**Computational Biology and Bioinformatics**
2022; 10(1): 9-13
http://www.sciencepublishinggroup.com/j/cbb
doi: 10.11648/j.cbb.20221001.11
ISSN: 2330-8265 (Print); ISSN: 2330-8281 (Online)

# Lentil Variety Development for Yield and Disease Resistance for Potential Areas: Registration of a Lentil Variety Named Debine

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**To cite this article:**
Amanuel Tekalign, Tadele Tadesse, Belay Asmare. Lentil Variety Development for Yield and Disease Resistance for Potential Areas: Registration of a Lentil Variety Named Debine. *Computational Biology and Bioinformatics*. Vol. 10, No. 1, 2022, pp. 9-13.
doi: 10.11648/j.cbb.20221001.12

**Received**: February 22, 2022; **Accepted**: March 28, 2022; **Published**: March 31, 2022

**Abstract:** The development of new varieties with high yield and acceptable levels of stability is an important in breeding program. The performance of a given genotype depends on its genetic potential and the environment upon which it is grown. Debine is a commercial name given for a newly released Lentil (Lens culinaris) variety with pedigree designation of 'DZ - 2012-LN-0051' was released in 2021 for highland areas of Bale, Southeastern Ethiopia and other similar agro ecologies. The variety has been registered by Sinana Agricultural research center and it was tested at better representative environments (Sinana and Agarfa) representing highland (2300 to 2600) meter above sea level) agro-ecologies during 2016 to 2018 main cropping season. The variety is mainly characterized by its superior mean grain yield as compared from standard check Asano based on different yield measurement and stability testing parameters across locations and over years. It also had comparable resistance/tolerant level to major Lentil diseases such as Aschocyta blight, Rust and Root Rot. Debine has dark gray seed color and could be cultivated across a number of locations in the highlands of Bale and other similar agro-ecologies for increasing productivity of the crop.

**Keywords:** Disease Resistance, Grain Yield, Lentil (*Lens culinaris*), Stability, Variety Registration

## 1. Introduction

Lentil (Lens Culinaris Medikus.; Fabaceae) is an autogamous, diploid (2n = 2x = 14), self-pollinated and annual cool season grain legume with ~4 Gbp genome size [10, 2]. It is one of the first agriculture crop grown more than 8500 years ago [1, 3]. Its annual production is ~5 million ton globally and Canada, India, Turkey, USA, Nepal, Australia, Ethiopia, Bangladesh, Kazakhstan is the major lentil producing countries of the world sequentially. Approximately 50% of world's lentils are grown in South Asia, and nearly 1.5 billion people in this area consume ~70% of the global lentil supply [2, 5].

Lentil plays a significant role in human and animal nutrition and in maintenance and improvement of soil fertility [8, 9]. Its cultivation enriches soil nutrient status by adding nitrogen, carbon and organic matter which promotes sustainable cereal-based systems of crop production [8]. It is a nutritious food legume. It is cultivated for its seed and mostly eaten as split [6]. The primary product of lentil is its seed which has relatively higher contents of protein, carbohydrate and calories compared to other legumes [7]. It is the most desired crop because of its high average protein content and fast cooking characteristic in many lentil producing regions. It can be used as a main dish, side dish, or in salads. Seeds can be fried and seasoned for consumption but sometimes difficult to cook because of the hard seed coat those results from excessive drying [12]. Its flour is used to make soups, stews, purees, and mixed with cereals to make bread and cakes; and as a food for infants [11].

Because of its significant economic role and social conditions, lentil production has recently been expanding in both stressed and non-stressed environments. In Ethiopia in 2017 cropping season, the total area of production of pulse crops is about 2,092,357.57 hectares and the total production was 328,734.78ton. Among these pulse crops, lentil covered 124,915.16 hectares with production of 170.09ton. The national productivity of lentil was 1.44 t ha$^{-1}$ [4], which was far below the potential yield of the crops and productivity in different parts of the world. The reason for this yield gap is mainly due to poor genetic makeup of the available cultivars, and other biotic and abiotic factors. Therefore, the objective of this study was to register stable high yielding and disease resistant/tolerant Lentil variety for highlands Bale and other similar agro-ecologies in Ethiopia.

# 2. Materials and Methods

### 2.1. Descriptions of Experimental Sites

The experiment was conducted at two potential areas of Bale Zone, Sinana and Agarfa in South Eastern Ethiopia. Description of the study sites at Regional Variety Trail is given below.

***Table 1.*** *Description of the test locations for geographical position and physico-chemical properties.*

| | Location | |
|---|---|---|
| Parameter | Sinana | Agarfa |
| Geographical position | | |
| Latitude | 07°07’ N | 07°15’44”N |
| Longitude | 40°10’00”E | 039°50’38”E |
| Altitude (m.a.s.l.) | 2400 | 2509 |
| Soil property | | |
| pH | 6.2 | 6.3 |
| Texture | Clay | Clay loam |
| OMC (%) | 3.9 | 3.4 |
| Total N (%) | 0.24 | 0.2 |
| Pav (ppm) | 30.4 | 32.41 |
| K (mg/Kg) | 240 | 572 |
| CEC (meq/Kg) | 64.4 | 71.5 |
| Moisture Regime | SH2 | SH2 |

Key: OMC = Organic matter content, N = Nitrogen, Pav = Phosphorus availability, K = Potassium, CEC = Cation exchange capacity, SH2 = Sub-humid tepid to cool sub-humid mid-highlands.

### 2.2. Breeding Procedures

Adapted Lentil line “Dz-2012-Ln-0051, which was selected from the last stage of variety trial. The crossing was done at Debre Zeit Agricultural Research Center. Screen houses were routinely used in the early generations, i.e., F1, F2, F3 and F4, of a breeding cycle. During these phases, selection for traits with high heritability such as; seed size, grain yielding ability, plant habit, time of flowering and resistance to major diseases were undertaken. selected individual lines from F5 generation were evaluated for yielding ability, large seed size, disease reaction and stability in preliminary yield trial (PYT) conducted at Sinana Agricultural Research Center. From this trial, 15 promising genotypes were promoted and evaluated in a regional variety trial (RVT) along with standard checks ‘Asano’ at multi-locations (Sinana and Agarfa) during 2016 to 2018 main cropping seasons. Lastly, Dz-2012-Ln-0051 and Dz-2012-Ln-0085 were selected as the most promising candidate varieties and verified along with best standard checks ‘Asano’ on 10 m x 10 m plots. National Variety Release Technical Committee were evaluated each one on-station and two on-farm fields during the 2020/21 cropping season. Finally, the committee decided the first genotypes coded as Dz-2012-Ln-0051, and named “Debine”, for official release.

# 3. Result and Discussions

### 3.1. Agronomic and Morphological Characteristics

In an attempt to develop Debine, higher yield, and resistance to major lentil diseases were important traits of consideration. The newly released Lentil variety ‘Debine’ is characterized by an erect growth habit. Its flower color is light Pink. The seed coat and cotyledon colors are dark gray and light red, respectively. The average number of days required to reach its 50% flowering and 95% physiological maturity were 62 and 122, respectively, with the average plant height being 32 cm (Table 2). The average number of pods per plant is 33 (Table 4). It has good general acceptance for lentil with high quality. The appropriate planting date for this variety would range from end of July to early August (Table 2).

### 3.2. Yield and Quality Performance

Highly significant variations among Lentil genotypes were observed throughout the trial evaluation. Debine consistently out-yielded other tested Lentil genotype over three years. Combined location over years analysis revealed that it had produced an average yield of 22-25 Q/ha at Research field and 14-16 Q/ha on farm yield. This means that the grain yields of Debine was found to be 29.76% yield advantage over standard check Asano (Table 4). Debine offers new hope for resource poor farmers in study areas and other similar agro ecology.

### *3.3. Reaction to Major Diseases*

Developing Lentil cultivars with high yielder, resistant or tolerant varieties to major lentil diseases such as Ascochyta lentis *(ascochyta blight),* Rust (Uromyces viciae-fabae) and Root Rot is among the major objectives of the Lentil breeding program. Accordingly, above mentioned disease is among the major bottleneck for Lentil production in Southeastern part of the country, Bale. Disease data across location and years were scored and analyzed. Debine variety showed resistance to moderate resistance to the above-mentioned diseases throughout the field evaluation periods (Table 5).

### *3.4. Performance Stability and Adaptation Domain*

The variety 'Debine' was released for high altitude agro-ecologies of the country receiving 750-to-1000 mm average annual rainfall. It is well adapted to an altitude range of 1800 – 2600 meters above sea level such as Sinana, Goba, Agarfa, Gassera, Goro (Meliyu), Adaba, Dodola and other similar agro-ecologies (Table 2). Based on most stability parameters, 'Debine' showed relatively comparable performance stability across a range of environments (Table 4).

### *3.5. Variety Maintenance*

The breeder and foundation seed will be maintained by Sinana Agricultural Research Center/ Oromia Agricultural Research Institute.

***Table 2.*** *Agronomical and Morphological Characteristics and Agro-ecological Zones of Adaptation of Debine, Lentil variety.*

| No | Variety name: | | Debine (DZ-2012-LN-0051) |
|---|---|---|---|
| 1 | Adaptation area | | Sinana, Goba, Agarfa, Gassera, Goro (Meliyu), Adaba, Dodola and other similar agro-ecologies |
| 2 | Altitude (m.a.s.l.) | | 1800 – 2600 |
| 3 | Rainfall (mm) | | 750 – 1000 |
| 4 | Seed Rate (Kg/ha) | | 65 |
| 5 | Planting date | | End of July to Early August |
| 6 | Days to Flower | | 62 |
| 7 | Days to Maturity | | 122 |
| 8 | Plant Height (cm) | | 32 |
| 9 | Growth habit | | Erect |
| 10 | 1000 Seed Weight (gm) | | 3.7 |
| 11 | Seed Color | | Dark Gray |
| 12 | Cotyledon Color | | Light red |
| 13 | Seed size | | Large |
| 14 | Flower Color | | Light Pink |
| 15 | Yield (Qt/ha) | Research Field | 22-25 |
| | | On-farmer's field | 14-16 |
| 16 | Disease reaction | | Tolerant to rust, wilt and Aschochyta blight |
| 17 | Yield advantage over Asano (%) | | 29.76 |
| 18 | Year of Release | | 2021 |
| 19 | Breeder and Maintainer | | SARC/ IQQO |

***Table 3.*** *Mean grain yield (kg/ha) of 17 Lentil genotypes across locations and years.*

| Entry | Sinana | | | Agarfa | | | Mean | Yield Adv. over St. check |
|---|---|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2018 | 2016 | 2017 | 2018 | | |
| DZ -2012-LN-0051 | 1810 | 2404 | 3364 | 1690 | 1458 | 1623 | 2058 | 29.76% |
| DZ -2012-LN-0057 | 916 | 2018 | 3441 | 766 | 933 | 2113 | 1698 | |
| DZ -2012-LN-0059 | 1363 | 2375 | 3308 | 614 | 694 | 861 | 1536 | |
| DZ -2012-LN-00118 | 1484 | 2581 | 3089 | 1574 | 1412 | 1640 | 1963 | |
| FLIP-96-49L | 1384 | 2347 | 3278 | 1498 | 1272 | 1142 | 1820 | |
| DZ -2012-LN-0038 | 1480 | 2360 | 3084 | 1991 | 1036 | 1338 | 1881 | |
| DZ -2012-LN-00107 | 1408 | 2195 | 3300 | 2003 | 987 | 1175 | 1845 | |
| DZ -2012-LN-0058 | 1220 | 1857 | 2853 | 1425 | 884 | 993 | 1539 | |
| DZ -2012-LN-0048 | 1505 | 2542 | 3457 | 1195 | 916 | 1461 | 1846 | |
| FLIP-97-33L | 1194 | 2398 | 3021 | 1467 | 1138 | 1870 | 1848 | |
| DZ -2012-LN-0065 | 1621 | 2329 | 3003 | 1173 | 611 | 1118 | 1643 | |
| FLIP-86-38L | 1635 | 2289 | 3614 | 1939 | 1135 | 1170 | 1964 | |
| FLIP-89-19L | 1284 | 1788 | 2323 | 1569 | 675 | 1885 | 1587 | |
| DZ -2012-LN-0095 | 1715 | 2746 | 2678 | 1648 | 1019 | 2055 | 1977 | |
| DZ -2012-Ln-0085 | 1882 | 2836 | 3237 | 1838 | 1582 | 2496 | 2311 | |
| Asano (St. check) | 1211 | 1634 | 2020 | 1525 | 1032 | 2095 | 1586 | |
| Local check | 1805 | 1901 | 1345 | 1544 | 763 | 574 | 1322 | |
| Means | 1466 | 2271 | 3136 | 1498 | 1032 | 1506 | 1790 | |
| LSD (<0.05) | 479.5 | 590.0 | 907.5 | 565.2 | 634.6 | 716.1 | 291.9 | |
| C.V | 23.0 | 18.0 | 20.0 | 22.5 | 23.0 | 23.0 | 20.6 | |

***Table 4.*** *Mean Seed yield and other agronomic traits for 17 lentil genotypes tested in regional Variety Trial combined over two locations (Sinana and Agarfa) over three years (2016-2018).*

| Entry | DF | DM | Stand % | PH (cm) | NPP | NSP | HSW (g) | SY (kg/ha) |
|---|---|---|---|---|---|---|---|---|
| DZ -2012-LN-0051 | 62 | 122 | 76 | 32 | 33 | 1 | 3.7 | 2058 |
| DZ -2012-LN-0057 | 64 | 126 | 77 | 34 | 31 | 1 | 4.0 | 1698 |
| DZ -2012-LN-0059 | 63 | 125 | 75 | 33 | 37 | 1 | 3.1 | 1536 |
| DZ -2012-LN-00118 | 61 | 122 | 78 | 31 | 33 | 1 | 3.6 | 1963 |
| FLIP-96-49L | 62 | 123 | 75 | 31 | 36 | 1 | 3.5 | 1820 |
| DZ -2012-LN-0038 | 62 | 123 | 78 | 31 | 33 | 1 | 3.6 | 1881 |
| DZ -2012-LN-00107 | 62 | 123 | 79 | 31 | 33 | 1 | 3.6 | 1845 |
| DZ -2012-LN-0058 | 61 | 125 | 74 | 31 | 35 | 1 | 2.7 | 1539 |
| DZ -2012-LN-0048 | 61 | 124 | 76 | 32 | 37 | 1 | 3.2 | 1846 |
| FLIP-97-33L | 62 | 123 | 76 | 32 | 35 | 1 | 3.4 | 1848 |
| DZ -2012-LN-0065 | 61 | 125 | 77 | 35 | 36 | 1 | 3.0 | 1643 |
| FLIP-86-38L | 62 | 122 | 77 | 32 | 31 | 1 | 3.6 | 1964 |
| FLIP-89-19L | 61 | 125 | 79 | 32 | 30 | 1 | 3.6 | 1587 |
| DZ -2012-LN-0095 | 63 | 125 | 78 | 34 | 39 | 1 | 2.7 | 1977 |
| DZ -2012-LN-0085 | 62 | 125 | 79 | 34 | 37 | 2 | 2.8 | 2311 |
| Asano (St. Check) | 61 | 124 | 77 | 31 | 32 | 1 | 3.7 | 1586 |
| Local check | 62 | 122 | 74 | 33 | 33 | 1 | 2.4 | 1322 |
| Mean | 62 | 124 | 77 | 32 | 34 | 1 | 3.3 | 1790 |
| LSD (<0.05) | 0.8 | 1.2 | 3.3 | 2.0 | 7.7 | 0.2 | 0.1 | 291.9 |
| CV% | 2.4 | 1.7 | 7.5 | 10.8 | 23.9 | 22.6 | 7.1 | 20.6 |

***Table-5.*** *Mean seed yield, agronomic traits and disease reaction of 'Debine' along with standard and Local checks tested in two environments at varietal verification levels during 2015-2017 cropping seasons.*

| Entry | Agronomic traits | | | | | | | | Disease Reaction (1-9) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | DF | DM | Stand % | PH (cm) | NPP | NSP | HSW (g) | SY (kg/ha) | ASB | Rust | RR |
| DZ -2012-LN-0051 | 62 | 122 | 76 | 32 | 33 | 1 | 3.7 | 2058 | 4 | 3 | 3 |
| Asano | 61 | 124 | 77 | 31 | 32 | 1 | 3.7 | 1586 | 5 | 3 | 4 |
| DZ -2012-LN-0085 | 62 | 125 | 79 | 34 | 37 | 2 | 2.8 | 2311 | 4 | 3 | 3 |
| Local check | 62 | 122 | 74 | 33 | 33 | 1 | 2.4 | 1322 | 5 | 5 | 4 |

Note: DF = days to 50% maturity, DM, days to 90% maturity, PH = plant height (cm), NPP = Number of pods per plant, NSP =Number of seed per plant, HSW = Hundred seed weight (g), GY = grain yield (kg), ASB = Aschocyta Blight, RR = Root Rot.

# 4. Conclusion

Grain yield is the primary trait of interest and a prime objective in Lentil breeding programs for many decades. "Debine" produced high yield, and it had a more stable performance in seed yield over locations and years than the standard check variety. The current variety, Debine has 29.76% yield advantages over the widely cultivated lentil varieties, Asano. Therefore, wide cultivation of Debine variety will boost productivity and marketability of the crop and improve farmers' income. Debine was resistant to major diseases of Lentil that prevailed in the growing areas. Farmers also preferred the variety for its superior performance over the existing local variety, which is manifested by good plant height, better pods load and number of branches per plant. Hence, Debine was verified and officially released for large scale production in major Lentil growing areas of Bale highland and other similar agro-ecologies.


# Acknowledgements

The authors would like to thank Oromia Agricultural Research Institute for funding the research throughout the varietal development process. They also thank all staff members of the Pulse and Oil crops research case Team of the Sinana Agricultural Research Center for their unreserved efforts in field trail management and data collection during the experimental period.


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