The results of analysis of variance for the 13 morph-metric and agronomic traits of the ginger collection are given in table 3. Most of the characters under study showed significant differences ($P < 0.01$) except tillers number per plant. The highly significant variation for all the characters studied in the ginger population implies that there is a large genetic variability within the ginger germplasm collection in south-west area of Burkina Faso. This is in agreement with the reports of [17]which reported significant genetic variation in ginger collected from Ethiopia. Similar findings concerning the variability have been reported by [20] for ginger agro morphological characters such as plant height, tiller thickness, rhizome thickness and days taken to harvest.

Mean squares of the genotype were largely relative to error for all the characters studied. These high values of the mean square of genotype than those of error imply that the variation within the ginger collection is essentially due to the ginger accessions. In similar study with ginger landraces grown in Ethiopia, [17] reported that mean squares of genotype for rhizome yield, rhizome length and rhizome width were superior to mean square of error. In the contrary mean squares of error of leaf length and plant height were high than those of the genotype. According to [19], variability tends to limit in cultivars grown in the same region compared to the ones growing in geographically distant locations. In spite of the restriction of the zone of study, considerable diversity was observed between the cultivars for most of the characters. Variability is the basis of selection and the characters showing direct and/or indirect influence on yield and yield contributing traits. Maximum variability was recorded for rhizome weight per plant, followed by rhizome yield, rhizome length and rate of emerged shoots. Mean squares of the genotype were large relative to replication for rate of emerged shoots, leaf width, tiller thickness, rhizome weight per plant and average yield.

Table 3: Mean squares and variability of variance for 13 quantitative traits in 55 ginger cultivars from Burkina Faso

Sources of variation	df	Emg (%)	NL/T	LLen (cm)	LWid (cm)	PlH (cm)	TilTh (mm)	Til/P
replication	3	567	104.56	74.23	0.21	6975.80	0.57	49.22
Genotype	54	787.6**	9.27**	11.84**	1.15**	632.7**	4.04**	10.55ns
Error	162	309	5.38	5.21	0.09	124	0.61	7.69

Sources of variation	ddl	Dm (days)	RhL (mm)	RhWid (mm)	RhTh (mm)	RhW/P (g)	YLD(t ha^{-1})
Replication	3	3243.6	6505	1224.4	114.1	20941	942.6
Genotype	54	62.05**	1574.5**	193.92**	40.08**	79668**	2978.08**
Error	162	27.19	551.2	76.75	15.28	2332	46.33

Keys: df: degree of freedom**; Emg:** rate of emerged shoots **; NL/P:** number of leaves per plant**; LLen:** leaf length**; LWid:** leaf width**; PlH:** plant height**; TilTh:** Tiller thickness**; Til/P:** number of tillers**; Dm:** days taken to maturity**; RhL:** rhizome Length**; RhWid:** rhizome width**; RhTh:** rhizomethickness**; RhW/P** The rhizome weight per plant; **YLD:** average yield; ** *indicate significant difference at 1%,* ***ns****: Not significant*

Phenotypic and genotypic correlations

All the characters studied had positive correlations among themselves (Table 4). Rhizome length had significant correlation with number of leaves, leaf length, leaf width, tiller thickness and plant height. The correlation was also positive and significant between plant height and the leaf dimensions. Rhizome weight per plant had high correlation with all the other characters. Positive and significant correlations between rhizome weight per plant and others yield components traits in this study are in accordance with previous reports [18]. On the contrary, negative correlation had observed between yield per plant and tiller thickness [20].In addition, Leaf width had negative correlations with tiller number per plant and day taken to maturity [18]. The correlation coefficient study showed that rhizome thickness, plant height, leaf length and leaf width served as most important selection indices of rhizome yield and should be emphasized in the breeding programs for genetic improvement. Significant positive correlations between rhizome weight per plant and various traits such as tiller thickness, plant height and rhizome thickness have been reported in ginger [21, 19]. Partitioning of the correlation coefficients into direct and indirect effects revealed that plant height followed by leaf length exhibited maximum direct effect on rhizome yield [18].

Table 4: Estimates of phenotypic (P) and genotypic (G) correlation coefficients for 13 quantitative traits in ginger

Characters		NL/T	LLen	LWid	TilTh	PlH	Til/P	Dm	RhL	RhW	RhTh	RhW/P
Emg	P	0.02	0.02	0.01	0.01	0.13	0.02	0.04	0.17	0.04	0.02	**1.30**
	G	0.02	0.03	0.01	0.01	0.16	0.03	0.05	0.22	0.05	0.03	**1.68**
NL/T	P		0.05	0.01	0.02	0.30	0.03	0.08	**0.39**	0.13	0.03	**0.97**
	G		0.07	0.01	0.03	**0.47**	0.04	0.12	**0.61**	0.21	0.05	**1.51**
Llen	P			0.02	0.03	**0.45**	0.04	0.16	**0.52**	0.19	0.08	**3.49**
	G			0.02	0.04	**0.60**	0.05	0.21	**0.71**	0.26	0.11	**4.71**
Lwid	P				0.04	**0.43**	0.03	0.15	**0.51**	0.19	0.10	**5.02**
	G				0.04	**0.45**	0.03	0.16	**0.53**	0.20	0.10	**5.27**
TilTh	P					**0.43**	0.03	0.15	**0.53**	0.18	0.09	**4.75**
	G					**0.47**	0.03	0.16	**0.58**	0.20	0.10	**0.99**
PlH	P						0.04	0.13	**0.55**	0.21	0.09	**4.48**
	G						0.04	0.14	**0.62**	0.24	0.10	**5.04**
Til/P	P							0.06	0.32	0.08	0.05	**2.08**
	G							0.11	**0.63**	0.15	0.09	**4.04**
Dm	P								0.28	0.10	0.07	**3.95**
	G								**0.37**	0.13	0.09	**5.31**
RhL	P									0.18	0.08	**3.45**
	G									0.23	0.10	**4.31**
RhWid	P										0.09	**3.71**
	G										0.11	**4.82**
RhTh	P											**4.32**
	G											**5.54**

Keys: Emg: rate of emerged shoots**; NL/P:** number of leaves per plant**; LLen:** leaf length**; LWid:** leaf width**; PlH:** plant height**; TilTh:** Tiller thickness**; Til/P:** number of tillers**; Dm:** days taken to maturity**; RhL:** rhizome Length**; RhWid:** rhizome width**; RhTh:** rhizome thickness**; RhW/P** The rhizome weight per plant; Values in bold are highly significant at **1%** level.

Estimates genetic parameters

The phenotypic and genotypic variance, phenotypic and genotypic coefficient of variability, broad sense heritability and genetic advance studied in ginger accessions are recorded in table 5. Lowest genotypic and phenotypic variance values (<5) were obtained for leaf width, tiller thickness, number of leaves and number of tiller per plant as well as leaf length. While, highly significant values was found for rhizome yield, rhizome weight per plant and rhizome length. On the contrary, [17] obtained a lower value for rhizome length. Maximum value of phenotypic coefficient of variability was recorded for rhizome yield (170.64) followed by rhizome weight per plant (160.64). The intermediate value showed by leaf width (21.25) and rate of emerged shoots (19.22). Days taken to maturity showed the lowest value (2.28) whereas number of leaves per tiller) and leaf length displayed low values 7.22 and 7.95 respectively. Genotypic coefficient of variability showed that rhizome yield and rhizome weight had higher values (169.31and 129.70 respectively), intermediate for leaf width (20.40) and the lowest values were recorded for days taken to maturity (1.71) and number of leaves (5.07). The phenotypic coefficients of variability are slightly higher than genotypic coefficients of variability for all the characters. This may suggest that the influence of environment was expected to be minimal. It indicates that the genotype component contributed more to the expression of the morph-metric and agronomic characters compared to the contribution of the environment. This result corroborates the findings of [22] and [17]who observed slight difference between phenotypic and genotypic coefficient variation in characters studied in *C. olitorius* and *Z. officinale*, respectively. The genotypic coefficient of variability was found highest for rhizome yield (169.31) and rhizome weight per plant (129.70). It indicates the presence of maximum amount of genetic variability, which emphasized the wide scope of selection for the improvement of these characters [20].

Table 5. Estimates of genetic parameters for 15 characters in 55 ginger landraces

Characters	δ^2ph	δ^2g	PCV (%)	GCV (%)	H^2 (%)	GA	GA/X
Emg	196.9	118.48	19.22	14.91	60.17	17.39	0.24
NL/P	2.32	0.97	7.82	5.07	41.95	1.32	0.07
LLen	2.96	1.66	7.95	5.95	55.98	1.98	0.09
LWid	0.29	0.26	21.25	20.41	92.2	1.02	0.4
PlH	158.18	127.18	15.44	13.85	80.4	20.83	0.26
TilTh	1.01	0.86	14.89	13.73	85.01	1.76	0.26
Til/P	2.64	0.71	14.75	7.68	27.1	0.91	0.08
Dm	15.51	8.72	2.28	1.71	56.18	4.56	0.03
RhL	393.63	255.83	14.26	11.49	64.99	26.56	0.19
RhWid	48.48	29.29	15.58	12.11	60.42	8.67	0.19
RhTh	10.02	6.2	15.52	12.21	61.88	4.03	0.2
RhW/P	19917	19334	131.64	129.7	97.07	282.21	2.63
YLD	744.52	732.94	170.64	169.31	98.44	55.33	3.46

Keys: Emg: rate of emerged shoots **; NL/P:** number of leaves per plant**; LLen:** leaf length**; LWid:** leaf width**; PlH:** plant height**; TilTh:** Tiller thickness**; Til/P:** number of tillers**; Dm:** days taken to maturity**; RhL:** rhizome Length**; RhWid:** rhizome width**; RhTh:** rhizome thickness**; RhW/P** The rhizome weight per plant; **YLD:** average yield**;δ^2ph:** phenotypic variance**;δ^2g:** genotypic variance**; PCV:** Phenotypic Coefficient of Variability**; GCV:** Genotypic Coefficient of Variability**;H^2:** broad-sense Heritability **;GA:** Genetic Advance**; GA/X:** Genetic Advance compared to the mean of the character

The estimated broad-sense heritability varied from 98.44 to 27.1%. [23] classified heritability estimates as low (5-10%), medium (10-30%) and high (> 30%). Based on this scale, the broad-sense heritability estimated was high (> 40%) for all the studied characters except the number of tillers per plant which was moderate (27.10%). Maximum heritability was recorded for rhizome yield (98.44%), rhizome weight per plant (97.07%), leaf width (92.20%), tiller thickness (85.01%) and plant height (80.40%). These characters with high heritability values could express the presence of more additive gene effects for possible improvement[15]. High heritability values were observed by [15]. Whereas, [20] report low heritability for days taken to maturity with ginger accessions collected from different location in India. Heritability estimates have been understood to be useful in indicating the relative value of selection based on phenotypic expression of different characters [24]. However, [25]reported that heritability values along with estimates of genetic advance were more useful than heritability alone in predicting study effect of selection. High heritability estimates associated with high genetic advance were obtained in rhizome weight per plant, rhizome yield, plant height, rhizome length and rate of emerged shoots. Phenotypic selection based on these characters for ginger yield improvement could be possible. High heritability values followed by high genetic advance showed the presence of additive gene action [26, 15].Therefore, selection based on rhizome weight per plant, plant height, rhizome length and rate of emerged shoots will be rewarding for increasing of rhizome yield and last two parameters can be improvement predictor. Along with our findings, improvement of ginger yield by direct selection of plant height and rhizome length has been also reported by [26].

CONCLUSION

Ginger is important crop plant in Burkina Faso view of its multi-purposes. Our study reveals genetic and phenotypic coefficient variation in morph-metric and agronomic traits studied. That shows the genetic diversity of the ginger accessions cultivated in South-west area of Burkina Faso. In addition the results indicate the high heritability of the rhizome weight per plant, rhizome yield, plant height, rhizome length and rate of emerged shoots. Consequently there is genetic variation in the ginger population for yield improvement through breeding regard to high heritability of its components.

ACKNOWLEDGEMENTS

We appreciate the financial support of the FONRID (in English: National Fund for Research, Innovation and Development) in achieving this work.

REFERENCES

1. Jatoi, S.A., A. Kikuchi, M. Mimura, S.S, Yi and N. Watanabe, 2008. Relationship of *Zingiber* species and genetic variability assessment in ginger (*Z. officinale*) accessions from ex-situ genebank, on-farm and rural markets. Breeding Sciences, 58: 261-270.

2. Pawar, N., S. Pai, M. Nimbalkar, F. Kolar and G. Dixit, 2010. Induction of chlorophyll mutants in Zingiberofficinale Roscoe by Gamma Rays and EMS. Emirate Journal of Food Agriculture, 22 (5): 406-411.

3. Sivasothy, Y., W.K. Chong, A. Hamid, I.M. Eldeen, S.F. Sulaiman and K. Awang, 2011. Essential oils of *Zingiberofficinale* var. rubrum Theilade and their antibacterial activities. Food Chemistry, 124: 514-517.

4. Joshi R.K., S. Mohanty, B. Kar and S. Nayak, 2012. Assessment of Genetic Diversity in *Zingiberaceae* through Nucleotide Binding Site-Based Motif-Directed Profiling. Biochemistry and Genetic, 50:642–656.

5. Daimei P. and Y. Kumar, 2013. Ethnobotanical uses of gingers in Tamenglong district, Manipur, Northeast India. Genetic Resources and Crop Evolution, 61: 273-285.

6. Preeti, C., W. Dnyaneshwar, J. Kalpana and P. Bhushan, 2008. Development of SCAR (sequence-characterized amplified region) markers as a complementary tool for identification of ginger (*Zingiberofficinale* Roscoe) from crude drugs and multicomponent formulations. Biotechnology and Applied Biochemistry, 50, 61-69.

7. Abdullah, S., S.A.Z. Abidin, N.A. Murad, S. Makpol, W.Z.W. Ngah and Y.A.M. Yusof, 2010. Ginger extract (*Zingiberofficinale*) triggers apoptosis and G0/G1 cells arrest in HCT 116 and HT 29 colon cancer cell lines. African J. Biochemistry Research 4 (4): 134-142.

8. Tokuhara, D., T. Shimada, A. Asami, A. Takahashi, H. Kobayashi, H. Saimaru and M. Aburada, 2013. Pharmacokinetics of 6-shogal, a pungent ingredient of Zingiberis Rhizoma, and the anti-inflammatory activity of its metabolite, 6-paradol.J. Trad. Med., 30: 199-205.

9. Jayashree, E., K. Kandiannan, D. Prasath, R. Pervez, B. Sasikumar, K.C.M. Senthil, V. Srinivasan, B.R. Suseela and C.K. Thankamani, 2014. Ginger (Extension Pamphlet). ICAR-Indian Institute of Spices Research, Kozhikode, Kerala, 10pp.

10. Parthasarathy, V.A., V. Srinivasan, R.R. Nair, Z.T. John, A. Kumar and D. Prasath, 2012. Ginger: Botany and Horticulture. Indian Institute of Spices Research Indian Council of Agricultural Research. Calicut, Kerala, India, 388pp.

11. Ayodele T.J. and B.E. Sambo, 2014. Ginger (*Zingiberofficinale* Roscoe) Production efficiency and constraints among small scale farmers in Southern Kaduna, Nigeria. Journal of Agricultural Science6 (8): 141-148.

12. Okwuowulu P.A., 2005. Ginger in Africa and the Pacific Ocean Islands. In Medicinal and aromatic plants-Industrial profiles: Ginger, the genus *Zingiber* (Eds P.N. Ravindran and K.N. Babu,) pp. 279-304. CRC Press. Washington DC.

13. Babu, K.N., E.J. Suraby, J. Cissin, D. Minoo, T. Pradeepkumar, V.A. Parthasarathy and K.V. Peter, 2013. Status of transgenics in Indian spices. Journal of Tropical Agriculture, 51 (1-2): 1-14.

14. Nandkangre, H., M. Ouedraogo et M. Sawadogo, 2015. Caractérisation du système de production du gingembre (*Zingiber officinale* Rosc.) au Burkina Faso: Potentialités, contraintes et perspectives. International Journal of Biology and Chemistry Sciences, 9 (2): 861-873.

15. Jalata, Z., A. Ayana and H. Zeleke, 2011. Variability, heritability and genetic advance for some yield and yield related traits in Ethiopian barley (*Hordeumvulgare* L.) mandrake and crosses. Internatinal. Journal of Plant Breeding and Genetics, 5 (1):44-52.

16. Miller, P.A., J.C. Williams, H.F. Robinson and R.E. Comstock, 1958. Estimated of genotypic and environmental variances and covariance in upland cotton and their implication in selection. Agronomy Journal,50: 126-131.

17. Aragaw M. S. Allamerew, G.H. Michael and A. Tesfaye, 2011. Variability of ginger (*Zingiberofficinale*) accessions for morphological and some quality traits in Ethiopia. International Journal of Agricultural Resources, ISSN 1816-4898 / DOI: 10.3223/ijar.2011.

18. Sasikumar B., K.N. Babu, J. Abraham and P. N. Ravindran, 1992. Variability, correlation and path analysis in ginger germplasm. Indian J. Genet., 52(4): 428-431.

19. Ravindran, P.N., N.K. Babu and K.N. Shiva, 2005. Botany and crop improvement. In: Medicinal and aromatic plants-Industrial profiles: Ginger, the genus *Zingiber*(Eds P.N. Ravindran and K.N. Babu,) pp. 15-86. CRC Press. Washington DC.

20. Ravishanker, S. Kumar, A. Chatterjee, D.K. Baranwal and S.S. Solankey, 2013. *Genetic*vari ability for yield and quality traits in ginger (Zingiberofficinale Roscoe). TheBioscan, 8(4): 1383-1386.

21. Jatoi S.A and K.N. Watanabe, 2013.Diversity analysis and relationships among ginger landraces. Pakistan Journal of Botany, 45 (4): 1203-1214.

22. Nwangburuka C.C. and O.A. Denton, 2012. Heritability, characters association, and genetic advance in six agronomic and yield related characters in leaf Corchorusolitorius. International Journal of Agricultural . Research, ISSN:1816-4897 / DOI: 10.3923/ijar.2012

23. Dabholkar, A.R., 1992. Elements of Biomtrical Genetics. Concepts publishing Company, New Delhi, India, pp: 138-140.

24. Hosseini, S.J., Z.T. Sarvestani, H. Pirdashti, A. Afkhami and S. Hazrati, 2012. Estimation of heritability and genetic advance for screening some rice genotypes at salt stress conditions. Internaional Journal of Agronomy and Plant Production, 3 (11): 475-482.

25. Johnson, H.W., H.F. Robinson and R.E. Comstock, 1955. Estimates of genetic and environmental variability in Soybeans. Agronomy Journal,47 (7): 314-318.

26. Abraham Z. and M. Latha, 2003. Correlation and path analysis in ginger *(Zingiberofficinale* Rosc.). Journal of Spices and Aromatic12 (2): 187-189.