Available Online at ESci Journals
Journal of Plant Breeding and Genetics
ISSN: 2305-297X (Online), 2308-121X (Print)
http://www.escijournals.net/JPBG

GENETIC DIVERSITY ANALYSIS OF ETHIOPIAN CORIANDER (*CORIANDRUM SATIVUM* L.) GENOTYPES FOR SEED YIELD AND OIL CONTENT

[a]Geremew Awas*, [b]Firew Mekbib, [c]Amsalu Ayana
[a] *International Maize and Wheat Improvement Center (CIMMYT-Ethiopia).*
[b] *Haramaya University College of Agriculture and Environmental Science, P.o.box 138, Dire Dawa, Ethiopia.*
[c] *Integrated Seed Sector Development Ethiopia Program, Addis Ababa, Ethiopia.*

A B S T R A C T

Genetic diversity is highly significant for the improvement of many crop species including coriander. Eighty one Ethiopian coriander genotypes were evaluated in 9x9 simple lattice design with two replication for genetic diversity analysis in yield and yield related traits at Adami Tulu Agricultural Research Center, Ethiopia during 2011 main cropping season. Data were collected on 21 traits. The studied genetic divergence of the 81 coriander genotypes were grouped in to eight clusters using Mahalanobis D2 statistics. The largest cluster (II) and the smallest cluster (VIII), contains about 51.8% and 2.4% of studied genotypes respectively. Maximum and minimum intra cluster distance were observed in cluster II and VIII (D2=7.48 and 1.31 respectively). Maximum inter cluster distance was observed between cluster VI and VIII (D2=329.85) and the minimum distance was observed between cluster I and IV (D2=19.02), suggesting the possibility of getting suitable genotypes for hybridization program among the genotypes. In conclusion, despite the diverse favorable agro- ecologies, germplasm availability and released opportunities, research attention given to this crop was very low till recent time. The present investigation indicated that there is wide range of genetic diversity in the tested germplasm for most of the characters studied. Hybridization among accessions from different clusters identified in this study could lead to considerable genetic improvement by following appropriate selection strategies in the segregating generations.

Keywords: Coriander, essential oil, fatty oil, genotype, variability.

INTRODUCTION

Coriander (*Coriandrum sativum* L, 2n=2x=22) is a diploid annual plant, belonging to the Apiaceae/Umbliferae family [15]. It is also known as 'Cilantro' particularly in Americas [6]. It is a culinary and medicinal plant native to Mediterranean and Western Asian regions [14], and cultivated worldwide [21]. Green coriander (also called Chinese, Mexican or Japanese parsley) has been called the most commonly used flavoring in the world due to its usage across the Middle East into all of southern Asia as well as in most parts of Latin America [4]. Coriander was used in Egypt for medicinal and culinary purposes as early as 1550 BC and is mentioned in the Eber Papyrus and also used in traditional Greek medicine by Hippocrates and other Greek physicians during 460–377 B.C[15]. The seeds of coriander were found in the ancient Egyptians tomb of Ramses the second [9], for this the Egyptians called this herb the 'spice of happiness' because it was considered to be an aphrodisiac.

Coriander plays an important role in the Ethiopian domestic spice trade and its seeds are used for the flavoring of 'berbere' (which is a spiced, hot red pepper powder used for numerous meat and vegetarian dishes), 'injera', cakes and bread andits leaves added as an aromatic herb to 'wot' and tea [12]. In 'Kefa', seeds are added to cheese and to a porridge made of *Colocasiaesculenta* (taro) [7]. In India, the fruits are also extensively employed as a condiment in the preparation of pickling spices, sausages and seasonings, and for flavoring of pastry, cookies, buns and cakes, tobacco

* Corresponding Author:
Email ID: gerewas@gmail.com

products and also used in flavoring of several alcoholic beverages i.e. gin [5] and [8].

The extent of genetic diversity available in the crop decides the success of any crop improvement program with manifested objectives. To make the crossing program effective, parents should belong to different genetic cluster. The more distant the parents within over all limits of fitness are the greater the chances of obtaining higher amount of heterotic expression in F1's and broad spectrum of variability in segregating populations [1]. However, crossing of genotypes belonging to the same genetic cluster would not be expected to yield desirable recombinants. Before any hybridization work, genetic diversity of the existing genotypes needs to be known. Moreover, evaluation of genetic diversity is important to know the source of genes for particular trait within the available germplasms [3]. Even though Ethiopia is one of the centers of origin of coriander, research attention given to this crop was very low till recent time. Therefore the current study aimed to analyze genetic divergence among 81 Ethiopian coriander genotypes.

ABBRIVIATIONS AND ACRONYMS

DE=days to emergence, DSF=days to start of flowering, DF=days to 50% flowering, DM=days to maturity,SYPH=seedyield/hectare(kg),TSW=thousand seed weight(g), HI=harvest index in percentage, FOC=fatty oil content(%), and EOC=essential oil content(%)(v/w dry based), PHF=plant height at flowering(cm), PHM=plant height at maturity(cm), NPB=number of primary branches, NSB=number of secondary branches, UNP=umbelnumber/plant,UNU=umbellete number/umbel, NSU=number of seed/umbellete, NSP=numberofseed/plant,SYP=seed yield/plant(g),LBLL=longest basal leaf length(cm), LN=leaf number, BYPt=biomass yield /plant(g), ATARC=Adami Tulu Agricultural Research Center, OARI=Oromia Agricultural Research Center, IBC=Institute of Biodiversity Conservation of Ethiopia, HARC=Holeta Agricultural Research Center, m.a.s.l=meters above sea level.

MATERIALS AND METHOD

Description of the Study Area: The experiment was conducted at Adami Tulu Agricultural Research Center of Oromia Agricultural Research Institute (OARI) with rain fed during 2011 main cropping season. Adami Tulu Agricultural Research Center (ATARC) is located in the Mid Rift Valley of Ethiopia 167km south of Addis Ababa. It lies at a latitude of 7˚ 9'N and longitude of 38˚ 7' E. It has an altitude of 1650 m.a.s.l and it receives a bimodal unevenly distributed average annual rainfall of 760.9 mm per annum. The long term mean minimum and maximum temperature is 12.6 °C and 27 °C respectively. The pH of soil is 7.88 and it is fine sandy loam in texture with sand, clay and silt in proportion of 44, 22 and 34% respectively [20].

Experimental Material: Eighty (80) population of Ethiopian coriander genotypes along with one released variety (waltai) were used in this study (Table 1). The genotypes were collected from different agro- ecologies of varying altitude, rainfall, temperature and soil type by Institute of Biodiversity Conservation of Ethiopia (IBC).

Experimental Design: Treatments/genotypes were arranged in a 9x9 simple lattice design with two replications. Each replication contained 81 plots divided into 9 incomplete blocks. Each incomplete block contains nine plots with an area of 2.4m2(1.5 m length x 1.6 m width). The respective spacing between rows was 40 cm and seeds were drilled in the rows. The trial was planted on September 06/2012. Thinning was done to 10cm between plants after seedlings attain true leaves. There were four rows per plot and the middle two rows were used for data collection in order to remove the boarder effect. Weeding and other cultural practices were employed as required and no fertilizer and chemicals was applied.

Data Collection: A total of 21 quantitative traits (days to emergency, days to start of flowering, days to 50% flowering, days to maturity, seed yield per plant and per hectare, number of seed per plant, thousand seed weight, biomass yield per plant, harvest index per plant, plant height at flowering, plant height at maturity, number of primary and secondary branches, longest basal leaf length, leaf number per plant, umbel number per plant, umbellate number per umbel, number of seed per umbellete, essential and fatty oil content) were collected according to International Plant Genetic Resource Institute [11] to evaluate the genotypes.

Essential Oil Content (EOC): A seed sample was taken from each plot to determine the essential oil content (%) and it was determined by hydro-distillation as illustrated by [10]. Hydro-distillation is a distillation method in which the coriander seed comes in direct contact with boiling water. Heat was provided by electro mantle. The emerging vapor from the flask containing

the volatile essential oil was led to a condenser for condensation and collected in the oil separate unit (Clevenger), this analysis was done at JIJE LABOGLASS plc.

Fatty Oil Content (FOC): Fatty oil content (%) was determined from an oven dried 22 g composite seed samples taken from each plot by subjecting into the Nuclear Magnetic Spectrometer Reader (NMRS) and this analysis was done at Holeta Agricultural Research Center (HARC).

Cluster Analysis: Data on 21 traits were collected on both plant and plot basis and mean data of each treatment over replications was used for statistical analysis. The data was standardized to mean of zero and variance of unity to avoid differences in scales used for recording data on the different characters before under taking a clustering and divergence analysis. Mahalanobis D2 (Mahalanobis D2) was used to estimate the genotypic divergence between the clusters in the experimental population based all 21 yield and yield contributing characters. All the genotypes used were clustered into different groups based on D2 statistics following Tocher's Methods [16]. Clustering of the genotypes into different groups(i.e., based on 21 traits) was carried out by average linkage method and the appropriate number of clusters were determined from the values of Pseudo F and Pseudo T statistics using SAS computer software (Version 9.0) The intra and inter distance was computed by the following formula [18].

$D2ij = (xi - xj)\text{-}1\ cov\text{-}1\ (xi - xj)$

Where,

D2ij = the distance between i and j

Genotypes

xi and xj=mean vector values for i^{th} and j^{th}

Genotypes

Cov=the pooled within group variance covariance matrix.

Table 1. Geographic origins of 81 Ethiopian coriander genotypes used in the study at Adami Tulu Agricultural Research Center, 2011/12.

S.No	Accession No.	Regions	Zone	District	Altitude (m.a.s.l)
1	90301	Oromiya	Arsi	Gedeb	NA
2	90302	Amara	Misrak Gojam	Enarj Enawga	NA
3	90304	Amara	Misrak Gojam	HuletEjEnese	2510
4	90305	Amara	Semen Gondar	Alefa	1760
5	90307	NA	NA	NA	NA
6	90311	NA	NA	NA	NA
7	90312	NA	NA	NA	NA
8	205149	Amara	Semen Gondar	Debark	NA
9	207515	Amara	Debub Gondar	Lay Gayint	NA
10	207516	Amara	Debub Gondar	Tach Gayint	NA
11	207517	Amara	Debub Gondar	Tach Gayint	NA
12	207518	Amara	Debub Gondar	Tach Gayint	NA
13	207519	Amara	Debub Gondar	Tach Gayint	NA
14	207520	Amara	Debub Gondar	Simada	NA
15	207973	Benishangul Gumuz	Asosa	Asosa	1150
16	207974	Benishangul Gumuz	Asosa	Asosa	1340
17	208455	Amara	Misrak Gojam	Enarj Enawga	NA
18	208766	Oromiya	Mirab Wellega	Sayo	NA
19	211471	SNNP	Bench Maji	Konso Special	1560
20	211503	Oromiya	Mirab Wellega	Boji	NA
21	212691	Amara	Debub Gondar	Kemekem	1900
22	212830	Oromiya	Bale	Goro	NA
23	212832	Oromiya	Bale	Nensebo	NA
24	215191	Amara	Semen Wello	Guba Lafto	NA
25	215291	Amara	Misrak Gojam	Goncha SisoEnese	NA

26	216857	Oromiya	Arssi	Tiyo	2340
27	219805	Tigray	Mehakelegnaw	Laelay Maychew	NA
28	219806	Tigray	Mirabawi	Asegede Tsimbela	NA
29	223066	Amara	Misrak Gojam	Baso Liben	NA
30	223067	Benishangul Gumuz	Metekel	Dangur	NA
31	223068	Amara	AgewAwi	Ankesha	NA
32	223114	Oromiya	Illubabor	Yayu	NA
33	223289	Oromiya	Mirab Harerge	Guba Koricha	NA
34	223290	Oromiya	Mirab Harerge	Guba Koricha	NA
35	229707	Amara	Agew Awi	Banja	NA
36	229709	Amara	Agew Awi	Guangua	1550
37	229712	Amara	Misrak Gojam	Enarj Enawga	2550
38	229713	Amara	Misrak Gojam	Enarj Enawga	2550
39	229714	Amara	Misrak Gojam	Enarj Enawga	2570
40	230576	Oromiya	Bale	Goro	1590
41	230577	Oromiya	Bale	Goro	1600
42	234051	Tigray	Mehakelegnaw	Adwa	NA
43	235787	Amara	Semen Gondar	Alefa	2130
44	235827	Amara	Semen Gondar	Alefa	NA
45	236401	Oromiya	Misrak Wellega	Abay Chomen	NA
46	240406	SNNP	Keficho Shekicho	Yeki	NA
47	240546	NA	NA	NA	NA
48	240547	NA	NA	NA	NA
49	240549	NA	NA	NA	NA
50	240550	NA	NA	NA	NA
51	240551	NA	NA	NA	NA
52	240552	NA	NA	NA	NA
53	240553	NA	NA	NA	NA
54	240554	NA	NA	NA	NA
55	240555	NA	NA	NA	NA
56	240556	NA	NA	NA	NA
57	240557	NA	NA	NA	NA
58	240558	NA	NA	NA	NA
59	240559	NA	NA	NA	NA
60	240560	NA	NA	NA	NA
61	240561	NA	NA	NA	NA
62	240562	NA	NA	NA	NA
63	240563	NA	NA	NA	NA
64	240567	NA	NA	NA	NA
65	240568	NA	NA	NA	NA
66	240569	NA	NA	NA	NA
67	240571	NA	NA	NA	NA
68	240572	NA	NA	NA	NA
69	240803	SNNP	Semen Omo	Damot Weyde	1850
70	240805	SNNP	Semen Omo	Mareka Gena	2320
71	242241	Amara	Debub Wello	Kalu	1530
72	242242	Tigray	Mirabawi	Medebay Zana	2080

73	242243	Amara	Semen Wello	Guba Lafto	1910
74	242244	Amara	Semen Wello	Guba Lafto	2000
75	242330	SNNP	Keficho Shekicho	Chena	2100
76	242849	Oromiya	Arssi	Sherka	2310
77	242918	SNNP	Keficho Shekicho	Chena	2200
78	244651	Amara	Semen Gondar	Dembia	1917
79	244652	Amara	Semen Gondar	Alefa	1840
80	249714	amara	Misrak Gojam	Enarj Enawga	2500
81	*Waltai*		Released variety		

Source: Ethiopian Institute of Biodiversity Conservation, Addis Ababa.*NA= Data not Available.

RESULTS

The largest cluster (II) accommodates about 51.8% of the genotypes followed by cluster I(19.7%) and cluster IV and V (8.6%).On the other hand cluster VIII accommodates the smallest number of genotypes (2.4%) followed by cluster VI and VII (3.7%) and cluster III (4.9%) respectively Table 3 and fig 1. The intra and inter-cluster distances (D2) values are presented in Table 4. The intra-cluster distance is lower than the inter-cluster distances, which suggested heterogeneous and homogenous nature between and within groups, respectively. The highest intra-cluster distance (7.4) was observed in cluster VIII, followed by cluster III, VI and VII (6.59) and cluster IV (6.01). Minimum intra-cluster distance was observed in cluster II (1.31) followed by cluster I (3.24) Table 4.

The magnitude of inter- cluster distance (D2) were generally high and were indicators for the presence of genetic divergence in Ethiopian coriander genotypes. The highest inter-cluster distance(329.85) was observed between cluster VI and VIII, followed by cluster II and cluster VIII (248.13), cluster IV and VIII (247.32),suggesting wide diversity among the genotypes included in these clusters and crossing between these clusters will result in high heterotic response and thereby better segregants. The lowest inter-cluster distance (D2) was observed between cluster I and IV (19.02) followed by cluster II and IV (19.62) and cluster I and II (33.3) which indicates that, genotypes involved in these clusters have low genetic diversity.

When the mean performance of each clusters are compared for each characters, the highest mean seed yield per hectare were obtained in cluster VI (2767.2 kg) followed by cluster IV (1877.48kg) and VII (1180.53kg) Table 2. Similarly cluster III were characterized by the highest fatty and essential oil content (10.28 and 0.83 respectively). Cluster VIII is characterized by genotypes which contained highest thousand seed weight (12.64g) and harvest index per plant (27.54%). Similarly Cluster VII is characterized by highest umbellate number per umbel and number of seed per umbellate (7.17 and 9.3 respectively). Cluster V and VII are characterized by high mean seed yield per plant (16.05 g and 16 g respectively).

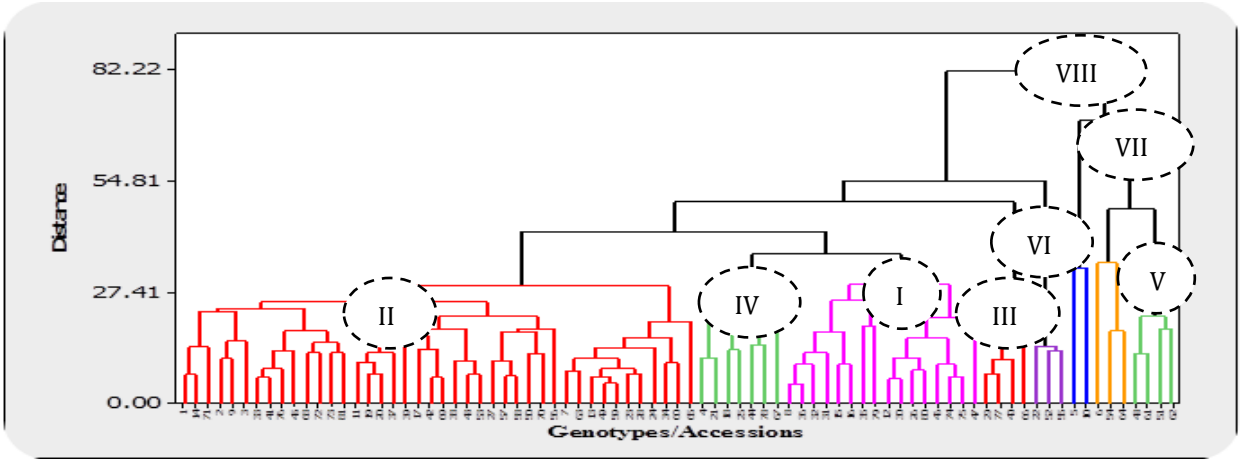

Figure 1. Cluster groups of 81 coriander genotypes based on 21 different traits at Adami Tulu Agricultural Research Center, 2011.

Table 2. Mean values of eight clusters for 21 traits of the 81 Ethiopian coriander genotypes.

Clusters	I	II	III	IV	V	VI	VII	VIII
DE	13.25	14.69	14.25	11.5	12.75	10.83	13	10.75
DSF	60.5	44.16	53.25	35.72	53.75	39.17	50.83	34
DF	77.25	61.72	67.75	49.82	68.75	57.17	66.83	42.63
DM	119.75	106.16	116	95.29	101.5	105.17	114.33	81.38
SYPH	640.63	1149.6	1037.5	1877.48	175.45	2767.2	1180.53	1093.83
TSW	4.94	8.19	7.14	10.67	3.56	11.66	7.55	12.64
HI	9.35	19.27	17.8	19.19	8.15	20.68	15.6	27.54
PHF	77.12	48.88	74.15	35.99	59.6	48.3	72.7	26.93
PHM	88.31	68.63	91.25	61.71	71.63	75.5	85.87	44.65
NPB	9.25	8.25	10.45	10.2	6.5	12.2	9.83	9
NSB	44.51	30.82	44.5	24.89	19.35	32.38	43	20.83
UNP	24.38	34.3	40.73	41.75	22.5	53.4	37.08	32.24
UNU	5.36	5.57	6.65	6.02	5.3	5.8	7.17	5.03
NSU	7.12	7.77	9.1	8.48	6.25	7.93	9.3	8.4
NSP	536.6	676.58	1090.8	801.55	413.25	1089.47	938.23	453.63
SYP	3.25	5.94	8	8.46	1.5	13.17	7.17	5.5
LBLL	13.65	10.94	15.23	11.92	16.05	15.78	16	8.79
LN	114.43	77.98	145.18	53.22	134.75	79.55	129.12	30.88
BYPt	35.25	30.92	43.75	45.82	20	68.17	44.83	21.13
FOC	6.68	7.62	10.28	9.26	4.95	8.68	9.25	10.01
EOC	0.56	0.82	0.83	0.71	0.6	0.55	0.75	0.6

DE=days to emergence; DSF= days to start of flowering; DF= days to 50% flowering; DM= days to maturity; SYPH=seed yield/hectare(kg); TSW= thousand seed weight(g); HI=harvest index in percentage; FOC=fatty oil content(%); and EOC=essential oil content(%)(v/w dry based); PHF=plant height at flowering(cm); PHM=plant height at maturity(cm); NPB=number of primary branches, NSB= number of secondary branches, UNP=umbel number/plant, UNU=umbellete number/umbel; NSU=number of seed/umbellate; NSP=number of seed/plant; SYP=seed yield/plant(g); LBLL= longest basal leaf length(cm); LN=leaf number; BYPt=biomass yield /plant(g).

Table 3. Distribution of 81 Ethiopian coriander genotypes in different clusters.

Cluster	No.	Accessions number
Cluster- I	16 (19.7%)	205149, 207518, 207974, 229707, 242244, 223068, 249714, 240546, 244652 , 240406, 242330, 223114 , 207973, 229709, 216857, 223067
Cluster -II	42 (51.8%)	90301, 90302, 90304, 207515, 207517, 207519, 211471, 207520, 20 8455, 211503, 212832 ,215191, 219805, *waltai*,219806 223289, 223290, 229712, 229713, 229714, 230577, 234051, 235787, 236401, 240549,240550, 240553, 240556, 240557, 240558, 240805, 242241, 242242, 242243, 242849, 90312, 240560, 240559, 240563, 240568, 240572, 240803
Cluster -III	4 (4.9%)	223066, 230576, 240569, 242918
Cluster- IV	7(8.6%)	90305, 208766, 212691, 215291, 235827, 240571, 244651
Cluster- V	4(4.9%)	240547, 240551, 240561, 240562
Cluster -VI	3(3.7%)	212830, 240552, 240555
Cluster VII	3(3.7%)	90311, 240554, 240567
Cluster VIII	2(2.4%)	90307, 207516

Table 4. Average intra (bold main diagonal) and inter-cluster distance (off diagonal) value in 81 Ethiopian coriander genotypes.

Cluster	I	II	III	IV	V	VI	VII	VIII
I	3.24	33.30 ns	51.84**	19.02ns	65.24**	119.63**	48.73**	195.07**
II		1.31	42.40**	19.62 ns	86.40**	42.24**	55.36**	248.13**
III			6.59	54.79**	114.46**	121.88**	112.16**	218.58**
IV				4.63	79.56**	79.58**	46.18**	247.32**
V					6.01	118.49**	55.40**	179.63**
VI						6.59	112.50**	329.85**
VII							6.59	238.76**
VIII								7.40

X2= 40.2 and 33.9 significant at 1% and 5% probability level, respectively.

DISCUSSION

The studied genetic divergence of the 81 Ethiopian coriander genotypes was grouped into eight clusters using Mahalanobis D2 statistics. These analyses were carried out to know the extent of divergence in the genotypes to identify the superior genotypes for further utilization in hybridization program and to find out the contribution of different characters towards genetic divergence in coriander. The range of intra-cluster distance in the current finding (1.31 to 7.4) was in agreement with the findings of [2] and [19]. The current grouping pattern was similar with the findings of [19] grouping pattern, which didn't show relationship between genetic diversity and geographical distribution in coriander accessions collected from different agro-ecology. The range of inter-cluster distance (D2) values (19.02 to 329.85) obtained in the current study were similar with findings [2] (23.72 to 480.5) and it is higher than the result reported by [19] (32.41 to 96.2) in coriander.

CONCLUSSION

In conclusion, despite the diverse favorable agro-ecologies, germplasm availability and released opportunities, research attention given to this crop was very low till recent time. The present investigation indicated that there is wide range of genetic diversity in the tested germplasm for most of the characters studied. Hybridization among accessions from different clusters identified in this study could lead to considerable genetic improvement by following appropriate selection strategies in the segregating generations. However, it would be worthwhile to study more available germplasm over years and locations to identify more diverse accessions as well as to confirm the importance of the traits identified as predictors of seed yield and/or oil content.

ACKNOWLEDGEMENTS

I Acknowledge the Financial Support of Oromia Agricultural Research Institute for This Study.

REFERENCES

Arega, G., H. Mohammed and H. Singh. 2007. Genetic divergence in selected durum wheat genotypes of Ethiopian plasm. African crop science journal, Vol 15(2), Pp: 67-72.

Beemnet, M., G. Alemaw, B. Tesfaye. 2011. Genetic divergence in Ethiopian coriander accessions and its implication in breeding of desired plant types. African Crop Science Journal. 19(1):39–47.

Begum, S, M. A. Islam, A. Husna, T. B. Hafiz and M. Ratna. 2011. Genetic Diversity analysis in sesame (S. Indicum L.). International Journal of Plant Breeding and Genetics, 9: 228-237.

Blade S. and R. Spencer. 2008. Practical information for Alberta's Agriculture Industry/coriander. Alberta Agriculture and Rural Development Fact Sheet, Pp:101-105.

Diederichsen, A. 1996. Coriander (Corianderum sativum L). Promoting the conservation and use of underutilized and neglected crops. Institute of Plant Genetics and Crop Plant Research, Gaterslbebn/International Plant Genetic Resources Institute, Rome, Italy. 83p.

Dinkov, D. and T. Ivanov. 2010. Sensorial characteristics and composition of Bulgarians coriander (Coriander sativum) honey. Asian Journal of Food and Agro Industry, Special Issue, S217-S221.

Engels, J. M. M., J. G. Hawkes and M. Worede. 1991.Plant genetic resources of Ethiopia. Cambridge University Press, New York. 396p.

Farahani, A., L. Hussein, H. Mohammad, A. H. Shiranirad, V. A. Reza and D. Jahanfar. 2008. Effects of arbuscular mycorrhizal fungi, different levels of

phosphorus and drought stress on water use efficiency, relative water content and proline accumulation rate of Coriander (*Coriandrum sativum* L.). Journal of Medicinal Plants Research, 2(6):pp:125-131.

George, A., L. Burdock and G. Iona. 2009. Safety assessment of coriander (Coriandrum sativum L.) essential oil as a food ingredient. Food and Chemical Toxicology Journal, pp.22-34.

Guenther, E. 1972. The production of essential oils: Methods of distillation, enflorage, maceration and extraction with volatile solvents. In: Guenther, E. (Ed.), pp. 68. The Essential Oils. History-Origin in Plants. Production Analysis. Kreieger Publ. Co. Malabar, Florida, USA. 427p.

International Plant Genetic Resources Institute (IPGRI), 1996. Promoting the conservation and use of underutilized and neglected crops. Rome.83p.

Jansen, P. C. M. 1981. Spices, condiments and medicinal plants in Ethiopia, their taxonomy and agricultural significance. Wageningan: PUDOC, 56-67pp.

Mahalanobis, P. C. 1936. The generalized distance in statistics. Proceedings of National Institute of Science (India) 2:pp:49-55.

Maroufi, K., H. Aliabadi, J. Farahani and H. Darvishi. 2010. Importance of coriander (*Coriandrum sativum* L.) between the medicinal and aromatic plants. Advance in Environmental Biology. 4(3):Pp:433-436.

Parthasarathy, V., B. Chempakam and T. J. Zachariah. 2008. Chemistry of spices. CAB International. 455p. Rao C.R. 1952. Advanced Statistical Methods in Biometrics Research. Johan Wiley and Sons, New York Pp:191-211.

SAS Institute, 2001. SAS software. SAS Institute INC., Cary. NC. USA.

Singh, V. P. and B. D. Chaudary. 1977. Genetic divergence in some Indian and exotic barley varieties and their hybrid. Indian Journal of Genetics. 35:Pp:409-413.

Singh, S. P., R. S. Katiyar, S. K. Rai, S. M. Tripayhi and J. P. Srivastava. 2005. Genetic divergence and its implication in breeding of desired plant type in coriander (*Coriandrum sativum* L.). Genetika 37(2):155-163.

Teshome, A., N. Dechasa and Y. Alemayehu. 2012. Sweet potato growth parameters as affected by farm yard manure and phosphorus application at Adami Tulu Agricultural Research Center, Central rifty valley of Ethiopia. Agricultural Science Research Journal. 2 (1): Pp:1-12.

Weiss, E. A. 2002. Spice crops. CABI Publishing, New York, USA. 411p.