Scholars Journal of Agriculture and Veterinary Sciences **e-ISSN 2348–1854**
Sch J Agric Vet Sci 2016; 3(6):442-447 **p-ISSN 2348–8883**
©Scholars Academic and Scientific Publishers (SAS Publishers)
(An International Publisher for Academic and Scientific Resources) DOI: 10.36347/sjavs.2016.v03i06.008

Intra-Specific Genetic Variability and Relationships between Grain Yield and Its Components in Pearl Millet (*Pennisetum glaucum* (L.) R. Br.) Genotype HKP Affected by End Cycle Drought in Niger

Daouda Ousmane S[1*], Baragé M[2]
[1]Laboratory of Biotechnology and Plant Breeding, Institute of Radioisotopes, University Abdou Moumouni, Niamey Niger
[2]Department of Plant Production; Faculty of Agronomy University Abdou Moumouni Niamey, Niger

***Corresponding Author**
Name: Daouda Ousmane S
Email: dsaniri@yahoo.fr

Abstract: Experimentation took place during the 2009 rainy season on the experimental station of the Institute of Radio-Isotopes of the University of Niamey in Niger (latitude 13°29' N, longitude 2°10' E). The objective of this study was to demonstrate the intra-specific variability in pearl millet (*Pennisetum glaucum* (L.) Br. R.) through the evaluation of a seed lot, and to identify traits which are most correlated with grain yields in end-of-cycle water deficit. This study also serves as a reference to an attempt to improve the genotype HKP which is promoted in Niger. The experimental design is a complete randomized block with four replicates. After the emergence, crops were thinned out to one plant per pole so as to assess one single seed per pole. This study confirms the good correlations between grain yield and its main components. However, it has the merit of showing that in the case of end-of-cycle dryness, the number of tillers per pole and the size of the tillers are the most important traits for maintaining the grain yield. These two parameters must be taken into account by millet breeders in the semi-arid zone.
Keywords: Pearl millet, intra-specific variability, agro-morphological traits, drought, Niger

INTRODUCTION

Pearl Millet (*Pennisetum glaucum* (L.) Br. R.), diploid (2n = 14), is a crop of great importance in the semi-arid tropical zone, where it provides the staple food for several hundred million people. Millet is probably the most rugged crop in the world and represents a potential to be protected because of its ability to withstand the extreme limits of agriculture. Millet is the sixth largest cereal in the world. In the Sahel, millet is the basis of the daily diet of more than 50 million people [1]. Relatively tolerant to drought and well adapted to low fertile soils, millet is the first cereal crop and the preferred food of the inhabitants of rural Niger. Millet yields are still very low, 20% of the potential, notably due to the increased drought and irregular rainfall and the use of open pollinated varieties by farmers [2].

Millet has a rich genetic variability [3] whose exploitation can open the way to the development of new varieties or hybrids that are more productive in the context of climate change in the Sahel. Grain yield is a complex trait controlled by many genes. Selection of genotypes or parents based on grain yield alone is often misleading. Hence, the knowledge about relationship between yield and its contributing characters is needed for an efficient selection strategy [4]. Several studies have dealt extensively with this topic [5-12]. Most of this work was carried out under normal conditions of growth. The present work is an attempt to study the intra-specific, inside a lot of the HKP genotype. It analyzes the association and the interrelation between the yield and its components and between the components themselves under the constraining conditions of Niger. It is also a starting point for further work to improve this variety.

MATERIALS AND METHODS

The experiment was laid out at the Agricultural Research Station of the Radio-Isotopes Institute, located on the campus of the University Abdou Moumouni of Niamey (UAM), in Niger (latitude 13 ° 29 'N, Longitude 2 ° 10 'E), during the rainy season 2009. Experimental site is characterized by Sahelian climate, sandy deep soil, poor in nutrients and organic matter (0.16%). The pH is slightly acidic.

The experiment was conducted in a randomized complete block design with four replications. The experiment unit was a ten-row plot of 15 m long, spaced at 1 m on the line and between the lines. Seeds were sown manually along rows in 10 cm deep holes, 10 to 20 seeds per hole. An organic amendment (compost of cow dung) at the rate of 20 tons per hectare, and inorganic fertilizer (NPK 15-15-15) at the dose of 300 kg per hectare and a powdered natural phosphate at the dose of 100 kg per hectare were applied before sowing and incorporated by manual plowing. This practice should reduce the variance associated with the soil environment. Nitrogen fertilizer was applied at a total dose of 100 kg per hectare in the form of urea, one part, 3 weeks after emergence and the rest before heading. Seeds were sown by hand dibbling. Weeding was conducted when needs. All the recommended agronomic practices and need based plant protection measures were adopted. Sowing was carried out on July 7, 2009, in pockets 1 m apart on seed lines spaced 1 m apart, with a density of 10,000 poquets per hectare. Crops were thinned out to one plant per poquet two weeks after crop emergence, so as to characterize a single seed. The harvest took place from 11 to 15 October 2009. Besides the qualitative parameters, variability was studied through a set of the most important descriptors of millet according to the International Institute for Plant Genetic Resources [13]. Descriptors of phenological, morphological and agronomic type were evaluated during vegetative stage and/or harvesting. Each poquet represents an individual, corresponding to a germinated seed.

Ears that have reached maturity before the period of drought are called whole ears (EPe). They are labeled during grain ripening. The ears whose maturation took place in the water stress period are called stressed ears (EPs).

They generally correspond to the ears of the tertiary or secondary tillers. The observed yield is calculated using the formula:

$$RDt = (PG_{EPe}+PG_{EPs})$$

Where: RDt is the observed yield in tons per hectare; PG_{EPe} is the Grains weight of whole ears; PG_{EPs} is the Grains weight of stressed ears.

The potential grain yield RDtP without drought is given by the formula:

$$RDtP= PG_{Epe} \text{ X } EPt/Epe$$

Where EPt is the total number of ears and EPe is the number of whole ears of each individual plant.

The drought sensibility index of individual plant considered as the production gap due to drought is given by:

$$SS= (RDtP-RDt)/RDtX100$$

All the agromorphological parameters measured during the crop cycle and at the harvest and those calculated, were subjected to a statistical test using the STATISTICA software. The Bartlett sphericity test was used to analyze the correlations between the variables at the threshold $\alpha = 0.05$.

The genetic material used in this study is the variety of pearl millet (*Pennisetum glaucum* [L.] R. Br.) HKP genotype which is promoted by agricultural extension services in Niger (Table1).

Table 1: Agromorphological characteristics studied, their codes and their meaning

Characteristics	Code	Signification
Average number of tillers per poquet (Individual)	**TlT**	Total tillers counted at end of tillering
Average number of fertile tillers per poquet (Individual)	**TlE**	The tillers which rise in spike
Number of ears per poquet at harvest	**EP**	Counted at harvest
Plant length (cm)	**LgT**	Measured from ground level to panicle base
Stem diameter (cm)	**DmT**	Measured between the 3rd and 4th nodes from the top
Ear length (cm)	**LgE**	Measurement from the rachis to the top of the panicle
Ear diameter (cm)	**DmE**	Measurement in the middle of the ear
1000 grains weight (g)	**PG1000**	Counted and weigthed
ear beating index	**IRE**	Ratio between Seeds weight and ears weight
Sowing to earing duration (Days)	**CSE**	Vegetative cycle
Grains yield (g per poquet)	**RDt**	Measurement at harvest
Potential Grains Yield (g per poquet)	**RDtP**	Calculated
Drought susceptibility index (%)	**SS**	Calculated

RESULTS AND DISCUSSION

Rainfall and water stress

The 2009 rainy season took place in Niamey on 08 June and ended on 18 October. There were recorded 31 rains of 0.2 to 32 mm, spread over 132 days of wet season (Figure 1). Total cumulative rainfall is 593 mm, higher than normal at Niamey [14]. At the beginning of the season, climate is very hard, with small rains, high temperature (up to 45°C) and strong winds leading in high evaporation rate. Occurrence of drought is high. At the end of the season, corresponding to grain filling and maturation, it was recorded an average rain every 7 to 8 days. From flowering (JAE 55) to maturation (JAE 95), the mean daily rain received was less than the daily water requirement for pearl millet. This situation is almost common in Niger and the Sahel in general. Despite a large surplus of cumulative rainfall, a drought was observed at the critical period of water demand. It can have a negative impact on crop growth and yields. In the absence of supplementary irrigation, only the use of drought-tolerant varieties remains the feasible solution.

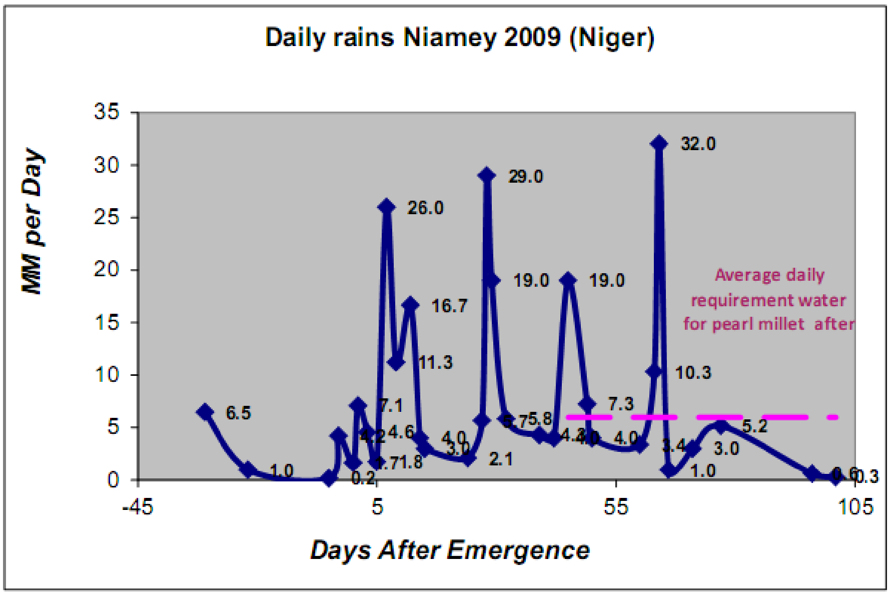

Fig-1: Daily rainfall 2009 in Niamey. Dashed line indicates the level of daily water requirement of millet after flowering

Agro-morphological parameters

The mean values of the descriptors observed for the pearl millet genotype HKP are shown in Table 2. The average number of tillers obtained was 16.7; Plant length 224.6 cm; ear length 61.7 cm and 1000 grains weight 10.3 g. These values are consistent with the references values under normal conditions [15]. Only the 1000 grains weight is relatively low, which can be explained by the effect of the rainfall deficit observed at the end of the cycle. The reproductive phase is highly sensitive to water stress in pearl millet and always ends with a negative impact on grain yield [16-19].

Table 2: Agro-morphological parameters observed for the pearl millet Genotype HKP

	Average	Standard deviation	Cv (%)
TlT	16.7	5.2	31.1
TlE	7.0	2.3	32.9
EP	6.9	2.4	34.8
LgT (cm)	224.6	29.2	13.0
DmT (cm)	1.45	0.29	20.0
LgE (cm)	61.7	9.6	15.6
DmE (cm)	2.28	0.41	18.0
PG (g)	10.3	1.8	17.5
IRE (%)	63.6	6.8	10.7
CSE (%)	56.5	3.3	5.8
RDt (gm^{-2})	241,4	86,1	35.7
RDtP (gm^{-2})	308,0	110,6	35.9
SS (%)	19,7	17,3	87.8

Principal Component Analysis

The Bartlett sphericity test indicates a significant correlation between the variables at the threshold α = 0.05. The mean values of the variables are summarized in Table 2. The correlation matrix between variables is given in Table 3. The RDt and the RDtP have a very good positive correlation between them (0.785). They also have a good positive correlation with the main classical yield components (TlT, TlE, EP). The correlation with the 1000-grain weight is much greater with the potential yield (0.203) than with the observed yield (0.071). The plant size parameters (LgT, DmT, LgE, DmE) correlated better with the observed yield, as did the Ear threshing index (IRE). The duration of the Semis-Epiaison cycle has a low negative correlation with both yields.

A Principal Component Analysis (PCA) was performed on the observed agromorphological parameters. This analysis is represented by a histogram of the Eigen values (Figure 2) and a circle of correlations (Figure 3). The factorial planes F1 and F2 account for 46.3% of inertia and represents the best plan for interpreting the relationships between observed variables. On the F2 axis, there is a positive correlation between the dimensions of the individual (LgT, DmT, LgE and DmE) with the observed yield (RDt). The greater the individual plant, the higher his yield. All of these parameters were negatively correlated with the drought sensibility index (SS), indicating that the larger the plant, the less susceptible to drought, or the smaller tillers being more sensitive to drought or the smaller tillers being more sensitive to drought.

The F1 axis shows a positive correlation between the numbers of total tillers (TlT), the number of spikes (EP) and the weight of the grain (PG). The more emitted tillers, the more ears and the better seeds are filled. We also note a negative correlation of these parameters with the sowing to earing duration (CSE). The earliness of the heading is linked to the emission of a greater number of heads and maximum weight for the grains.

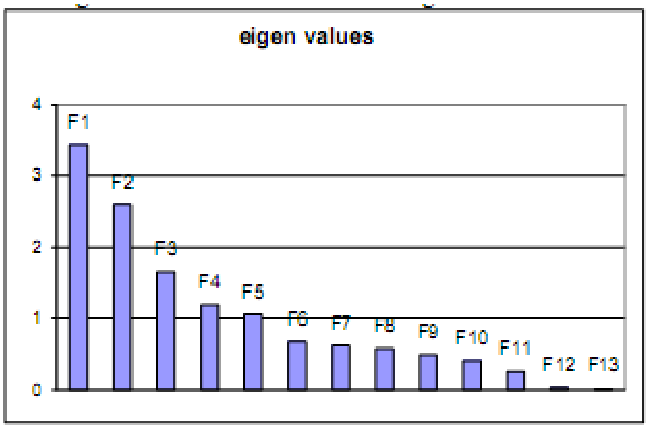

Fig-2: Eigen values relatives to different axes of correlations

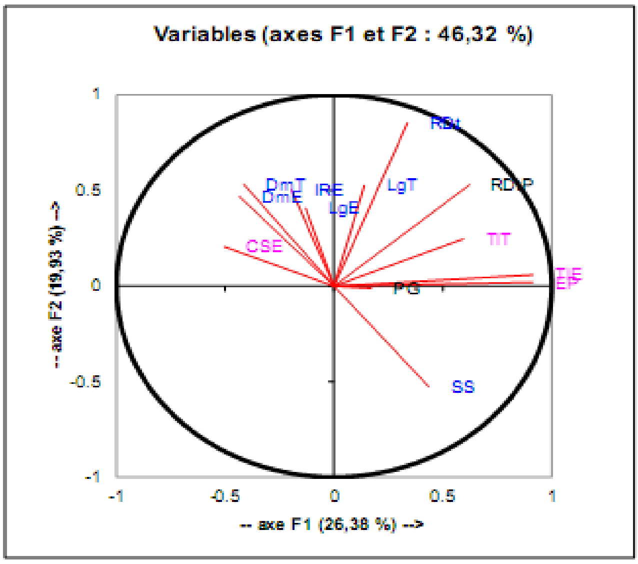

Fig-3: ***Correlation circle*** **between agromorphologic traits**

The study showed that grain yields correlated positively with the number of tillers per pole (TlT), the number of fertile tillers per pole (TlE) and the number of spikes per pole (EP). These results were in accordance with previous findings [20, 11] on pearl millet, as well as [9, 10] on eleusine (Finger millet). This result is also in line with previous finding [18-19] which showed that in the case of terminal water deficit, seed filling is mainly achieved by remobilization of stem reserves; from younger tillers to older tillers. The weak correlation between the yield observed and the weight of 1000 seeds indicates that in the case of water stress the yield becomes less dependent on the weight of 1000 seeds and becomes more dependent on the plant size parameters as evidenced by the good correlations obtained in this case. Selection for drought tolerance must take into account the dimensions of the tillers and their number per pole. Large plants should be preferred over small sizes that are most susceptible to drought. A negative correlation was found between the grain yield and the length of the sowing-heading cycle, as well as the sensibility to drought. This simply means that the later the flowering, the more likely it is to run in the end-cycle drought period. These relationships are similar to the results reported by Ezeaku *et al*. [21, 22].

CONCLUSION

This work shows that there is significant intra-specific variability in millet. It confirms the good correlations between grain yield and its main components. However, it has the merit of showing that in the case of end-of-cycle dryness, the number of tillers per pole and the size of the tillers are the most important traits for maintaining the grain yield. These two parameters must be taken into account by millet breeders in the semi-arid zone. This suggests selecting for these two characters would improve the grain yield in pearl millet in semi-arid conditions.

Table 3: *Correlation between variables* (Principal Component Analysis, Pearson Correlation Coefficient)

	TlT	TlE	EP	LgT	DmT	LgE	DmE	PG	IRE	CSE	RDt	RDtP	SS
TlT	1	**0.507**	**0.492**	**0.194**	-0.120	0.033	-0.152	-0.066	-0.020	-0.125	**0.305**	**0.335**	0.059
TlE	**0.507**	1	**0.968**	0.177	**-0.272**	-0.102	**-0.340**	0.017	**-0.230**	**-0.344**	**0.303**	**0.489**	**0.249**
EP	**0.492**	**0.968**	1	0.138	**-0.291**	-0.138	**-0.343**	0.033	**-0.236**	**-0.363**	**0.273**	**0.471**	**0.260**
LgT	**0.194**	0.177	0.138	1	0.187	**0.365**	0.013	-0.110	0.000	0.072	**0.330**	0.182	**-0.243**
DmT	-0.120	**-0.272**	**-0.291**	0.187	1	**0.267**	**0.411**	-0.090	**0.197**	**0.278**	0.191	0.038	**-0.300**
LgE	0.033	-0.102	-0.138	**0.365**	**0.267**	1	-0.052	-0.013	0.012	0.162	0.181	0.060	**-0.211**
DmE	-0.152	**-0.340**	**-0.343**	0.013	**0.411**	-0.052	1	-0.003	**0.209**	**0.340**	**0.272**	0.100	**-0.278**
PG1000	-0.066	0.017	0.033	-0.110	-0.090	-0.013	-0.003	1	**0.257**	**-0.382**	0.071	**0.203**	**0.207**
IRE	-0.020	**-0.230**	**-0.236**	0.000	**0.197**	0.012	**0.209**	**0.257**	1	-0.121	**0.412**	0.122	**-0.427**
CSE	-0.125	**-0.344**	**-0.363**	0.072	**0.278**	0.162	**0.340**	**-0.382**	-0.121	1	-0.010	-0.143	**-0.221**
RDt	**0.305**	**0.303**	**0.273**	**0.330**	0.191	0.181	**0.272**	0.071	**0.412**	-0.010	1	**0.785**	**-0.313**
RDtP	**0.335**	**0.489**	**0.471**	0.182	0.038	0.060	0.100	**0.203**	0.122	-0.143	**0.785**	1	**0.310**
SS	0.059	**0.249**	**0.260**	**-0.243**	**-0.300**	**-0.211**	**-0.278**	**0.207**	**-0.427**	**-0.221**	**-0.313**	**0.310**	1

In bold, significant (off diagonal) values at the alpha threshold = 0.050 (bilateral test)

REFERENCES

1. Saïdou AA, Mariac C, Luong V, Pham J-L, Bezançon G, Vigouroux Y. Association Studies Identify Natural Variation at PHYC Linked to Flowering Time and Morphological Variation in Pearl Millet. Genetics. 2009;182:899-910.
2. Rai KN, Kulkarmi VN, Thakur RP, Haussmann VIG, Mgonja MA. Pearl millet hybrid parents research approaches and achievements. PP 11-74 in Hybrid parent research at ICRISAT (Gowda CLL, Rai KN, Reddy BVS and Sexena KB eds). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 2006;11-74.
3. Berwal KK, Khairwal IS. Genetic divergence in Pearl millet. International Sorghum and Millet Newsletter. 1997;38:103-106.
4. Govindaraji M, Selvi B, Rajarathinam S, Soumathi P. Genetic variability and heritability of grain yield components and grain mineral concentration in India's Pearl millet (Pennisetum glaucum (L.) R. Br.) accessions. Afr. J. food Agric. Nutr. Dev. 2011;11(3):4758-4771
5. Unnikrishnan KV Govila OP, Ramesh Singh, Verma APS, Balzor Singh, Singh KP: Population improvement in pearl millet [Pennisetum glaucum(L.) R. Br.]. Indian J. Genet. 2004;64(4):295-298.
6. Shanmuganathan M, Gopalan A, Mohanraj K. Genetic Variability and Multivariate Analysis in Pearl Millet (Pennisetum glaucum (L.) R. Br.) Germplasm for Dual Purpose, Journal of Agricultural Sciences. 2006;2(1):73-80.
7. Vidyadhar B, Chand P, Swarnalatha Devi I. Genetic Variability and Character Association for Yield Attributes in Pearl Millet (Pennisetum sp.) Germplasm. J. Res. Angru. 2006;34(4)114-117.
8. Sumathi P, Sumanth Madineni, Veerabadhiran P. Genetic Variability For Different Biometrical Traits In Pearl Millet Genotypes (Pennisetum glaucum L. R. BR.). Electronic Journal of Plant Breeding. 2010;1(4):437-440.

9. Nandini B, Ravishankar CR, Mahesha B, Shailaja H, Kalyana MKN. Study of correlation and path analysis in F2 population of finger millet. Int. J. Plant Sc. 2010;5(2):602-605.
10. Wolie A, Dessalegn T. Correlation and path coefficient analyses of some yield related traits in finger millet (Eleusine coracana (L.) Gaertn.) germplasms in northwest Ethiopia. African Journal of Agricultural Research. 2011;6(22):5099-5105.
11. Abuali AI, Abdelmulla AA, Idris AE. Character Association and Path Analysis in Pearl Millet (Pennisetum glaucum L.). American Journal of Experimental Agriculture. 2012;2(3):370-381.
12. Sathya M, Kumari Vinodhana N, Sumathi P. Hierarchial clustering of pearl millet (Pennisetum glaucum (L.) R. Br) inbreds for morpho-physiological traits. Int. J. Curr. Microbiol. App. Sci. 2013;2(12):647-652.
13. IBPGR, ICRISAT. Descriptors for pearl millet (Pennisetum glaucum L. R. Br.). International Board for Genetic Resources, Rome, Italy; International Crops Research Institute for the Semi-Arid Tropics, Patancheru, India, 1993.
14. Sivakumar MVK. Agroclimatology Progress report. 1. Climat of Niamey. ICRISAT, Niamey Niger. 1986;36.
15. Inran. Catalogue des variétés recommandées de mil, sorgho, niébé et autres cultures au Niger. Institut National de Recherche Agronomique du Niger. 1987;5-26.
16. Siene LAC, Soko DF, Diouf O, Ake S. Evaluation de l'impact de stress hydriques sur la croissance et le rendement du mil (Pennisetum glaucum (L.) R. Br.) pour deux conditions de fertilisation azotée dans un environnement tropical semi-aride. International Journal of Innovation and Applied Studies. 2016;14(3):779-789.
17. Do FC. Réponses écophysiologiques in situ des plantes aux fortes contraintes hydriques : Applicabilité, intérêt et limites de l'approche hydraulique plante-entière. Thèse d'Habilitation à Diriger des Recherches. Ecophysiologie Végétale ; Ecole Doctorale des Sciences de la Vie et de la Sante. Présentée le 14 Juin 2013;58.
18. Winkel T, Do F. Caractères morphologiques et physiologiques de résistance du mil (Pennisetum glaucum L. Br.) à la sécheresse. Agronomie Tropicale. 1992;46(4):339-351.
19. Do F, Daouda S, Marini P. Etude agrophysiologique des mécanismes de résistance du mil à la sécheresse (cas d'un stress hydrique terminal). ACCT. Revue du Réseau pour l'Amélioration de la Productivité Agricole en Milieu Aride. 1989;1:57-74.
20. Kumar M, Kumar M, Gupta PC, Soni RK. Genetic Diversity for Yield and its component traits in Pearl millet [Pennisetumglaucum(L.) R. Br.] Hybrids. Indian Res. J. Genet. & Biotech. 2015;7(4):471– 473.
21. Ezeaku IE, Angarawai II, Aladele SE, Mohammed SE. Correlation, path coefficient analysis and heritability of grain yield components in pearl millet (Pennisetum glaucum (L.) R. Br.) parental lines. Journal of Plant Breeding and Crop Science. 2015;7(2):55-60.
22. Ezeaku IE, Angarawai II, Aladele SE, Mohammed SE. Genotype by environment interactions and phenotypic stability analysis for yield and yield components in parental lines of pearl millet (Pennisetum glaucum (L.) R. Br.). Journal of Plant Breeding and Crop Science. 2014;9(37):2827-2833.