The African Journal of Plant Science and Biotechnology ©2013 Global Science Books

Agro-Morphological Variability of *Ocimum gratissimum* L. and Three Other Accessions of Basil in South-western Nigeria

Christian Okechukwu Anyaoha

Spices Improvement Programme, National Horticultural Research Institute, PMB, 5432, Idi-ishin, Ibadan, Oyo State, Nigeria

Corresponding author: **kriskoty@yahoo.com**

ABSTRACT

Basil *Ocimum basilicum* is one of the highly valued medicinal and aromatic plants that is widely used in different parts of the globe. Field evaluation of 4 basil accessions (2 indigenous and 2 exotic types), was carried out at Ibadan, Nigeria. Considerable level of genetic variation for the various traits studied was recorded. Thirteen quantitative and six qualitative traits were evaluated. Relatively high variation was recorded for plant height, number of branches, leaf length, inflorescence length, petiole length and days to 50% flowering an indication that these traits can be further improved through selection. Least variability was recorded for 1000 seed weight, number of seeds per pod, canopy cover and leaf width. Leaf length and width varied from 3.9 to 20.0 cm and 1.7 to 10.95 cm, respectively. Also, a wide range of variation was recorded for qualitative traits such as seed, stem, flower, leaf and stem colour. Absence of hairiness on the entire plant parts was observed in all the accessions. The results of this study indicated that the two local accessions (Tree and Bush basil) could be used as good parents for basil improvement programmes geared towards enhancement of leaf size based on market demand, taller plants with durable stems, better stability and adaptability to West African environments.

Keywords: bush-basil, *effinrin-nia*, leaf size, *nchonwu*, traits

INTRODUCTION

Basil, *Ocimum basilicum*, popularly known as "scent leaf" in Nigeria, is an aromatic plant that grows as a wild plant and also cultivated for culinary, medicinal and ornamental purposes (Simon *et al*. 1990). It belongs to the family Labiatae and it is the most abundant of the genus. It is known to be made up of over 30 species of herbs and shrubs from tropical and sub tropical regions of the world but the main center of origin appears to be Africa (Paton 1992). The popularity of basil has led to the introduction of many products into the market (Simon *et al*. 1999). The popular cultivars for fresh market and garden have dark green leaves and white flowers, with a rich spicy pungent aroma due to the presence of linalool, methylchavicol and/or 1,8-cineole (Simon *et al*. 1999).

Two main types of basil are commonly found locally in Nigeria, they are the "tree basil", tall with large leaves and the "bush basil", usually dwarf with smaller leaves. The tree basil popularly called *effinrinnia* by the Yoruba speaking tribe, *nchonwu* in Igbo, and *daidoya* by the Hausas in the northern part of Nigeria (Effraim *et al*. 2001). Darrah (1980) classified *Ocimum basilicum* cultivars into seven groups (**Table 1**). The taxonomy of basil is complicated by the existence of numerous varieties, cultivar names and chemotypes within the species that may not differ significantly in morphology (Simon *et al*. 1990). The morphological diversity within basil has been accentuated by centuries of cultivation with great variation in pigmentation, leaf size and shape (Anon 1980).

In Nigeria, numerous studies have been undertaken on pharmacology and essential oils of basil to the neglect of its agro morphological characterization and evaluation that are the main bases for breeding improvement programmes needed for better adaptability and sustainability of this essential crop. Plant extracts and different parts of basil have been reported to be used in traditional medicine and also have shown to contain biological active ingredients that are insecticidal and antimicrobial (Simmon 1990; Adebolu and Oladimeji 2005; Nweze *et al.* 2009; Oboh *et al.* 2009; Oparaocha *et al*. 2010), antidiabetic, anti-tumor and anti-cancer (Ekunwe *et al.* 2010), analgesic (Iroanya *et al.* 2009) activities.

Ehiagbonare (2007) indicated that the propagation of these important local basil plants is highly neglected. *O. gratissimum* could be said to be endangered due to its rare occurrence during a survey of the plant carried out in the western part of Nigeria (Kayode 2006). Due to continuous genetic erosion of these valuable plants; collection, characterisation and evaluation of basil germplasm are some of the important basic steps in basil breeding programme in Nigeria. This brings to mind the need to preserve and maintain these multipurpose plants in situ and ex situ for present and future utilization by mankind.

The value of a germplasm collection depends not only on the number of accessions it contains, but also upon the diversity in those accessions (Ren *et al*. 1995). Morphological characterization is the first step in the classification and description of any crop germplasm (Singh and Tripathi 1985; Smith and Smith 1989). Variation between and within populations of crop species is useful in predicting potential genetic gain in a breeding programme (Hayward and Breese 1993). Therefore understanding the nature and magnitude of variability existing among the different traits of *O. gratissimum* and other basil accessions is very vital in Nigeria for effective utilization of such germplasm geared towards breeding purposes that will help to harness and make the best use of these crops for both agro and medicinal purposes. Also from **Table 1**, it can be easily deduced that reports on agro-morphology and diversity studies of *O. basilicum* genotypes have been carried out in different parts of the globe with little or none coming from West Africa environment with Nigeria inclusive. Thus, this study was carried out to estimate the level of agro-morphological variability that exists between the two main popular indigenous accessions of basil and two exotic varieties in South-western Nigeria.

Received: 5 September, 2012. Accepted: 8 November, 2012.

Research Note

Table 1 Review of agro morphology and genetic diversity of *Ocimum basilicum* around the globe.

Observations/reports	Reference
Classified cultivars into seven types: (1) tall slender types, which include the sweet basil group; (2) large-leafed, robust types (3) dwarf types, which are short and small leafed, such as 'Bush' basil (4) compact types (5) *purpurascens*, the purple-colored basil types with traditional sweet basil flavor; (6) purple types such as 'Dark Opal' (7) *citriodorum* types, which includes lemon-flavored basils.	Darrah 1980
Differences in plant height (46-64 cm), leaf area (11.4-70.9 cm), with 4 accessions having hairy leaf and stems among 12 accessions of *O. gratissimum* studied.	Vieira *et al.* 1999
Wide diversity reported among cultivars of *O. basilicum* such as in growth habit, flower, leaf /stem colors, and aromas in America. The mean height of bush, sweet and tree basil were observed as 23, 49 and 48 cm, respectively while days to flowering for bush, sweet and tree basil are 109, 100, 120 days, respectively.	Simon *et al.* 1999
Farthest genetic distance between *O. kilimandscharicum* and *O. basilicum* while nearest genetic distance was exhibited among accessions of sweet basil and dark opel basil.	Abd-El-Zaher *et al*. 2006
Differences in leaf characters such as colour (light/dark green or purple), size (very small, small, medium or large), flower colour (white or violet), plant height (29.5-55.7 cm), etc. was revealed among 12 basil accessions studied.	De Masi *et al*. 2006
Significant variation among basil traits such as maximum plant height, number of shoots (53.4 cm and 16 cm, respectively) were produced by 'sweet basil'. Leaves were light green (majority of varieties) to purple. With 'Bush basil' having the smallest leaves as compared to other varieties studied. Days to flowering ranged between (44- 126 days) while flower colour ranged from white, pink and violet.	Nurzynska-Wiedak 2007
Wide morphological variability reported for both quantitative and qualitative traits; plant height (39-129 cm), plant diameter (40-105 cm), days to flowering initiation (54-77 days), leaf width (0.9-5.8 cm), leaf length (2.7-9.0 cm), leaf shape and colour, flower colour, stem colour, etc. of 19 accessions of basil growing in Sudan.	Abduelrahman *et al*. 2009
The plant height varied from 14.3 (spicy bush) to 57.0 cm while flower spike varied from 2.9 to 178 cm. Plant spread ranged from 21.3 cm (Spicy Bush) to 61.0 cm in *O. basilicum* with most cultivars having glabrous leaves. Prevalent leaf colour varied from green to dark green while flower colour varied from white to purple.	Svecov and Neugebauerova 2010
Wide variation in 11 germplasm grown on sodic soil. Morphological variation ranged from 39-49 cm, 15-25, 58-84 days, 5.52-16.89 cm for traits such as plant height, primary branches, days to flowering and inflorescence length, respectively.	Gautam *et al*. 2011
High and medium values of genotypic coefficients of variation (GCV) and phenotypic coefficients of variation (PCV), was observed for seed yield per plant and spike length among 30 genotypes studied in India.	Pansaw *et al*. 2011
Comparative high variation for world collection such as in germination % (5-70%), plant height (50-90 cm), canopy cover (180-400 cm), spikes /plant (26-97), leaf area (6-40 cm^2), petiole length (0.5-3.1 cm).	Shazia *et al*. 2011
Observed high variability in plant diameter (30-180 cm), plant height (92.5-134 cm), 52-81 days for days to flowering initiation among *Ocimum* accessions studied in Malaysia. Also flower color ranged from green to pink.	Zurich and Azhari 2011
Wide range and coefficient of variability observed for different characters including plant height (63.03-127.73 cm), number of primary branches (2-7), leaf length (3.0-5.67 cm), leaf width (1.63-2.83 cm), number of inflorescence/plant (53-130), length of inflorescence (7.83-27.27 cm), days to flowering (58.2-71.47 days), etc. in 25 *Ocimum* genotypes studied.	Shehbaz *et al.* 2012

Table 2 Pattern of variations among 4 accessions of basil studied (n = 45 plants were sampled out of 81 plants per accession).

Characters	Mean ± SE	Range	CV%	Pr>f	LSD
Plant height	106.6 ± 2.01	82-157.5	8.8	0.01*	17.58
No of branches	12.46 ± 1.69	4-19	16.6	<0.001**	3.90
Height of 1st branching	7.8 ± 3.67	0.0-36	57.6	<0.001**	8.47
Leaf length	9.74 ± 1.87	3.9-20.1	26.14	0.001**	4.30
Leaf diameter	4.38 ± 12.75	1.7-10.95	46.0	0.077 ns	3.78
Petiole length	2.97 ± 1.00	1.5-8.6	41.4	0.008*	2.31
Stem diameter	1.84 ± 0.40	0.65-2.50	26.6	0.563 ns	0.92
Plant cover	65.2 ± 6.82	49-83	12.8	0.114 ns	15.73
Days to 50% flowering	56.0 ± 1.04	30-72	2.3	<0.001 **	2.43
Inflorescence length	17.3 ± 3.94	9.5-30	27.04	0.030*	9.08
1000-seed weight	0.98 ± 0.009	0.53-1.25	0	-	0

SE: standard error, CV: coefficient of variation

MATERIALS AND METHODS

Methodology

Seedlings of two indigenous basil accessions (tree and bush) locally called "scent leaf and curry leaf respectively" with two exotic types (sweet and purple basil), were raised in deep nursery trays in the month of May, 2011 at National Horticultural Research Institute (NIHORT), Ibadan, Nigeria. Transplanting was done four weeks after sowing in nursery i.e. at 3-4 leaf stage. The four accessions of basil were planted out in a randomized complete block design with three replicates and plot size of 2 m × 2 m at a plant spacing of 0.75 m × 0.75 m with each experimental plot consisting of 9 plants/plot.

Data collection

The four accessions were characterized for 13 quantitative and 6 qualitative traits. Morphological data collected were plant height (cm), number of branches, leaf width (cm), days to 50% flowering, inflorescence length (cm), leaf length (cm), stem diameter (cm), number of seeds/seed sac, petiole length (cm), 1000-seed weight (g), point of first branching (cm), seed colour, leaf colour, flower colour, leaf and stem hairiness. Data was taken from 5 tagged plants/plot in each accession with border plants excluded. Data were analyzed using GenStat 12th Edition. Analysis of variance (ANOVA) and least significant difference (LSD) was applied for comparison among the 4 accessions of *Ocimum*. Leaf colour, seed colour, stem pigmentation, flower colour, leaf and stem hairiness were excluded from the analysis since they were qualitative traits.

RESULTS AND DISCUSSION

The analysis of variance showed significant differences among the accessions for most of the characters studied (**Table 2**). Significant differences were recorded for the following characters such as plant height, number of branches, leaf length, inflorescence length, petiole length and days to 50% flowering, indicating considerable level of variability for the traits while leaf length, canopy cover, stem diameter, 1000 seed weight and number of seeds per pod all showed no significant differences (**Table 2**).

Table 3 The quantitative variability parameters of the 4 basil accessions at the flowering stage (n = 45 plants (stands) per accession).

Quantitative parameters	Tree basil	'Bush' basil	Purple basil	Sweet basil
Plant height (cm)	149.7	84.2	98.2	94.3
Number of branches/plant	5.0	13.0	16.0	17.0
Point of initial branching (cm)	25.7	5.6	0	0
Leaf length (cm)	16.7	4.3	6.3	9.8
Leaf width (cm)	7.0	1.8	4.5	4.2
Petiole length (cm)	6.0	1.8	2.2	1.9
Stem diameter (cm)	2.1	1.6	2.0	1.7
Plant cover (cm)	56.8	62.0	75.7	66.2
Days to 50% flowering	70.7	58.3	34.0	61.0
Inflorescence length (cm)	11.3	23.5	21.9	12.6
Days to flower bud initiation	45.0	25.0	21.0	28.0
1000-seed weight (g)	0.5	1.0	1.2	1.2
Number of seeds/seed sac	4.0	4.0	4.0	4.0

The highest range was recorded for plant height 82-157 cm, followed by days to 50% flowering with a range of 30-70 days while stem diameter had the lowest range of 0.65-2.50 cm (**Table 3**). Days to 50% flowering ranged from 34 days for purple basil to 71 days for the popular local tree basil. Leaf length ranged from 4.3 cm for the bush basil to 16.7 cm for the tree basil. Variation for plant height ranged from 84.2 cm for bush basil to 149.7 cm for tree basil (**Table 3**). Tree basil attained the highest height of 149.7 cm followed by purple basil 98.2 cm. Inflorescence length ranged from 11.3 cm in tree basil to 23.3 cm for bush basil, while purple and sweet basil had inflorescence lengths of 32.9 and 12.6 cm, respectively. 1000-seed weight recorded was from 0.5 g in tree basil to 1.2 g in sweet basil.

For the qualitative traits, considerable level of variability was observed for flower colour, leaf colour and stem colour that could be exploited for developing future breeding materials in basil. However, no variation was observed for stem and leaf hairiness among the basil accessions studied (**Table 4**) but others (Vieira *et al.* 1999; Svecove and Neugebauerova 2010) reported variation in leaf and stem hairiness among basil genotypes studied (**Table 1**). The leaf color ranged from leafy green to green and from purple green to yellowish green. Most of the accessions had greenish leaves than purple and this is in line with the findings of (De Masi *et al*. 2006; Svecove and Neugebauerova 2010) (**Table 1**). For stem colour, two of the accessions had light purple stem while stem colour of the other two accessions ranged from light green to yellowish green. With the tree basil, majority of the matured stems were brownish with the tip of the stems purple in colour. From this study, the tree basil tend to conform with the tall large leaf type while the bush basil was in line with the dwarf small leafed type described by others (Darrah 1980; De Masi *et al*. 2006; Nurzynska-Wiedak 2007) (**Table 1**).

Morphological variability has been recorded on *O. basilicum* from different geographical zones of the world (Grayer *et al.* 1996; Simon *et al.* 1999). Morphological characters such as leaf diameter, plant cover and seed characters like 1000-seed weight, number of seeds/seed sac, respectively showed the lowest variation thus improvement for these traits seemed to be difficult in the germplasm used for this study. The reports of Zurich and Azhari (2011) (**Table 1**) are not in line with the findings of this study with relation to plant diameter. High variability observed for number of branches, height of initial branching, plant height, and length of inflorescence indicates that selection for these traits will be effective in breeding of new basil varieties. Leaf size with good scent is an important character in basil breeding programs since this is one of the economic parts harvested in basil plant (Abduelrahman *et al*. 2009). The variation observed in leaf size of these accessions could be exploited to produce basil varieties with bigger, medium or intermediate leaves depending on market demand based on classifications of basil leaf size by (De Masi *et al*. 2006) (**Table 1**).

The results recorded for the qualitative traits, stem, flower and leaf colour, are in line with the findings of Simon *et al.* (1999) but do not conform with most of the quantitative traits. Sleper and Poehlman (2006) reported that quantitative traits are more influenced by environmental conditions than qualitative traits. The variation observed for days to 50% flowering and days to flower initiation could be exploited to identify and breed for both early and late maturing varieties. The results of this study that recorded lesser number of days to flowering for bush, purple, sweet and tree basil (58, 34, 61, and 71 days, respectively) are in contrast with most of the reports of Simon *et al.* (1999) but in line with results of Nurzynska-Wiedak (2007) for bush basil (**Table 1**). Shazia *et al.* (2011) recorded the mean height of sweet and purple basil as 75.7 and 85.33 cm, respectively, against heights of 94.3 and 98.2 cm observed in this study for the two accessions. The differences observed in the reports might be attributed to different agronomic practices during the experiment in conjunction with differences in climatic and environmental conditions in these locations. The two local accessions differed from each other mainly in leaf colour, leaf size, stem colour, height and inflorescence length while variation between the two exotic accessions in terms of leaf size and height seemed to be intermediate between the two indigenous accessions.

Also the inflorescence length is a function of the number of flower/seeds per seed sac that can be produced per plant. From the study, the bush basil had the highest inflorescence length and should be a good parent for breeding programme aimed at large-scale basil seed production.

From this preliminary field evaluation of four basil accessions, sufficient variability was observed in the traits studied that could lead to improvement, better adaptability and stability of the exotic accessions to our environment for both local and export purposes by exploiting the genes in the two local accessions. There is also need to broaden the genetic base of basil germplasm in Nigeria through collection and introduction backed up with proper conservation to prevent or reduce genetic erosion.

ACKNOWLEDGEMENTS

I wish to thank the NIHORT internal management committee, staffs and IT students of 2011 set of Spices Research Programme (NIHORT) for conducive research environment to carry out this investigation. Special regards as well to my classmates at the West African Centre for Crop Improvement (WACCI), University of Ghana, Diebiru Mercy and Sammy for taking time out of their busy schedules, to help in editing this manuscript. The author thanks Dr. Jaime A. Teixeira da Silva for significant improvements to style and language.

REFERENCES

Abd-El-Zaher MA, Abdelfattah B, Mohammed AE, Ahmed AM, Mervet GH (2006) Genetic diversity among *Ocimum* population in Egypt as reflected by morphological, seed proteins and isozyme polymorphism. *International Journal of Botany* **2 (3)**, 261-269

Table 4 Morphological description of the four basil accessions (n = 45 plants per accession making a total of 180 plants for the 4 accessions.).

Accessions	Seed colour	Flower colour	Leaf colour	Stem colour	Leaf hairiness	Stem hairiness
Tree basil	Brown	Milk/brownish white	Leafy green	Light purple/brown	None	None
Purple basil	Black	Whitish purple	Purple green	Light purple	None	None
Sweet basil	Brown/black	Bright white	Green	Light green	None	None
Bush basil	Brown/black	Dull white	Yellowish green	Yellowish green	None	None

Abduelrahman AHN, Elhuseein SA, Osman NAI, Nour AH (2009) Morphological variability and chemical composition of essential oils from nineteen varieties of basil growing in Sudan. *International Journal of Chemical Technology* **1 (1)**, 1-10

Adebolu TT, Oladimeji SA (2005) Antimicrobial activity of leaf extracts of *Ocimum gratissmum* on selected diarrhea causing bacteria in South Western Nigeria. *African Journal of Biotechnology* **4 (7)**, 682-684

Anon (1980) What you should know about basil? American spice trade. N. J., 5 pp

Darrah HH (1980) *The Cultivated Basils*, Buckeye Printing Co., MO.

De Masi L, Siviero P, Esposito C, Castuldo D, Siano F, Larata F (2006) Assessment of agronomic, chemical and genetic variability in common basil (*Ocimum basillicum*). *European Food Research Technology* **223**, 273-281

Effraim KD, Jacks TW, Sodipo OA (2003) Histopathological studies on the toxicity of *Ocimum gratissimum* leaf extract on some organs of rabbits. *African Journal of Biomedical Research* **6**, 21-25

Ehiagbonare JE (2007) Micropropagation of *Ocimum gratissimum* L: A multipurpose medicinal plant in Nigeria. *African Journal of Biotechnology* **6 (1)**, 13-14

Ekunwe SI, Thomas MS, Luo X, Wang H, Chen Y, Zhang X, Begonia GB (2010) Potential cancer-fighting *Ocimum gratissimum* (OG) leaf extracts: increased anti-proliferation activity of partially purified fractions and their spectral fingerprints. *Ethnicity and Disease* **20 (1) Suppl 1**, S1-12-6

Erum S, Naeemullah M, Masood S, Khan MI (2011) Genetic variation in living repository of *Ocimum* germplasm. *Pakistan Journal of Agricultural Research* **24**, 1-4

Gautam RK, Ojha A, Sharma V, Sharma VN, Rawat A (2010) Morpho-chemical fingerprinting and salt tolerance of sweet basil *Ocimum basilicum* L. genotypes grown in sodic soil. *Journal of Applied Sciences Research* **6 (12)**, 2173-2180

Grayer RJ, Kite GC, Goldstone FG, Bryan SE, Paton A, Putievsky E (1996) Intraspecific taxonomy and essential oil chemotypes in sweet basil, *Ocimum basilicum*. *Phytochemistry* **43**, 1033-1039

Hayward MD, Breese EL (Eds) (1993) Population structure and variability. In: *Plant Breeding. Principles and Prospects*, Chapman and Hall, London, pp 17-29

Ibrahim MM, Aboud KA, Hussein RM (2011) Genetic variability and path coefficient analysis in sweet basil for oil yield and its components under organic agriculture conditions. *Journal of American Science* **7**, 6

Iroanya OO, Okpuzor JE, Mbagwu H, Ojobo PD (2009) Analgesic properties of an indigenous polyherbal preparation. *The FASEB Journal* **23**, S1

Kayode J (2006) Conservation of *Ocimum gratissimum* in rural communities of Ekiti state of Nigeria and its use in self medication. *African Scientist* **7**, 3

Khan MS, Bahuguna DK, Kumar R, Kumar N, Lone IA (2012) Study on genetic variability and heritability in *Ocimum* spp. *HortFlora Research Spectrum* **1 (2)**, 168-171

Mohammed A, Tanko Y, Okasha MA, Magaji RA, Yaro AH (2007) Effects of aqueous leaves extract of *Ocimum gratissimum* on blood glucose levels of streptozocin-induced diabetic Wistar rats. *African Journal of Biotechnology* **6 (18)**, 2087-2090

Nurzynska-Wiedak R (2007) Comparing the growth and flowering of selected basil *Ocimum basilicum* L. varieties. *Acta Agrobotanica* **60 (2)**, 127-131

Nweze EI, Eze EE (2009) Justification for the use of *Ocimum gratissimum* L in herbal medicine and its interaction with disc antibiotics. *BMC Complementary and Alternative Medicine* **9 (37)**, 1472

Oboh FOJ, Madsodje HI, Enabulele SA (2009) Nutritional and antimicrobial properties of *Ocimum gratissimum* leaves. *Journal of Biological Sciences* **9 (4)**, 377-380

Oparaocha ET, Iwu I, Ahanaku JE (2010) Preliminary study on mosquito repellent and mosquitocidal activities of *Ocimum gratissimum* L. grown in eastern Nigeria. *Journal of Vector Borne Diseases* **47 (1)**, 45-50

Panwar NS, Kumar Ashok, Malik SS, Dwivedi VK, Kumar Gunjeet, Singh PB (2011) Assessment of variability parameters for agro-morphological and phyto-chemical traits in basil *Ocimum basilicum* L. germplasm. *Indian Journal of Plant Genetic Resources* **24 (1)**, 91-95

Paton A (1992) A synopsis of *Ocimum* L. *Labiatae* in Africa. *Kew Bulletin* **47**, 403-435

Ren J, McFerson J, Kresovich RLS, Lamboy WF (1995) Identities and relationship among Chinese vegetable *Brassicas* as determined by RAPD markers. *Journal of the American Society of Horticultural Science* **120 (3)**, 548-555

Simon JE, Chadwick AF, Craker LE (1984) *Herbs: An Indexed Bibliography 1971–1980*, Archon Books, Hamden, pp 7-9

Simon JE, Morales MR, Phippen WB, Vieira RF, Hao Z-G (1999) Basil: A source of aroma compounds and a popular culinary and ornamental herb. In: Janick J (Ed) *Perspectives on New Crops and New Uses*, ASHES Press, Alexandria, VA, pp 499-505

Simon JE, Quinn J, Murray RG (1990) Basil: A source of essential oils. In: Janick J, Simon JE (Eds) *Advances in New Crops*, Timber Press, Portland, OR, pp 484-489

Singh SB, Tripathi BK (1985) Genetic divergence in pea. *Indian Journal of Genetic Plant Breeding* **2**, 389-393

Sleper DA, Poehlman JM (2006) *Breeding Field Crops* (5th Edn), Blackwell Publishing, Ames, Iowa, USA, 53 pp

Smith JSC, Smith OS (1989) The description and assessment of distances between inbred lines of maize: The utility of morphological, biochemical and genetic descriptors and a scheme for testing of distinctiveness between inbred lines. *Maydica* **34**, 151-161

Svecov E, Neugebauerova J (2010) A study of 34 cultivars of basil *Ocimum* L. and their morphological, economic and biochemical characteristics, using standardized descriptors. *Acta University Sapienttiae, Alimentaria* **3**, 118-135

Vieira RF, Grayer RJ, Paton A, Simon JE (2001) Genetic diversity of *Ocimum gratissimum* L. based on volatile oil constituents, flavonoids and RAPD. *Biochemical Systematics and Ecology* **29**, 287-304

Zuriah I, Nour AH (2011) Morphological characterization and essential oil composition of basil *Ocimum basilicum* L. accessions introduced and growing in Malaysia. *Universiti Malaysia Terengganu International Annual Symposium* UMTAS, 11-13th July 2011, Kuala Terenggan, Malaysia PCO2