IJABBR- 2014- eISSN: 2322-4827

International Journal of Advanced Biological and Biomedical Research

Journal homepage: www.ijabbr.com

Original Article

Phenotypic Variability in Ethiopian Castor (*Ricinuscommunis* L.) Accessions

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A R T I C L E I N F O

Article history:
Received: 09 Sep, 2014
Revised: 28 Oct, 2014
Accepted: 23 Nov, 2014
ePublished: 30 Dec, 2014

Key words:
Castor
Ethiopia
***Ricinuscommunis* L.**
Variability

A B S T R A C T

Objective: Castor (*Ricinuscommunis L.)* is an industrial oilseed that belongs to the family Euphorbiaceae. Castor is believed to be originated in East Africa probably Ethiopia. Although Ethiopia is known as a primary diversity for castor the knowledge on nature and extent of variation of the indigenous germplasm is limited. The present test was conducted to study the nature and extent of variability among Ethiopian castor accessions. **Methods:** The test was conducted at Melkassa and Arsi Negelle, in the Central Rift Valley of Ethiopiaduring the main season of 2013/14. A total of 105 accessions were arranged in a randomized complete block design with three replications. Data of 12 characters were collected and analyzed statistically. Combined analysis of variance over locations reveled the existence of significant variation among accession in all the traits considered in this study. The interaction between accessions and environment was significant for eight of the 12 traits studied. **Results:** The accessions showed a wide range of variation on days to first flowering (52-148), days to second flowering (65-161), days to first maturity (118-217), days to second maturity (142-237), inflorescence length (13-74 cm), node length (2-32 cm), number of nodes/plant (5-26), number of inflorescence/plant (1-26), plant height (89-356), number of branches/plant (1-9), number of capsules/plant (10-350), hundred seed weight (21-99 g),number of seeds/plant (30-990). Overall highest value of heritability, genetic coefficient of variability and genetic advance as percent of the mean was recorded for number of nodes/plant, number of capsules/plant and 100 seed weight.

1.INTRODUCTION

Castor (RicinuscommunisL.) an annual/perennial shrub and non edible oil seed crop that belongs to a member of Euphorbiaceae family (Weiss, 2000). The plant is believed to be native of East Africa and probably originated in Ethiopia where it shows tremendous variability (Anjani, 2012). In Ethiopia, Castor grows as annual in the low lands to small tree perennial in the high lands. India, china, Brazil and USA are the major castor producers globally.
Castor oil is non edible and has been used almost entirely for pharmaceutical and industrial applications (Serverinoet al., 2012). Castor oil is unique among vegetable oil because it is the only commercial source of a hydroxylated fatty acid or ricinoleic acid (Liv et al., 2012). This unique fatty acid comprises about 90% of the

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castor oil (Serverinoet al., 2012). No other commercial vegetable oil produces such a high level of ricinoleic acid. It appears that the level of ricinoleic acid is not significantly influenced by environment. Serverinoet al (2012) also reported that thehigh content of ricinoliec acid in castor allows the production of high purity derivatives. The hydroxyl group in ricinoleic acid is important point of chemical reaction that allows several chemical reactions (ICOA, 1992; Ogunniyi, 2006). Castor oil is highly soluble in alcohol at room temperature that facilitates several chemical reactions (da Silva et al., 2006). Castor oil has also high viscosity over a wide range of temperatures which makes it a valuable ingredient of lubricants (Serverinoet al., 2012).Mutlu and Meier (2010) stated that castor oil is one of the most promising renewable raw materials for the chemical and polymer industries due to its manifold uses and to a series of well established industrial procedures that yield a variety of different renewable platform chemicals.

Although Ethiopia is considered as one of the centers of diversity, little effort was made to evaluate the nature and extent of castor variation that exists in Ethiopian germplasm. This lack of information is a prerequisite to exploit the wealth of castor diversity through plant breeding in the country. Therefore, the available germplasms should be properly evaluated and their attributes have to be known to the breeders. Therefore, the present study was designed with the objective of evaluating the available germplasm for morphological and agronomic traits.

2. MATERIALS AND METHODS

The experiment was conducted on two locations in the centeral rift valley of Ethiopa at Melkassa and ArsiNeglle. Melkassa Agricultural Research Center is found at 8 º 24'N and longitude of 39 º 21'E an altitude of 1650 meters above sea level. The site receives average annual rain fall of 853 mm. The average annual temperature of Melkassa testing site ranges from 13.45 to 28.8^{0}c. The soil textural class is clay loam with a pH of6.7. Geographically ArsiNegelle is located at latitude 7º 20'N, longitude 38º 9'E and 1960 meter above sea level. The site receives average annual rain fall of 888 mm. The average annual temperature of ArsiNegelle testing site ranges from 9.1 to 26^{0}c.

The experiment included 105 germplasm of castor arranged in randomized complete block design with three replications. Seeds were sown on a two rows and five meters long and plant spacing of 80 and 60 cm.Two seeds were planted in a single hole by hand and thinned out to one at four leaf stage. All plots were cultivated once and weeded twice and no fertilizer or pesticide was applied. Data on days to first flowering, days to second flowering, days to first maturity, days to second maturity, inflorescence length, node length, number of nodes/plant, number of inflorescence/plant, plant height, number of branches/plant, number of capsules/plant, hundred seed weight, number of seeds/plant.

Variability among Ethiopian castor germplasm were estimated using range, mean, least significant difference, phenotypic and genotypic variance and coefficient of variability according to Burton and Devane (1953). Statistical analysis of experimental data was performed by analysis of variance (ANOVA) using SAS PROC GLM (2002) at P<0.05. Differences between means were assessed using the least significance difference (LSD) test at P<0.05. Broad sense heritability, genetic advance and genetic advance as percent of the mean were analyzed according to Johnson *et al*. (1955).

3. RESULTS AND DISCUSSION

Estimates of mean squares, range, mean and standard errors from combined analysis of variance for 12 traits of 105 Ethiopian castor accessions over two locations is shown on Table 1. Mean squares from the combined ANOVA revealed a highly significant variation (P<0.01) among the accessions for all the traits considered in this study. The variation among the germplasm is expected for the reason of Ethiopia is the center of diversity for castor (Anjani, 2012).

Location had a significant influence (P<0.01) on days to first flowering, days to second flowering, days to first maturity, days to second maturity, inflorescence length (cm), node length, number of nodes/plant, number of inflorescence/plant, plant height (cm), number of branches/plant, number of capsules/plant, 100 seed weight (g) and number of seeds/plant. This indicates these traits were influenced by a change in the environment. The significance of location effect was expected because Melkassa and Arsi Negelle vary in their rainfall, temperature and other environmental factors. The influence of location on morpho agronomic characteristics of oil bearing plants were also reported for *CoriandrumsativumL*. (Beemnet and Getinet, 2010), *Oreganum vulgaris* L. (Beemnet*et al*., 2014), *Aloysiatriphylla*L. (Beemnet*et al*., 2013), *Cymbopogoncitratus*L. (Beemnet*et al*., 2011), *Artemisia annua*L. (Belay, 2007; Zewdinesh*et al*., 2011), *Stevia rebaudiana*Bertoni (Beemnet*et al*., 2012) and Aflatuni (2005) for *Menthaarvensis*L. and *M.piperiata*L.

Interaction effects of accessions and location excreted a significant influence on days to second flowering, days to first maturity, days to second maturity, node length, number of inflorescence/plant, plant height (cm), number of branches/plant, number of capsules/plant and number of seeds/plant, thus, indicating performance inconsistency of accessions to varied environments; hence, wider agro-ecological test trial is inquired to evaluate these traits. In agreement to the present study,Fehr (1991) reported that every factor that is a part of the environment of a plant has the potential to cause differential performance. Likewise, Frankel *et al*. (1994) and IRRI (1996) reported that fluctuating features of the location such as rainfall, relative humidity, temperature, etc. are some of the environmental factors that cause performance variation in plants.

Table 1.

Analysis of variance of combined data of 12 agronomic traits for 105 castor accessions grown at ArsiNegelle and Melkassa during 2013/14.

Trait	Location (L)	Accession (A)	L x A	CV
Days to first flowering	*	*	ns	27.0
Days to second flowering	*	*	*	10.8
Days to first maturity	*	*	*	5.6
Days to second maturity	*	*	*	4.4
Inflorescence length in cm	*	*	ns	23.6
Node length in cm	*	*	*	21.6
Number of nodes per plant	*	*	ns	17.5
Number of inflorescence per plant	*	*	*	37.0
Plant height in cm	*	*	*	15.1
Number of capsules per plant	*	*	*	44.4
Seed weight g/100	*	*	ns	20.3
Number of seeds per plant	*	*	*	44.3

*=Significant at $P< 0.01$ and ns=Non significant at $P< 0.05$

A very wide range of values in agronomic traits was observed at both locations (Table 2). The accessions demonstrated a wide range of variation on days to first flowering (52-148), days to second flowering (65-161), days to first maturity (118-217), days to second maturity (142-237), inflorescence length (13-74 cm), node length (2-32 cm), number of nodes/plant (5-26), number of inflorescence/plant (1-26), plant height (89-356), number of branches/plant (1-9), number of capsules/plant (10-350), 100 seed weight (21-99 g), number of seeds/plant (30-990). The values of range and mean observed shows that accessions had more capsules, branches, seeds/plant and heavier seeds but took longer time to flower and mature at Arsi Negelle than Melkassa. This is because Arsi Negelle is located at higher altitude and receives more rainfall with lower temperature than Melkassa. However, plant height was taller at Melkassa probably due to higher temperature. The values reported in this study are much higher than that reported by Bolaji*et al*. (2013), Goodarzi*et al* (2012), Wang *et al* (2013), Anjani*et al* (2014) and Lu *et al* (2010). Wang *et al* (2011) reported that the range of 100 seed weight in the entire USDA castor collection was 10.1 to 73.3 as compared to 21 to 91 g observed at Melkassa and 22 to 99 g at ArsiNegelle observed in this study. The wide range of days to flower and maturity observed in this study is indicative of the possibility of developing early genotypes through selection. In addition, the values observed in plant height and branches per plant shows that selection of genotypes containing few or single inflorescence with short plant height can be realized. From this it is possible to conclude that there is sufficient genetic variability among the tested accessions to initiate castor breeding program in Ethiopia.

Table 2.

Range, mean and standard deviation of castor accessions for agronomic and morphological traits

Trait	Locations					
	Melkassa			ArsiNegelle		
	Range	Mean	SD±	Range	Mean	SD±
Days to first flowering	52-111	72	26.5	76-148	111	13.2
Days to second flowering	65-138	93	32.0	93-161	134	14.2
Days to first maturity	118-182	146	27.0	163-217	192	13.1
Days to second maturity	142-196	164	26.5	182-237	218	11.9
Inflorescence length	13-67	36	0.5	15-74	39	11.0
Node length	8-32	20	7.8	2-27	13	4.8
Number of nodes per plant	7-26	12	2.8	5-22	13	3.2
Number of inflorescence per plant	1-26	3	2.0	1-12	4	1.9
Plant height in cm	139-356	239	21.0	89-353	208	47.9
Number of branches per plant	1-7	3	1.2	1-9	3	1.57
Number of capsules per plant	10-180	48	0.5	13-350	98	52.3
Seed weight per g 100 seeds	21-91	50	10.0	21-99	47	15.5
Number of seeds per plant	30-540	143	1.5	39-990	294	156.9

Table 3.

Estimation of variance components (phenotypic coefficient of variability, genotypic coefficient of variability and environmental coefficient of variability), heritability in a broad sense, genetic advance and Genetic Advance as Percent of mean for 105 castor germplasm tested at ArsiNegele and Melkassa during 2013/2014.

Traits	DF1	DF2	DM1	DM2	IL	NN	NIP	PHT	NBP	NCP	HSW	NSP
Phenotypic Variance	51.80	77.10	91.20	79.00	26.70	2.60	0.70	527.20	0.40	555.00	134.90	4891.50
Genotypic Variance	28.90	51.90	53.60	42.7	12.50	1.70	0.30	100.30	0.20	276.50	116.70	2394.90
Environmental variance	22.91	25.23	37.67	36.26	14.23	0.94	0.39	426.99	0.22	278.47	18.18	2496.63
Phenotypic Coefficient of Variation	7.85	7.70	5.65	4.65	13.75	12.95	23.43	10.27	20.12	31.84	23.80	31.31
Genotypic Coefficient of Variation	5.86	6.32	4.33	3.42	9.40	10.38	15.21	4.48	13.17	22.47	22.14	21.91
Environmental coefficient of Variation	5.22	4.41	3.63	3.15	10.03	7.75	17.82	9.24	15.21	22.55	8.74	22.37
Heritability (%)	56.00	67.00	59.00	54.00	47.00	64.00	42.00	19.00	43.00	50.00	87.00	49.00
Genetic Advance	6.17	9.99	8.85	7.28	3.41	1.72	0.46	3.92	0.36	17.07	19.25	49.36
Genetic Advance as (% of mean)	6.73	8.76	5.23	3.81	9.06	13.73	13.20	1.75	11.63	23.07	39.46	22.09

DF1= Days to first flowering, DF2= Days to second flowering, DM1= Days to first maturity, DM2= Days to second maturity, IL= Inflorescence length NN= Number of nodes per plant, NIP= Number of inflorescence per plant, PHT= Plant height in cm, NBP= Number of branches per plant, NCP= Number of capsules per plant, HSW= 100 seed weight in g, NSP= number of seeds per plant.

Estimates of genetic variance ranged from 0.2 for number of branches/plant to 2394.9 for number of seeds/plant. The range of phenotypic variancewas 0.4 for number of branches/plant AND 4891.5for number seeds/plant (Table 3). Compared with environmental variance, genetic variancewas larger for days to first flowering, days to second flowering, days to first maturity, days to second maturity, number of nodes/plant, plant height and 100 seed weight. Therefore, thehigher proportion of phenotypic varianceobserved on these traits was due to the largerproportion of genotypic variance. According to Miller *et al*. (1957), these traits can be utilized inbreeding programme to evaluate castor accessions for seed yield by using few replicates,location and years.

The higher value of genotypic coefficient ofvariability (>10%) was obtained for number of nodes/plant, number of inflorescence/plant, number of branches/plant, number of capsules/plant, 100 seed weight and number of seeds/plant (Table3) indicating that these traits were leastaffectedby the environment. Genetic coefficient ofvariation indicates the genetic variability presentin various quantitative characters without thelevel of heritability. Genetic coefficient of variationtogether with heritability estimates would givethe best indication of the amount of gain due toselection (Johnson *et al.,* 1955).

Broad sense heritability of more than 50% wasobtained for 7 of the 12 characters (Table 3). The heritability estimates were ranged from 19% for plant height to 87% for 100 seed weight.When heritability of a character is very high (>80%), selection for such charactermay be fairly easy owing to close correspondencebetween the genotypes and the phenotypesarising from a relatively smaller contribution ofthe environment to the phenotype (Singh, 1990). For a character with low heritability (<40%),selection may be considerably difficult orvirtually impractical due to the masking effect ofenvironment on the genotypic effects (Singh,1990). Thus, in the present study, selection ofaccessions based on seed number/plant would be more satisfactory toincreaseseed yield of castor.

The genetic advance and genetic advance as percent of mean was larger for number of capsules/plant, 100 seed weight and number of seeds/plant; moderate for days to start first flowering, days to second flowering and days to first maturity; and lowest for remaining characters (Table 3). Johnson *et al. (*1955) indicated that the estimate of heritability and genetic advance should always be considered simultaneously as high heritability is not always associated with high genetic gain. The utility of heritability estimates increased when they are used in conjunction with genetic advance expressed on a percentage of mean (Johnson *et al*., 1955; Allard, 1960). In addition, Panes (1957) reported that association of high heritability with high genetic gain is due to additive gene effect. In the present study, the overall highest value of heritability and genetic advance as percent of means was found higher for number of nodes/plant, number of capsules/plant and 100 seed weight (Table 3). Therefore, selection based on these traits could predict the performance of the progenies.

CONCLUSION

The data presented in the preceding paragraphs had shown the presence of substantial variability in Ethiopian castor germplasm. Hence, the possibility for further improvement using these variations is wide. Therefore, some of the major economical traits of castor such as seed yield and fatty oil contents which are important for oleochemical industry, pharmaceutical industry, processing industry and trade can possibly be improved for their quality and quantity through selection.

ACKNOWLEDGEMENT

We would like to acknowledge Bio-energy Plants Research Project for providing all the necessary facilities and support during the entire experimentation. Our sincere thanks also go to all who made input for this study.

REFERENCES

Aflatuni A (2005). The yield and essential oil content of mint (*Mentha spp.*) in Northern Ostrobothnia. PhD thesis, University of Oulu, Finland.

Allard RW (1960). Principles of plant breeding. John Willy and Sons., Inc., New York. 663pp.

Anjani K. (2012). Castor genetic resources: A primary gene pool for exploitation. Ind. Crops Prod. 35:1–14

Beemnet M, Getinet A (2010). Variability in Ethiopian Coriander Accessions for Agronomic and Quality Traits. African Journal of Crop Science 18(2): 43-49.

Beemnet MK, Samuel T, Zewdinesh DZ, Zinash T, Mihret M, Bekri M (2014). Morpho-agronomic Characteristics, Essential Oil Content and Essential Oil Yield of Oregano (*Origanum vulgare* L.) in Ethiopia. Scholarly Journal of Agricultural Science,4(12): 565-571.

Beemnet MK, Zewdinesh DZ, Wossen K, Hailesilasie G (2012). Performance of Stevia (*Stevia rebaudiana* Bertoni) for Morphological and Economic Traits under Different Ecologies of Ethiopia. Journal of Agriculture and Development 2(2): 54-67.

Beemnet MK, Solomon A, Zinash TA, Haileslassie GK, Beniyam Y, Gizachew A, Bekri M, Wossen KM, Texeria DS (2011). Performance of Lemongrass (*Cymbopogon citratus* L. (DC) Stapf) for Agronomic and Chemical Traits in Different Agro-Ecologies of Ethiopia. Medicinal and Aromatic Plant Science and Biotechnology 5(2): 133-138.

Beemnet MK, Wondu B, Solomon AM (2013). Performance of Lemon Verbena (*Aloysia triphylla* L.) for Morphological, Economic and Chemical Traits in Ethiopia. American-Eurasian Journal of Agricultural and Environmental Sciences 13(11): 1576-1581.

Belay B (2007). Assessment of crop growth and artemisinin content of the medicinal plant Artemisia annua Anamed in the Gamo highlands of SW Ethiopia. MSc. Thesis, University of Hohenheim, Sttutgart, Germany.

Bolaji SZ, Andrew GK, Samuel AA, Abasianyanga IE, Shaahu A 2(013). Genetic Divergence, Principal Components and KMeans Clustering Analyses of Some Agronomic Characteristics of Eleven Castor (*Ricinus communis* L.) Accessions. International Journal of Science and Research 2(2012): 129-132.

Burton GA and Dorane EH (1953). Estimation of heritability in tall Festca (*Festuca arundinacea*) from replicated clonal material. Agronomy Journal 45:478-479.

da Silva NL, Maciel MRW, Batistella CB, and Filho RM (2006). Optimization of biodiesel production from castor oil. Appl. Biochem. Biotechnol. 130:405–414.

Fehr WR (1991). Principles of Cultivar Development Theory and Technique. Iowa State University, USA, pp. 247-260.

Frankel OH, Brown AHD, Burdon JJ (1994). The Conservation of Plant Diversity. Cambridge University Press, UK, pp. 22-29.

Gomez KA and Gomez AA (1984). Statistical Procedures for Agricultural Research. 2nd ed. John Willy and Sons., inc., New York. Pp. 680.

Goodarzi F, Darvishzadeh R, Hassani A, and Hassanzaeh A (2112). Study on genetic variation in Iranian castor bean (*Ricinus communis* L.) accessions using multivariate statistical techniques, Journal of medicinal Plants Research 6 (7): 1160-1167.

IRRI (International Rice Research Institute) (1996): Plant Adaptation and Crop Improvement. CAB International, Manila, Philippines, pp. 3-5.

ICOA (1992). The chemistry of castor oil and its derivatives and their applications. International Castor Oil Assoc., Cinnaminson, NJ.

Johnson HW, Robinson HF and Comstooc RE (1955). Estimates of genetic and environmental variability in soybeans. Agronomy Journal 47:314-318.

Liv SS, Dick LA, Baldanzi M, Magno JDC, Chen G, Crosby W, Tan D, He X, Lakshmamma P, Lavanya C, Olga LTM, Mielke T, Milani M, Travis D, Morris JB, Stephen AM, Alejandro AN, Dartanhã JS, Sofiatti V, Ming LW, Maurício D, and Zieler H (2012). A Review on the Challenges for Increased Production of Castor. Agronomy Journal 104(4): 853-880.

Lu Z, Ql JM, Fang PP, Su JG, Xu JT and Tao AF (2010). Genetic diversity and phytogenetic relationship of castor germplasm as revealed by SRAP analysis. Journal of Wuhan Botanical Research, 28(1):1-6.

Miller, PA, Williams JC, Robinson HF, Comstock RE (1957). Estimates of genotypic and environmental variances in upland cotton and their implications in selection. Agron. J (50): 126.

Mutlu H, and Meier MAR (2010). Castor oil as a renewable resource for the chemical industry. Eur. J. Lipid Sci. Technol. 112:10-30.

Ogunniyi DS (2006). Castor oil: A vital industrial raw material. Bioresour. Technol. 97:1086–1091.

Panes VG (1957). Genetics of quantitative characters in relation to plant breeding. Indian Journal of Genetics 17:318-328.

SAS (Statistical Analysis System) (2002). SAS/STAT. Guide Version 9. SAS, Institute Inc. Raleigh, North Carolina, USA

Singh BD (1990). Plant breeding: Principles and methods. Kalyani Publishers, New delhi-Ludhiana, India. 458pp.

Wang ML, Morris JB, Pinnow DL, Davis J, Raymer PP (2011). A survey of the castor oil content, seed weight and seed coat color on the United States Department of Agriculture germplasm collection. J. Agric and Food Chem. 59: 9250-9256.