RUFORUM Working Document Series (ISSN 1607-9345), 2018, No. 17 (1):611-620.
Available from *http://repository.ruforum.org*

Research Application Summary

Analysis of agro-morphologic diversity of Zambian sesame *(Sesamum indicum* (l.)) landraces

Munkombwe, G.,[1] Mwala, M.[2] & Nguni, D.[1]

[1]Zambia Agriculture Research Institute, Private Bag 7, Chilanga, Zambia
[2]University of Zambia, P. O. Box 32379, Lusaka, Zambia
Corresponding author: munkombwegraybill@gmail.com

Abstract

Twenty-eight sesame landraces were grown in the field at Mt Makulu Research Station during the 2013/14 cropping season and agro-morphological variation estimated based on 24 morphologic and agronomic descriptors. The landraces were obtained from the National Gene Bank at Mount Makulu Research Station. Multivariate analyses were performed in order to establish similarity and dissimilarity patterns. Principal component analyses revealed that the first 5 principal axes explained 75.1 % of the total variation while the rest of the principal axes contributed 24.1 % to the total variation. Cluster analysis grouped accessions into 2 major clusters at coefficient approximately 0.75 with each cluster further generating two sub-clusters. Cluster analysis could not group accessions based on collection location, indicating that there is possibility of exchange of seeds across locations. These results therefore indicate that there are morphological variations in the Zambian sesame germplasm. Traits that were responsible for classifying the germplasm are: plant height, days to flower, number of seeds per capsule, seed weight, flower colour, main stem colour, leaf arrangement, leaf shape, leaf hairiness and seed colour.

Key words: Agro-morphological, diversity, Sesame landraces

Résumé

Vingt-huit variétés locales de sésame ont été cultivées sur le terrain à la station de recherche du mont Makulu pendant la saison de récolte 2013/14 et la variation agro-morphologique estimée sur la base de 24 descripteurs morphologiques et agronomiques. Les variétés locales ont été obtenues auprès de la National Gene Bank à la station de recherche du mont Makulu. Des analyses multi-variées ont été effectuées afin d'établir des modèles de similitude et de dissimilarité. Les analyses des composantes principales ont révélé que les 5 premiers axes principaux expliquaient 75,1% de la variation totale tandis que les autres axes principaux contribuaient à 24,1% à la variation totale. L'analyse des grappes a regroupé les accessions en 2 grappes principales à un coefficient d'environ 0,75, chaque grappe générant en outre deux sous-grappes. L'analyse des grappes n'a pas pu regrouper les accessions en fonction du lieu de collecte, ce qui indique qu'il y a possibilité d'échange de semences entre les sites. Ces résultats indiquent donc qu'il existe des variations morphologiques dans le germoplasme zambien du sésame. Les caractères responsables de la classification du matériel génétique sont les suivants: hauteur de la plante, jours de floraison, nombre de graines par capsule, poids des graines, couleur des fleurs, couleur de la tige principale, disposition des feuilles, forme des feuilles, pilosité des feuilles et couleur des graines.

Mots-clés: Agro-morphologique, diversité, races locales de sésame

---

Introduction

Sesame is mainly grown in the tropics although its cultivation ranges from 40o N to 40o S latitude (IPGRI and NBPGR, 2004). Developing countries account for about 99 per cent of the world's sesame area and its cultivation is usually by small-holder farmers (Ahmed, 2004). Sesame seed is an important source of high quality oil and protein. Its oil is stable due to the presence of natural antioxidants such as sesamolin, sesamol and sesamin (Kamal-Eldin, 1993).

Sesame maybe one of the oldest oil crop known to man, but it is still an underutilized crop. It does not feature prominently in the research agenda of most international agricultural research centers hence often referred to as an ''orphan crop'' (Ashri, 1995). This could be one of the reasons why there is lack of research works in sesame (Ashri, 1995). However, sesame is now slowly gaining ground, because of its increasing commercial value and thus interest in improving the crop is certainly emerging. Therefore, the need for well characterised germplasm in now important. Zambia has conserved several sesame accessions in the Zambia National Plant Genetic Resources Centre (ZNPGRC). These are however not characterized. The overall goal of this study was to generate information that would guide the utilization (development of suitable varieties) of sesame germplasm. Specific objectives of this study were to (1) determine traits which are useful in classifying accessions of sesame, and (2) characterize sesame genotypes conserved in the national gene bank.

Materials and methods

The 28 accessions of sesame used in this study were obtained from the Zambia National Plant Genetic Resources Center (ZNPGRC). These accessions are landraces that were collected by ZNPGRC from Southern, Central, Copperbelt, Northern, North Western, Western and Lusaka provinces of Zambia as shown in Figure 1.

The field experiment was conducted at Zambia Agricultural Research Institute (ZARI) at Mount Makulu Station located at latitude 15^{o} 32.93' South, longitude 28^{o} 14.90' East with an altitude of 1237 m above sea level. The experimental site is situated in region II of the Zambian Agro-ecological regions and receives an average annual rainfall of 900 mm. The accessions were evaluated in the field using a randomized complete block design (RCBD) with three replications. Experimental plots measured 2m x 1m with 2 rows per plot spaced 70 cm between them. Land was prepared using a tractor drawn implement to an appropriate tilth for small seeded crops like sesame. Seeding was done by drilling directly in furrows made in soil. Fertilizer Compound 'D', which contains N: P: K (10:20:10), was applied to the crop a week after emergence at a rate of 100 kg/ha. Topdressing was done 40 days after sowing using Urea (46% N) applied at a rate of 100 kg/ha. When plants were about 15 cm tall, thinning was done to achieve a 30 cm space between plants. Weeds were controlled mechanically using a hand hoe and was done four times during the growing period. Web worm (Antigastra catalaunalis) infestation was a problem from two weeks after emergence and was controlled by spraying the crop with a systemic insecticide Cypermethrine at a rate of 2 millilitres per litre of water. Leaf spot (*Cercospora sesame Zimm*) infection was also serious throughout the growing period and was controlled through spraying with a systemic fungicide Tenazole 250 EW at rate of 2.25 millilitres per litre of water. Data were collected from ten randomly selected and tagged plants per plot (Table 1).

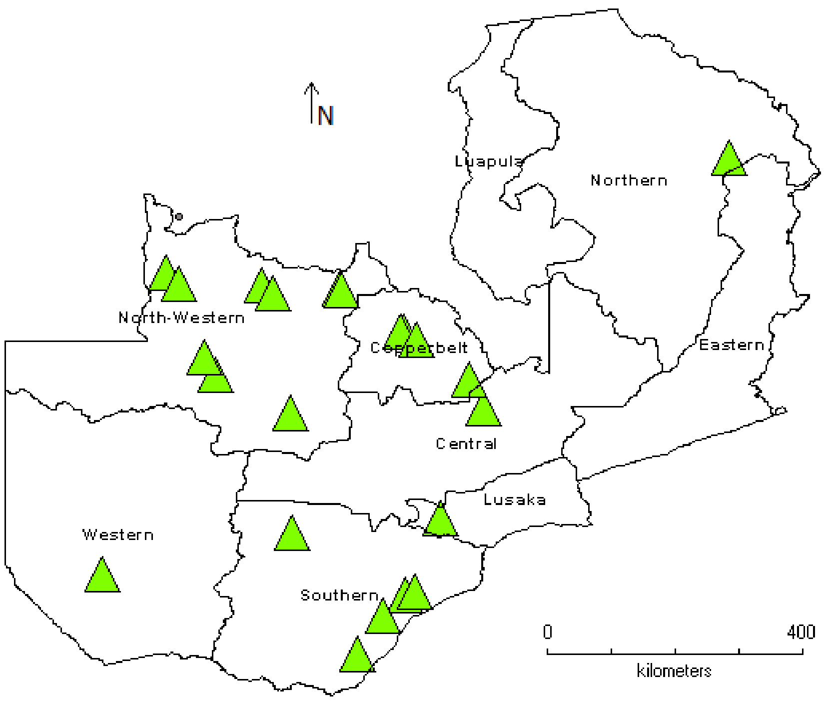

Figure 1. Map showing provinces where sesame landraces were collected

Mean, range, standard error of mean and coefficient of variation were computed for the seven quantitative parameters (i.e., plant height, days to 50 percent flowering, days to physiological maturity, seed yield, number of seeds per capsule and 1000 seed weight). Quantitative data were subjected to analysis of variance (ANOVA) using Minitab version 14 and means separated by Turkey's test. Quantitative data were standardized and subjected to principal component analysis (PCA).

Qualitative and quantitative data were standardized and subjected to cluster analysis based on Unweighted pair group method with arithmetic average (UPGMA) using the numerical taxonomy and multivariate analysis system (NTSYS version 2.11). A dendrogram was generated from Euclidean coefficient of qualitative and quantitative characters of sesame accessions.

Table 1. Plant characteristics measured for sesame accessions

Characteristic	Time scoring
Flower colour	At 50 % flowering
Capsule hairiness	At 50 % flowering
Capsule arrangement	At 50 % flowering
Capsule dehiscence at ripening	At 50 % flowering
Plant growth type	At 50 % flowering
Plant growth habit	At 50 % flowering
Main stem colour	At 50 % flowering
Stem hairiness	At 50 % flowering
Stem shape	At 50 % flowering
Stem branching	At 50 % flowering
Branching pattern	At 50 % flowering
Leaf colour	At 50 % flowering
Leaf arrangement	At 50 % flowering
Leaf shape	At 50 % flowering
Leaf hairiness	At 50 % flowering
Lodging susceptibility	At maturity
Seed colour	At harvest
Seed shape	At harvest
Days to 50% flowering	At 50 % flowering
Plant height	At 50 % flowering
Days to physiological maturity	At 75 % maturity
Seed weight	At harvest
Seed yield	At harvest
Number of seeds per capsule	At harvest

Results and discussion

Qualitative traits. Out of the eighteen qualitative traits observed, twelve traits did not show any variation among accessions (Table 2). These include: capsule hairiness, capsule dehiscence at ripening, capsule arrangement, plant growth type, plant growth habit, stem hairiness, stem shape, stem branching, branching pattern, leaf colour, lodging susceptibility and seed shape. All accessions were erect, indeterminate, completely shattering at ripening, hairless stem, square shape stem, opposite stem branching, not susceptible to lodging, basal stem branching pattern and oval with concave side seed shape. There was however, variation observed for leaf arrangement, leaf hairiness, seed colour, leaf shape, flower colour and main stem colour.

Table 2. Evaluation of sesame germplasm qualitative traits

Character	Description	Frequency (%)
Flower colour	white with deep pink shading	67.86
	white with pink shading	32.14
Capsule hairiness	Medium	100
Capsule arrangement	Monocapsular	100
Capsule dehiscence at ripening	Completely Shattering	100
Plant growth habit	Erect	100
Plant growth type	Indeterminate	100
Main stem colour	Green	85.71
	Purplish green	14.29
Stem hairiness	Hair absent	100
Stem shape	Square	100
Stem branching	Opposite	100
Branching pattern	Basal branching	100
Leaf colour	Green	100
Leaf arrangement	Alternate	50
	Opposite	25
	Mixed	25
Leaf shape	Lanceolate	57.14
	Ovate	39.29
	Narrowly cordate	3.57
Leaf hairiness	Hair absent	85.71
	Sparse	14.29
Lodging susceptibility	None lodging	100
Seed colour	Beige	29.29
	White	35.71
	Light brown	14.29
	Cream	3.57
	Dull black	3.57
	Medium brown	3.57
Seed shape	Oval with concave side	100

Quantitative traits . ANOVA of quantitative traits revealed significant variation among sesame accessions for all the traits analysed (P 0.05; Table 3). Plant height ranged from 78.60 cm to 132.27 cm with an average of 110.47 cm. Short sesame accessions were ZM664, ZM851, ZM4575, ZM4892, ZM4902, ZM6747, ZM6788, ZM6837 and ZM7191. Medium tall accessions were those that ranged from 100cm to 115 cm while the tall accessions were those that were taller than 115cm. Majority of accessions (11). Number of seeds per capsule ranged from 22 to 121 with an average of 57. The highest number of seeds per capsule were recorded in accession ZM4766. Thousand seed weight which is indicative of seed size, ranged from 0.1 to 2.98g with an average of 0.99g. ZM8259 had the highest thousand seed weight of all the 28 accessions used. Days to flower ranged from 79 to 102 days. The accessions were classified as early or late. The early ones flowered at 85 days or less while the late flowered after 85 days. The earliest to flower was ZM6740 while the latest was ZM664. There were no significant difference in days to maturity and seed yield in all the accessions.

Table 3. Sesame accessions used in the study, their average plant height (PH), days to flower (DTF), days to physiological maturity (DTPM), number of seeds per capsule (NSC), thousand seed weight (TSW), seed yield (SY) and analysed ranges, means, standard errors of mean and coefficient of variation

Accession	PH	DTPM	NSC	TSW	SY	DTF
ZM 664	95.53abc	159.00a	47.00bdec	0.76f	50.35a	102.00a
ZM 851	93.00abc	154.00a	24.00e	0.12on	8.36a	89.00b
ZM 4575	96.33abc	154.00a	36.00dec	1.93cd	38.68a	84.00c
ZM 4766	114.27abc	154.00a	121.67a	0.55x	64.97a	85.00d
ZM 4892	89.13bc	150.00a	43.00bdec	1.03gfh	17.69a	94.00e
ZM 4894	117.67abc	154.00a	53.00bdec	2.26cb	113.79a	92.00f
ZM 4895	132.27a	154.00a	116.00a	0.11o	214.67a	86.67b
ZM 4896	130.53a	154.00a	38.00dec	1.12gf	158.87a	86.67b
ZM 4897	111.93abc	159.00a	55.00bdec	1.37ef	87.69a	88.00b
ZM 4898	105.20abc	159.00a	60.00bdec	0.17on	50.86a	90.67g
ZM 4899	130.53a	154.00a	45.00bdec	0.54klm	180.94a	85.00h
ZM 4901	126.07ab	154.00a	75.00bdac	0.97gih	120.76a	85.67i
ZM 4902	88.73bc	151.00a	90.00ba	2.32b	21.82a	87.67b
ZM 5176	131.27a	154.00a	47.00bdec	0.27onm	142.37a	80.67j
ZM 5307	127.13ab	159.00a	48.00bdec	2.78a	144.94a	85.00k
ZM 5766	127.67ab	154.00a	47.00bdec	0.94gih	143.77a	85.67l
ZM 6724	128.67ab	154.00a	43.00bdec	0.82q	173.66a	82.67m
ZM 6740	124.20ab	150.00a	120.00a	0.37lonm	168.46a	79.33n
ZM 6747	97.00abc	154.00a	49.00bdec	0.91gjih	26.55a	89.00b
ZM 6766	117.33abc	159.00a	36.00dec	0.58x	116.14a	84.00o
ZM 6788	94.13abc	154.00a	41.00dec	1.17gf	7.28a	94.00p
ZM 6818	114.73abc	151.00a	62.00bdec	0.46klnm	58.43a	81.67q
ZM 6837	80.40bc	159.00a	31.00de	0.10o	45.08a	96.67r
ZM 7185	105.53abc	154.00a	22.00e	1.58ed	50.73a	100.00s
ZM 7191	78.60bc	154.00a	64.00bdec	0.11on	6.99a	96.00t
ZM 8258	110.67abc	150.00a	44.00bdec	0.63m	125.45a	80.67u
ZM 8259	117.33abc	150.00a	83.33bac	2.98a	65.08a	80.67u
ZM 8260	107.27abc	154.00a	54.00bdec	0.68n	95.68a	80.67u
Mean	110.47***	154.29ns	56.96***	0.99***	89.29ns	87.61***
CV %	14.9	1.89	47.16	82.31	68.05	6.96
SE mean	3.11	0.55	5.08	0.15	11.48	1.15
Range	78.60- 132.27	150-159	22 -121.67	0.10-2.98	6.99-214.67	79.33-102

Means with the same letters within a column (Trait) do not differ significantly (Tukey Test) at p 0.05; ***significant at p 0.001

Principal component analysis

The principal component analysis of qualitative and quantitative data revealed that the first five principal components with Eigen vectors >1.0 cumulatively accounted for 75.1 % of the total variation (Table 4).

Table 4. Proportional and cumulative variances and Eigen –vectors on five Principal Component (PC) based on qualitative and quantitative traits

Parameter	PC1	PC2	PC3	PC4	PC5
Eigen value	2.9859	1.8221	1.6526	1.5246	1.0245
Proportion	24.9	15.2	13.8	12.7	8.5
Cumulative	24.9	40.1	53.8	66.5	75.1
Character				Eigen-vectors	
Plant Height	-.519	0.077	0.071	0.048	-.029
Days to flowering	0.447	-.255	-.010	-.173	-.107
Days to maturity	0.060	-.206	0.089	-.504	-.374
Seed yield	-.523	-.066	0.031	-.049	-.121
Seed weight	0.055	0.576	0.061	-.126	0.093
Flower colour	-.323	0.071	0.017	-.513	0.287
Main stem colour	-.033	-.230	0.534	0.128	0.454
Leaf arrangement	-.198	-.307	-.388	-.062	0.455
Leaf shape	0.158	-.362	0.343	-.211	0.295
Leaf hairiness	-.130	-.007	0.578	0.322	-.250
Seed colour	0.250	0.420	0.040	0.098	0.422

The PC1 explained 24.9% of the total variation in the agro-morphological and seed quality traits. The major contributors of variation in principal component 1 were : plant height, seed yield and days to flowering. PC2 accounted for an additional 15.2% of the total variation and was positively associated with plant height, days to maturity, seed yield, seed weight and days to flowering. The PC3 contributed 13.8% variation to total variability. The variation in PC3 was mainly attributed to leaf hairiness, main stem colour and leaf arrangement.

Leaf hairiness explained variation in PC 4 while for PC 5 variation was explained by seed colour, leaf arrangement and main stem colour. PC4 and PC5 contributed 12.7% and 8.5% of total variation, respectively. If we are to consider only eigenvalues >1 as significant and component loading greater or equal to 0.30 as meaningful (Ng'uni, 2011) and that a high coefficient for a trait point to the relatedness of that trait to the respective PC (Ng'uni, 2011), only the first five components were significant in this study. The high degree of variation in the first five PC axes point to a high degree of variation for these characters.

Cluster analysis

Cluster analysis was performed following principal component analysis to further examine similarities and dissimilarities among 28 accessions of sesame. Cluster analysis based on agro-morphological traits assigned the 28 accession of sesame into 2 main clusters with sub cluster groups of sesame accessions at a co-efficient of 0.75. Accessions were grouped into cluster groups based on certain qualities unique to them. Both clusters recorded 14 accessions each (Table 5).

Table 5. Distribution of 28 sesame accessions in different clusters

Cluster	No. of accessions	Source	Accessions
1	14	Mwinilunga, Lusaka Masaiti, Solwezi Maamba, Shangombo, Chinsali, Kasempa Lufwanyama, Mufumbwe	ZM4896, ZM8258 ZM4897, ZM6724 ZM7191, ZM8259 ZM5766, ZM6747 ZM4899, ZM6740 ZM6837, ZM4901 ZM4575, ZM664
Sub cluster1 (a)	7	Mwinilunga, Lusaka Masaiti, Solwezi Maamba, Shangombo,	ZM4896, ZM8258 ZM4897, ZM6724 ZM7191, ZM8259 ZM5766
Sub cluster1 (b)	7	Chinsali, Kasempa, Lufwanyama, Mufumbwe	ZM6747 ZM4899,ZM6740 ZM6837, ZM4901 ZM4575, ZM664
2	14	Mufumbwe, Gwembe, Kasempa, Kapiri-Mposhi, Lufwanyama, Solwezi, Maamba	ZM851, ZM4892, ZM4894, ZM4895, ZM4896, ZM4898, ZM4902, ZM5176, ZM5307, ZM6766, ZM6788, ZM6818, ZM7185, ZM8260
Sub cluster 2 (a)	12	Mufumbwe, Gwembe, Kasempa, Kapiri-Mposhi, Lufwanyama	ZM851, ZM4892, ZM4895, ZM4896, ZM4898, ZM4902, ZM5176, ZM5307, ZM6766, ZM6788, ZM6818, ZM7185
Sub cluster 2 (b)	2	Maamba, Solwezi	ZM8260, ZM4894

Accessions with similar quantitative and qualitative morphological characters appeared well grouped in the same cluster. This study observed considerable variation among accessions just as reported by Morris (2009). Even though these genotypes were collected from various parts of the country there is an indication that there was a lot of germplasm exchange between farmers from different parts of the country. This is revealed by the dendrogram (Figure 2) in that the clusters did not have a unique relationship between cluster groups and collection site of landraces, this result is in agreement with the findings of Furat and Uzum (2010). Although sesame is described as self-pollinating plant, recent evidence raises the possibility of natural outcrossing (Baydar and Gurel, 1999). There could be some ecological conditions that could lead to gene flow between populations of different geographical origins (Furat and Uzum, 2010).

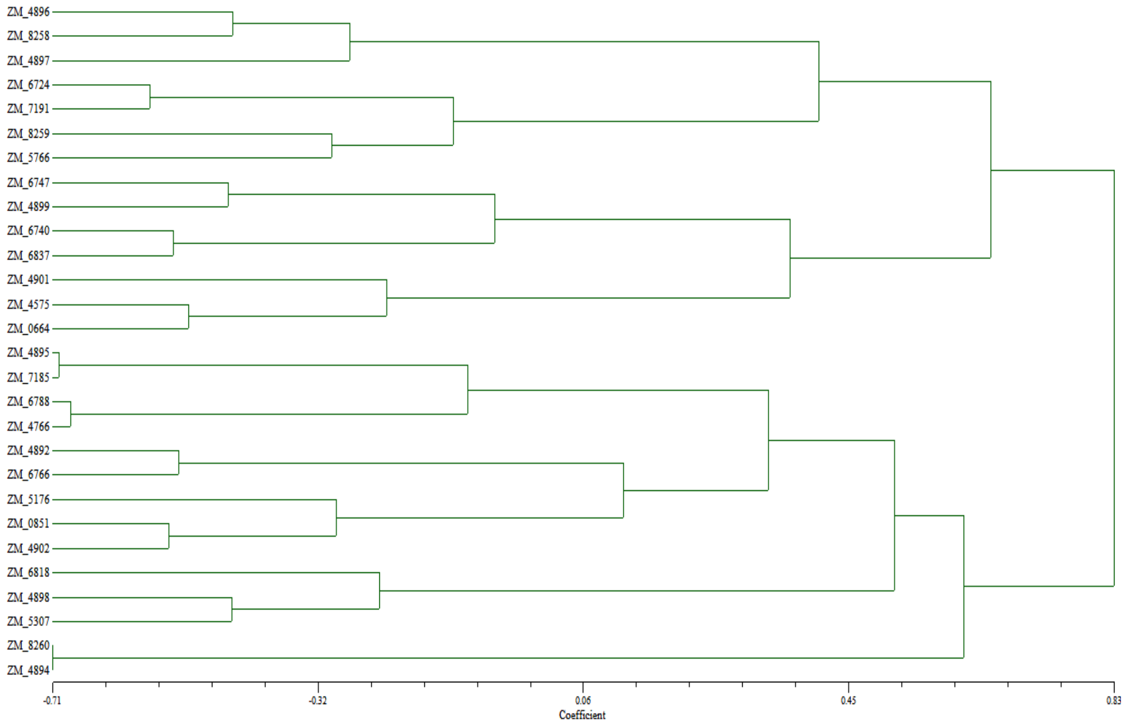

Figure 2. Dendrogram showing relationship among 28 Sesame accessions from Zambia

Conclusion

The study has revealed that there is morphological diversity among accessions of Zambian sesame landraces conserved at the National plant genetic resources centre. Principal component analysis accounted for 75.1 % of the total variation and cluster analysis grouped the genotypes into 2 major clusters with 4 sub-clusters. The most important characters which had a significant effect on variation were: Plant Height, Seed yield, Days to 50% Flowering, Days to Physical Maturity, Number Seeds per Capsule, Seed Weight (g), Flower Colour, Main Stem Colour, Leaf Arrangement, Leaf Shape, Leaf Hairiness and Seed Colour. These characters are therefore useful in agro-morphological characterisation of sesame. This significant morphological variation in sesame accessions presents an opportunity for sesame breeding. The success in genetic improvement of the crop, however, depends on the availability of genetic resources and their diversity.

This study provides an agro-morphologic based classification of genetic diversity that can help breeders understand the genetic structure of Zambian sesame landraces.

Acknowledgement

This paper is a contribution to the 2018 Sixth African Higher education Week and RUFORUM Biennial Conference.

References

Ahmed M. E. 2004. Genetic and geographical diversity of sesame. Ph.D. Thesis, Faculty of Agricultural Sciences, University of Gezira, Sudan.

Ashri, A. 1995. Sesame research overview: current status, perspectives and priorities. pp. 1-17. In: Bennett, M. R., Wood, I. M. (Eds.), Proceedings of sesame workshop. NT Dept. Primary Industry and Fisheries, Darwin.

Baydar, H. and Gurel, F. 1999. The effects of honey bees on cross-pollination and hybrid seed production in sesame (*Sesamum indicum* L.). *Turk J of Field Crops* 4: 21-24.

Furat. S. and Uzun, B. 2010. The use of agro-morphological characters for the assessment of genetic diversity in sesame (*Sesamum indicum* L.) *POJ* 3 3):85-9.

IPGRI. 2004. Descriptors for sesame (*Sesamum* spp.). International Plant Genetic Resources Institute, Rome, Italy.

Kamal Eldin, A. 1993. Seed oils of *Sesamum indicum* and wild relatives. Ph.D. dissertation, Swedish University of Agricultural Sciences, Uppsala.

Morris, J.B. 2009. Characterization of sesame (*Sesamum indicum* L) *Genet Resour Crop Evolution* 56 (7): 925–936.

Ngúni, D. 2011. Phylogenetics of the genus sorghum, genetic diversity and nutritive value of its cultivated species. Ph.D. Thesis, Swedish University of Agricultural Sciences, Uppsala.