ISSN: 2224-0616
Int. J. Agril. Res. Innov. Tech. 9(2): 9-14, December 2019
DOI: https://doi.org/10.3329/ijarit.v9i2.45404

Available online at http://ijarit.webs.com
https://www.banglajol.info/index.php/IJARIT

EVALUATION OF LENTIL VARIETIES FOR ADAPTATION AND YIELD PERFORMANCE UNDER MIDLAND ECOLOGY OF KAFFA ZONE, SOUTH-WEST ETHIOPIA

M.M. Geja

Received 10 July 2019, Revised 22 November 2019, Accepted 24 December 2019, Published online 31 December 2019

Abstract

A field experiment was conducted to identify the best adapted and high yielding lentil variety at Shishinda sub-testing site of Bonga Agricultural Research Center during 2012 main cropping season. The experiment was carried out in randomized complete block design with three replications. Eleven improved lentil varieties were used for this study. The varieties included in the study were Teshale, Alemaya, Alemtena, Assano, Gudo, EL-142, R-186, Ada'a, Derso, Chalew and Chekol. The parameters studied in this experiment were days to flowering and maturity, plant height, number of pods plant^{-1}, number of seeds pod^{-1}, thousand seeds weight and grain yield. The analysis of the experiment showed significant ($p<0.05$) differences among varieties for all studied parameters. The varieties Assano, Alemtena, Derso, EL-142, and Gudo were found to be high yielder with the value of 1.71, 1.59, 1.39, 1.36 and 1.31 ton ha^{-1}, respectively. In addition, farmers were invited to evaluate the performance of the tested varieties under field condition. Eventually, the farmers selected Assano and Alemtena as the most preferred varieties. Therefore, these varieties can be suggested to use for wider production in the study area. The involvement of farmers in variety selection processes may increases the adoption of new variety in the area.

Keywords: Lentil Varieties, Farmers' Preference, Grain Yield.

Bonga Agricultural Research Center, Bonga, Ethiopia.

*Corresponding author's email: mogisog22@gmail.com (M.M. Geja)

Cite this article as: Geja, M.M. 2019. Evaluation of lentil varieties for adaptation and yield performance under midland ecology of kaffa zone, south-west Ethiopia. *Int. J. Agril. Res. Innov. Tech.* 9(2): 9-14. DOI: 10.3329/ijarit.v9i2.45404.

Introduction

Lentil (*Lens culinaris* Medikus) is one of the most important cool season food legumes grown in many parts of the world as food crop (Erskine *et al.*, 2011). Globally lentil production ranking sixth in production among pulses after dry bean, pea, chickpea, faba bean, and cowpea (FAO, 2010). The area cultivated worldwide in 2016 was approximately 5.5 million hectares with 6.3 million tons of lentil grain with the average yield of 1.2 tons ha^{-1} while approximately 113.7 thousand hectares with 166.3 thousand tons with average yield of 1.5 tons ha^{-1} in Ethiopia (FAOSTAT, 2018). Thus, the productivity of the crop per unit area of land is high in Ethiopia than the world average yield in the year 2016. Furthermore, lentil is a cash crop gaining the highest price in domestic market compared to all other food legumes and major cereal crops (Bejiga *et al.*, 1995).

Lentil plays a significant role in human and animal nutrition as well as improvement of soil fertility. The crop has great importance in crop rotation because of its ability to fix atmospheric nitrogen (Saxena and Wassimi, 1980). It is the most desired crop compared to other legumes because of its higher contents of protein, carbohydrate and calories (Muehlbauer *et al.*, 1985; Iqbal *et al.*, 2006). Obviously, lentil seed is heavily consumed in every day diet in the majority of people in Ethiopia (Hanelt, 2001).

Lentil is mainly grown in the highlands of Ethiopia where rainfall is usually high (Jarso *et al.*, 2009). However, it is highly susceptible to excessive moisture stress (Mulugeta, 2009) and very sensitive to water logging and even with short period of exposure it can cause complete crop failure (Brennan *et al.*, 2002). Lentil is well adapted to various soil types ranging from sand to clay loam when there is good drainage (Janzen *et al.*, 2014). A soil pH of 6-8 is conducive for lentil production, but it can also tolerate a moderate alkalinity (Mulugeta, 2009). It is widely grown in areas having an altitude range of 1700-2400 meters above sea level with annual rainfall ranging from 700-2000 mm in Ethiopia (Korbu, 2009). In addition, the crop is capable of germinating at a temperature above freezing point but optimum germination occurs at the range of 18-21°C. On the other hand, a temperature exceeding 27°C can harm the crop aggressively however the ideal temperature for optimum growth and yields of lentil is around 24°C (Abraham, 2015).

The demand for lentil and the price of the produce has been growing steadily in recent years and there is a high need to increase its production for both domestic and export markets in Ethiopia (Abraham, 2015). Even though there are a suitable agro-ecologies and soil conditions for the production of lentil in Ethiopia, the production of the crop is currently limited to few areas. Kaffa zone is one of the administrative zones in the SNNPR, located in the south-west parts of Ethiopia. Besides, the long lasting rainfall in a year makes the area conducive for the production of different crops in the region. The major pulse crops widely grown in the area are faba bean, field pea, and common bean. ICARDA in association with Ethiopian Institute of Agricultural Research has been released several high yielding lentil varieties with recommended technology packages. Even though efforts have been made to popularize improved varieties of different crops, the cultivation of lentil is not well experienced in the zone and there is no research activity yet conducted with regard to the adaptation of lentil varieties. Therefore, to popularize, and expand its production for both domestic and export market, testing the varieties for their adaptability is one of the most important steps prior to cultivation in the study area. The objective of this experiment was to evaluate the adaptability and yielding performance of improved lentil varieties in Kaffa zone.

Materials and Methods

Description of the experimental site

The field experiment was conducted at Shishinda sub-testing site of Bonga Agricultural Research Center. Shishinda is located about 56 kilometers away from the zonal town, Bonga. The study area represents the midland agro-ecology of Kaffa zone. It is situated at 07° 14' N latitude and 35° 52' E longitude at an altitude of 2,029 meter above sea level. The average annual rainfall, the average maximum and minimum temperature of the area are 1,877 mm, 26 and 12°C, respectively.

Experimental materials

Eleven lentil varieties were tested in this study and evaluated for their adaptation and yield performance. The varieties used were Teshale (FLIP 96-46L), Alemaya (FLIP 89-63L), Gudo (FLIP 84-78L), Assano (FLIP 88-46 L), EL-142, Ada'a (FLIP 86-14L), Derso, R-186, Alemtena (FLIP 96-49L), Chalew (NEL 358), and Chekol (ENAL-2704).

Agronomic practices

The experimental field was ploughed, leveled, and rows were prepared 20 cm apart from each other. Sowing was done by hand drilling the seeds in rows @ 160 seeds row^{-1}. DAP fertilizer (NPK 18:46:0) was applied @ 50 kg ha^{-1} during sowing (Annual Report, 2010). Other than the treatment effects weeding, harrowing and fertilizer application were carried out uniformly in all experimental plots.

Experimental design and layout

The experiment was carried out in a randomized complete block design with three replications. Each experimental plot had six rows with 4.0 m long and 1.2 m wide (4.8 m^2) and the central four rows were considered as a net plot area. The distance between plots and blocks were 1.0 m. Plants from the internal rows of net plot area were used for data collection and analysis of the parameters under study.

Data collection

Ten plants from each plot were selected and pre-tagged for data collection. Numbers of pods plant^{-1}, number of seeds pod^{-1} and plant height (cm) were recorded from the pre-tagged sample plants of each plot at maturity. However, the phonological data *viz.* days to flowering and maturity were recorded on plot bases by counting the number of days from sowing to the time when 50% and 95% of the plants were flowered and fully matured, respectively. Thousand seeds weight was determined by weighing samples of randomly drown 1000 seeds of each plots using a digital balance. Grain yield (ton ha^{-1}) for the experimental varieties of each plot was also recorded and all the data of the measured traits were subjected to the statistical analysis.

Statistical analysis

The collected data were subjected to statistical analysis using Proc ANOVA procedures in SAS version 9.2 (SAS institute, 2007). Variations between the treatment means were compared using least significant difference (LSD) at 5% probability level ($p<0.05$). Besides, coefficient of variance (CV%) was calculated to reveal the relative measure of variation that existed within the data. In addition, Pearson correlation analysis was carried out to investigate associations between grain yield and yield components of lentil varieties. Preference ranking of the tested varieties was made based on the perception of the farmers' evaluation criteria (Adjei-Nsiah, 2012). A scale of 1-5 was used to compare their preferences in a manner indicating that higher preference =1, and lower preference=5.

Results

The results from analysis of variance showed significant ($p<0.01$) differences among the varieties for the parameters measured in the 2012 cropping season viz., days to 50% flowering and maturity, plant height, number of seeds pod^{-1}, hundred-seeds weight, and grain yield. However, there was significant ($p<0.05$) differences observed among the varieties for number of pods plant^{-1} (Table 1).

Table 1. Mean square values for grain yield and agronomic traits.

	Mean squares			
Parameters	Variety (10)	Replication (2)	Error (20)	CV (%)
Grain yield	0.311**	0.091	0.060	20.51
Pods plant^{-1}	93.371*	90.338	58.633	15.96
Seeds pod^{-1}	0.819**	0.042	0.016	7.88
1000 seeds weight	237.736**	1.146	2.927	5.96
Plant height	36.354**	1.179	4.892	7.34
Days to flowering	139.897**	2.758	5.324	3.80
Days to maturity	329.806**	1.485	11.752	3.28

*Values put in parenthesis indicates the degrees of freedom for respective source of variation; *, ** and ^{ns} = significant, highly significant and non-significant at LSD (%) 0.05 probability level; CV (%) = coefficient of variation.*

Days to flowering and maturity

Days to 50% flowering between tested genotypes varied from 52.7 to 78.3 days with mean of 60.7 days. The varieties Assano, Gudo and Alemtena were the earliest to flower with 52.7, 55.7 and 56.0 days, respectively. The variety Assano and Alemtena took a shorter time to flower and mature as compared to other tested varieties in the location while the longest days to flower and mature was recorded for variety R-186 which took 78.3 and 129 days. R-186 matured the latest with a difference of 42 days from the earliest variety Assano (Table 2). This result is contrary with the finding of Yasin (2015), who reported that the range from 43.5 to 48.5when sown under different location. The observed variation might be due to genetic and environmental Yasin (2015); Yirga and Zinabu (2018).

Table 2. Mean grain yield and agronomic data of lentil varieties tested in 2012.

Varieties	Mean values						
	GYD (t ha^{-1})	PPP	SPP	TSW(g)	PHT (cm)	DTF (50%)	DTM (95%)
Teshale	1.24	50.5	1.6	31.0	27.5	58.0	100.0
Alemaya	0.87	45.6	1.5	23.8	26.3	58.0	105.0
Gudo	1.31	41.2	1.4	44.5	36.4	55.7	110.0
Assano	1.71	51.6	1.2	44.2	26.8	52.7	87.0
EL-142	1.36	50.7	1.7	19.0	27.9	58.0	95.0
Derso	1.39	59.4	1.5	28.5	30.9	63.0	105.0
Ada'a	0.93	46.4	1.8	23.9	34.3	64.0	109.7
R-186	0.65	39.0	1.7	22.8	34.6	78.3	129.0
Alemtena	1.59	49.2	1.7	34.1	29.1	56.0	99.7
Chalew	0.94	44.4	1.7	22.4	27.8	63.0	105.0
Chekol	1.13	49.9	1.7	21.6	30.1	61.0	103.3
Means	1.19**	47.9*	1.59**	28.70**	30.15**	60.70**	104.42**
CV (%)	20.51	15.96	7.88	5.96	7.34	3.80	3.28
LSD (P<0.05)	0.42	13.04	0.21	2.91	3.77	3.93	5.84

GYD = Grain yield (ton ha^{-1}), PPT = Number of pods plant^{-1}, SPP = Number of seeds pods^{-1}, TSW = Thousand seeds weight (g), and PHT = Plant height (cm), DTF = Days to 50% flowering and DTM = Days to 95% physiological maturity.

Plant height

Plant height is an important agronomic component of lentil that affects the yield. The tested varieties Gudo, R-186, and Ada'a produced the highest plant height of 36.4, 34.6 and 34.3 cm, respectively. However, most of the varieties tested were produced shortest plant height in the location. The observed difference in plant height between the varieties may be due to the inherent genetic differences among varieties. This result is in line with the findings of Yirga and Zinabu (2018).

Number of pods plant^{-1}

The number of pods plant^{-1} ranged from 39.0 to 59.4. The comparisons of means indicated that the higher number of pods plant^{-1} recorded for most of the tested varieties; Derso (59.4), Assano (51.6), EL-142 (50.7), Teshale (50.5), Chekol (49.9), Alemtena (49.2) and Ada'a (46.4). The variability of the varieties on the number of pods plant^{-1} is one of the most important characteristics during selection. It determines the yield of a variety per unit area. In these study most of the tested varieties showed better performance in pod production. In this study all the varieties tested showed better performance in producing pods plant^{-1}. Actually several researchers were reported the response difference of genotypes in producing pods when tested in different locations (Yasin, 2015; Tilahun, 2016).

Number of seeds pods^{-1}

The varieties differed for the number of seeds produced pod^{-1}. The number of seeds pod^{-1} ranged from 1.2 to 1.8. Most of the tested varieties were produced higher number of seeds pod^{-1} i.e., Ada'a, R-186, Alemtena, Chalew, Chekol, Teshale, and El-142 whereas; the minimum number of seeds pod^{-1} was produced by varieties Assano (1.2).

Thousand seeds weight

Thousand seeds weight ranged from 19.0 to 44.5 g. The highest thousand seeds weight was recorded on varieties Gudo and Assano with 44.5 and 44.2 g, respectively. However, the lowest thousand seeds weight was recorded on EL-142 and Chekol with 19.0 and 21.6 g, respectively. The seed size of Assano and Gudo was by far bigger than that of El-142. The observed significant differences among varieties might be due to inherent genetic potential and existing environmental condition. The result is consistent with the findings of Yasin (2015); Yirga and Zinabu (2018).

Grain yield

Grain yield is the collective effects of yield components. Statistically significant ($p<0.05$) variation was observed among the varieties in grain yield. The yield difference was ranged from 0.65 to 1.71 ton ha^{-1}. The highest grain yield was produced by varieties Assano, Alemtena, Derso, EL-142 and Gudo with grain yield of 1.71, 1.59, 1.39, 1.36 and 1.31 ton ha^{-1}, respectively. R-186 produced the lowest grain yield of 0.65 ton ha^{-1}. This result is in contrary with the results of Tilahun (2016), he reported the lowest yield performance of these varieties in other environment. This is mainly associated with the soil and climatic conditions and other management practices. However, Alemaya, Ada'a and Chalew recorded statistically the same with R-186. Similar finding was observed by Bogale *et al.* (2015). This result is in line with the finding of Yasin (2015), he stated that the variation in yield performance of the varieties under different environmental conditions. The yield obtained from the tested varieties is clearly point out the production potential of the area.

Association between grain yield and yield components

Pearson's correlation coefficient analysis was done to show the associations between grain yield and yield components of the varieties (Table 3). Yield components generally showed positive relationships with grain yield; number of pods plant^{-1} was the most important, followed by thousand seeds weight. Grain yield had significantly positive association with number of pods plant^{-1} ($r= 0.52$) and thousand seeds weight ($r= 0.48$), but significantly negative association with days to flowering ($r= -0.70$) and maturity ($r= -0.74$). It is clearly indicated that the direct contribution of pods plant^{-1} and thousand seeds weight to grain yield.

The correlation was also carried out between yield and yield components (Table 3). Flowering had significantly positive association with days to maturity ($r= 0.86$), plant height ($r= 0.44$) and number of seeds pod^{-1} ($r= 0.39$) but non-significantly associated with number of pods plant^{-1}. Days to maturity had significantly positive association with plant height ($r= 0.64$) but negatively with number of pods plant^{-1}. On the other hand, non-significant association was observed with number of seeds pod^{-1}.

Table 3. Pearson's correlation coefficient between agronomic traits and grain yield.

Parameters	GYD	PHT	PPT	SPP	DTF	DTM	TSW
GYD	1.00						
PHT	-0.19^{ns}	1.00					
PPT	0.52^{**}	-0.24^{ns}	1.00				
SPP	0.22^{ns}	0.14^{ns}	-0.07^{ns}	1.00			
DTF	-0.70^{**}	0.44^{*}	-0.30^{ns}	0.39^{*}	1.00		
DTM	-0.74^{**}	0.64^{**}	-0.48^{**}	0.30^{ns}	0.86^{**}	1.00	
TSW	0.48^{**}	0.15^{ns}	-0.02^{ns}	-0.66^{**}	-0.49^{**}	-0.27^{ns}	1.00

GYD = Grain yield; PHT = plant height; PPT = total number of pods plant^{-1}*; SPP = number of seeds pod*$^{-1}$*; DTF = days to 50% flowering; DTM = days to maturity; TSW = 1000 seeds weight *, ** and* ^{ns} *= significant, highly significant and non-significant at 5% confidence interval.*

Table 4. Farmers' selection criteria and ranking for lentil varieties tested at Shishinda site.

Variety	Farmers' criteria					Rank
	Date to maturity	1000 seed weight (g)	plant height (cm)	Overall field performance	yield (t ha^{-1})	
Teshale	100.0	31.0	27.5	Very good	1.24	3
Alemaya	105.0	23.8	26.3	Very good	0.87	5
Gudo	110.0	44.5	36.4	Poor	1.31	5
Assano	87.0	44.2	26.8	Very good	1.71	1
EL-142	95.0	19.0	27.9	Poor	1.36	5
Derso	105.0	28.5	30.9	Good	1.39	4
Ada'a	109.7	23.9	34.3	Poor	0.93	5
R-186	129.0	22.8	34.6	Poor	0.65	5
Alemtena	99.7	34.1	29.1	Very good	1.59	2
Chalew	105.0	22.4	27.8	Poor	0.94	5
Chekol	103.3	21.6	30.1	Good	1.13	5
					Criteria	Rank
					Yield	1
					Maturity	2
					Seed size	3
					Plant height	4
					Overall field performance	5

Conclusion

Eleven improved lentil varieties were tested for adaptation and yielding performance at Shishinda sub-testing site of Bonga agricultural research center. Based on the finding of this study, the highest grain yield was produced by varieties Assano, Alemtena, Derso, EL-142 and Gudo with grain yield of 1.71, 1.59, 1.39, 1.36 and 1.31 ton ha^{-1}, respectively. In addition, farmers were also selected the most preferred varieties based on their selection criteria under field condition (Table 4). Therefore, the results of field experiment in combination with farmers' preference, varieties Assano and Alemtena can be suggested to use for production in the study area and other areas of similar agro ecological settings of Kaffa zone. The involvement of farmers in variety selection processes may increases the adoption of new variety in the area. On the other hand, the optimum crop management practices with these varieties are also suggested to use in order to achieve maximum lentil productivity in the study area.

Acknowledgments

I am thankful to the Southern Agricultural Research Institute (SARI) and Bonga Agricultural Research Center for providing the research budget. My special thanks go to Debrezeit and Sinana Agricultural Research Centers for providing seeds of lentil varieties for the study. I would like to thank the staff of Bonga Agricultural Research Center, particularly Andualem Gadissa and Aminat Hassen for their technical support during the implementation of the field work.

References

Abraham, R. 2015. Lentil (*Lens culinaris* Medikus) Current status and future prospect of production in Ethiopia. *Adv. Plants Agric. Res*. 2(2): 00040. DOI: 10.15406/apar.2015.02.00040.

Adjei-Nsiah, S. 2012. Role of pigeonpea cultivation on soil fertility and farming system sustainability in Ghana. *Int. J. Agron*. ID 702506, 8. DOI: 10.1155/2012/702506.

Annual Report, 2010. NP fertilizer rate determination on pulse crops, Ethiopia. 16p.

Bejiga, G., Tsegaye, S. and Tullu, A. 1995. Stability of seed yield of lentil varieties (*Lens culinaris* Medik) grown in the Ethiopian highlands. *Crop Res. HISAR*. 9: 337-343.

Bogale, D.A., Mekbib, F. and Fikre, A. 2015. Genetic Improvement of Lentil [*Lens culinaris* Medikus] between 1980 and 2010 in Ethiopia. *Malaysian J. Med. Biol. Res*. 2(3): 284-292.

Brennan, J.P., Aw-Hassan, A., Quade, K.J. and Nordblom, T.L. 2002. Impact of ICARDA research on Australian agriculture (No. 1160-2016-93028). Economic Research Report No. 11, NSW Agriculture, Wagga Wagga. Available on the web at: http://www.agric.nsw.gov.au/reader/10550.

Erskine, W., Sarker, A. and Kumar, S. 2011. Crops that feed the world 3. Investing in lentil improvement toward a food secure world. *Food Sec*. 3(2): 127.

FAO. 2010. Statistical Database of the Food and Agriculture Organization of the United Nations. FAO, Rome. 289p.

FAOSTAT. 2018. FAO Statistics Division. available online: http://www. fao. org/faostat/en/#data. *QC (accessed on January 2018)*.

Hanelt, P. 2001. *Lens* Mill. In: Hanelt P. (ed). Mansfeld's encyclopedia of agricultural and horticultural crops. *Springer–Verlag Berlin Heidelberg*. 2: 849–852.

Iqbal, A., Khalil, I.A., Ateeq, N. and Khan, M.S. 2006. Nutritional quality of important food legumes. *Food Chem*. 97(2): 331-335.

Janzen, J.P., Brester, G.W. and Smith, V.H. 2014. Lentils: Trends in Production, Trade, and Price. Montana State University Agricultural Marketing Policy Center briefing paper. 61p.

Jarso, M., Korbu, L., Gebeyehu, S. and Alemayehu, F. 2009. Improved Crop Production Practices for Major Pulses of Ethiopia; a training manual prepared for training of trainers Organized by Rural Capacity Building Project (RCBP). Ministry of Agriculture and Rural Development. Addis Ababa, Ethiopia. 50p.

Korbu, L. 2009. Improving production and productivity of Chickpea and Lentil in Ethiopia Production Manual. Melkasa, Ethiopia. 17p.

Muehlbauer, F.J., Cubero, J.I. and Summerfield, R.J. 1985. Lentil (*Lens culinaris* Medic.). In: Summerfield R.J. *et al.* editors. Grain Legume Crops. Collins, 8 Grafton Street, London, UK. pp. 266–311.

Mulugeta, F. 2009. Ethiopia Commodity Exchange Authority; Lentil Production, Supply, Demand and Marketing issues in Ethiopia. Organization (FAO). Italy: Rome.

SAS Institute. 2007. The SAS system for windows, V.9.3. SAS Institute, Carry, NC, USA.

Saxena, M.C. and Wassimi, N. 1980. Effect of fertilizer application and inoculation on the performance of lentil and subsequent wheat crop. *Lens*. 7: 52-53.

Tilahun, G. 2016. Participatory variety selection of improved lentil varieties: Reducing land degradation and farmers' vulnerability to climate change in the highland dry areas of north-western Ethiopia. International Center for Agricultural Research in the Dry Areas (ICARDA). 10p. https://hdl.handle.net/20.500.11766/5100.

Yasin, G. 2015. Performance evaluation and adaptation of lentil varieties in lemu, gumur and damot gale districts of southern Ethiopia. *Curr. Res. Agril. Sci*. 2(2): 53-59.

Yirga, K. and Zinabu, N. 2018. Participatory evaluation of lentil varieties in Wag-lasta, Eastern Amhara. *Cogent Food Agric*. 4: 1561171. DOI: 10.1080/23311932.2018.1561171.