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FOOD SCIENCE & TECHNOLOGY | RESEARCH ARTICLE

Participatory evaluation of lentil varieties in Wag-lasta, Eastern Amhara

Yirga Kindie[1]* and Zinabu Nigusie[1]

Abstract: Lentil is an important legume crop which has the ability in nitrogen fixation, and grow in marginal environments, but its productivity is very low in Wage-lasta areas due to lack of improved varieties. Therefore, the experiment was conducted in three places of district Wag-Lasta (Lalibela, Dehana and Hamusite). On both station and farmer's field in 2016 to evaluate the performance of improved lentil varieties. Seven improved lentil varieties including the local check were tested in a randomized complete block design with three replications at each location as mother trial. Three Farmers' fields in each testing location were used for varietal evaluation considering each farm as a replication. Farmers have evaluated at two different growth stages by setting their own criteria. Except the primary branch per plant and seed per pod other parameters showed significant differences at ($P \leq 0.01$) significant level. The promising varieties Derash (1120 kg ha^{-1}, 1460 kg ha^{-1} and 1060 kg ha^{-1}) and Danbi (1090 kg ha^{-1}, 1350 kg ha^{-1} & 1030 kg ha^{-1}) were the highest yielders at Lalibela, Dehana and Hamusite, respectively. Therefore, based on the farmer's evaluation and researcher's selection, varieties Derash and Danbi had selected and recommended for production in the selected districts and similar agro-ecologies.

Subjects: Agriculture & Environmental Sciences; Botany; Plant & Animal Ecology; Agronomy; Biodiversity & Conservation

Keywords: lentil; mother trial; participatory; productivity

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*Corresponding author: Yirga Kindie, Plus Crop Breeding, Amhara Region Agricultural Research Institute, Sekota, Ethiopia
E-mail: ykindie2007@gmail.com

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Additional information is available at the end of the article

Yirga Kindie

ABOUT THE AUTHORS

Yirga Kindie is full time researcher in Sekota Dry-Land Agricultural Research Center at Amhara region Agricultural Research Institute. He has four year research experience and strong analytical skills in plant breeding. Also, yirga has conducted many research activities related to pulse crop breeding and has released (developed) one Field Pea (*pisum sativum* L.) variety for Moisture Deficit Areas of Eastern Amhara, Ethiopia. In addition to this, he has three proceedings at Amhara region Agricultural Research Institute proceeding system. At this time, Yirga is specializing MSc in plant breeding at Haramaya University. In the future, he has an interest to develop many new varieties that enhance productivity.

Zinabu Nigusie is an Agronomist working in Sekota Dry-Land Agricultural Research Center. He holds MSc degree in Agronomy at Bahirdar University with six year research experience and has conducted different research activity related to plant protection and agronomy.

PUBLIC INTEREST STATEMENT

In Ethiopia, national economic development is highly dependent on agriculture. Lentil is one of the most essential pulse crops for this national economy. Lentil has high average protein content and fast cooking characteristic. Flour is used to make soups, stews, purees, and mixed with cereals to make bread and cakes, and as food for infants. But its productivity in wag-lasta is very low due to the use of old and low yielding local cultivars and unavailability of high yielder cultivars. So, Participatory variety selection is the most rapid and cost-effective way to identify farmer-preferred varieties and it ensures the adoption of new varieties. In addition to this, farmers' participation in varietal selection provides adequate exposure to new varieties and high rate of replacement, strong extension network that generally gave farmers access to new cultivars, to maximize their productivity and to improve the livelihood of their families.

1. Introduction

The lentil (*Lens culinaris Medik*.) is a lens-shaped grain legume well known as a nutritious food. It grows as an annual bushy leguminous plant typically 20–45 cm tall, which produce many small purse-shaped pods containing one to two seeds each. Lentil seeds are rich sources of protein, minerals (K, P, Fe, and Zn) and vitamins for human nutrition (Senayit & Asrat, 1994). Furthermore, because of its high lysine and tryptophan content, its consumption with wheat or rice provides a balance of essential amino acids for human nutrition (Bacchi et al., 2010).

Lentil is probably originated in the near east and rapidly spread to Egypt, central & south Europe, Ethiopia, etc. and now cultivated in most sub-tropical and also in the Northern hemisphere such as Canada & Pacific Northwest regions (Cokkizgin & Munqez, 2013). Lentil has the ability to use water efficiently and grown in marginal environments and tolerant of different soil types and low fertility and this has assured its place as a crop of marginal lands (Abraham, 2015).

Lentil is an important food legume crop component of farming and food systems of many countries. Globally, lentil ranks sixth in terms of production among the major pluses after dry bean, chickpea, faba bean, and cowpea. The total lentil cultivated area in the world is estimated around 4.34 million hectares with an annual production and productivity of 4.95 million tons and 1260 kg ha^{-1} respectively (FAO, 2014). Canada is the leading exporting nation, while India is the leading lentil consuming and producing nation (Bedard, Risula, Olekson, & Saskatchewan, 2010).

Lentil plays an important role in human, animal and soil health improvement occupying a unique position in cereal-based cropping systems (Bacchi et al., 2010; Yasin, 2015). Its ability in nitrogen fixation and carbon sequestration improves soil nutrient status, which intern provides sustainability in crop production systems (Abraham, 2015; Yasin, 2015). The consumption and use of lentil at the local level have been investigated within nutrition surveys in Ethiopia (Ghosh, 2004).

Lentil is an important dietary item in several – often poor – parts of developing countries, contributing to worn ding off malnutrition through a balanced diet. Clearly, the old adage that lentils are “poor man’s meat” still remains firmly applied today. About 30% of calories from protein, lentil has the third highest levels of protein, by weight of any other legume or nut, after soybeans and hemp (Bacchi et al., 2010; Yasin, 2015). Lentils are also commonly used in Ethiopia in a stew, like a dish called kick, or kick wot, one of the dishes people eat with Ethiopians national food Injera flatbread. Lentil is the most desired crop because of its high average protein content and fast cooking characteristic in many lentils producing regions (Senayit & Asrat, 1994). It can be used as a main dish, side dish, or in salads. Flour is used to make soups, stews, purees, and mixed with cereals to make bread and cakes, and as food for infants (Resenberg, 2005).

In wag-himra zone the lentil production covers about 297 427 ha within 45 948 numbers of holders and its productivity are 1 109 kg ha^{-1}, but the average productivity of this crop in other zones is 1 225 kg ha^{-1} (CSA, 2015). Though lentil has the ability to use water efficiently and grow in marginal environments and tolerant of different soil types and low fertility, its productivity is very low in wage-lasta areas. This is because of several yield-limiting factors.

The main production constraints include the inherent low yielding genetic potential of the widely grown local cultivar and use of traditional agronomic practices. Therefore, this study was designed to evaluate seven lentil varieties for their yield and yield-related traits under moisture deficit and lentil growing areas of Lasta and Wag-himra.

2. Materials and methods

2.1. Description of the study area

The study was conducted at Lalibela, Hamusite, and Dehana trial sites of Sekota dry land Agricultural Research Center on both station and farm. Three farmers field were used for on-farm evaluation and each farm was used as a replication. Lalibela is located in North Wollo Zone but both Hamusite and Dehana are located in Wag-himra Zone in Sekota and Dehana wards, respectively. Lalibela is situated at 2400 m above sea level with black (vertisol) soil and it receives mean annual rainfall of 895.2 mm. Hamusite is situated at 2200 m above sea level with black sandy soil, and it receives mean annual rainfall of 774.3 mm while Dehana is situated at 2400 m above sea level with black soil and it receives a mean annual rainfall of 998.2 mm.

2.2. Treatments and design

Seven released lentil varieties, such as; Alemaya, Checol, Danbi, Teshale, Alemtena, Derash, Gudo which are obtained from Debrezeite Agricultural Research center and Local check were evaluated. The trial was planted in a randomized complete block design with three replications from the 1st week to mid of July in 2016/17 cropping season. Plot area of the trial was 3 m * 2.4 m and seeds were drilled on six rows with the rate of 180 seeds per plot. Spacing was 1 m, 0.5 m, 0.3 m, and 0.1 m between replication, plots, rows, and plants, respectively. Diammonium phosphate (DAP) was applied with the rate of 100 kg ha^{-1}. Local checks of respective locations were used as checks at each trial site. Hand weeding was used to control weeds as per recommendation.

2.3. Data collected

The data were recorded on the days to flowering, days to maturity, plant height, pod per plant, seeds per pod, biomass, grain yield, and 100 seed weight. At harvest biomass and grain yield was taken from the four central rows and recorded in gram per plot, but it has converted into kg ha^{-1} for analysis. Whereas 100 seed weight was determined from 100 seeds that were randomly selected.

A total of 47 farmers in three districts; 3 agricultural development agents, 10 men and 4 women farmers at Lalibela, 3 agricultural development agents, 9 men, and 3 women farmers each at Dahina and Hamusite were invited to visit the trial site at flowering and physiological maturity. The participated farmers have made the discussion during selection and set the selection criteria to select the promising varieties. The selection criteria were plant establishment, overall performance, plant height, pod setting, earliness, seed size, biomass, number of branches per plant, lodging, and vigoursity. Based on the selection criteria, they were asked to give the rank score of the tested varieties.

2.4. Data analysis

Data recorded were subjected to analysis of variance (ANOVA) using the general linear model (GLM) procedures of statistical Analysis System. Farmers' selection data were analyzed using simple ranking methods in accordance with the given value (De Boef & Thijssen, 2007). Simple ranking is a tool often used to identify promising varieties based on farmers' preferences. The ranking procedure was explained to Kebele Agricultural development agents and farmer participants and then they set the selection criterion. Each selection criterion was ranked from 1 to 5 (5 = very good, 4 = good, 3 = average, 2 = poor and 1 = very poor) for each variety. Ranking was done on consensus where differences are resolved through discussion (De Boef & Thijssen, 2007).

3. Results and discussion

3.1. Agronomic traits of mother trial and farmer's variety evaluation at Lalibela

Mean of days to flowering, days to maturity, plant height, number of primary branches per plant, number of pods per plant, number of seeds per pod, biomass, grain yield, and hundred seed weight, were depicted (Table 1). The varieties significantly ($p \leq 0.01$) varied for days to flowering, days to maturity, plant height, number of primary branches per plant, pods per plant, seeds per pod, grain yield, and 100 seed weight. This finding agrees with Yasine (2015) who

Table 1. Agronomic traits of Lentil at Lalibela

Varieties	DF	DM	PH(cm)	BRP	PDP	SPD	BM(kgha^{-1})	GY(kgha^{-1})	SW(gm)
Checol	55	90	31.07	2.60	49.80	1.67	3277.80	820.37	30.00
Gudo	61	104	25.47	2.73	35.87	1.53	3055.60	820.37	51.67
Alemaya	53	100	27.60	3.07	66.80	1.53	3300.90	1024.07	40.00
Alemtena	52	92	26.28	2.47	37.00	1.40	2453.70	755.56	45.00
Teshale	53	92	27.49	2.80	51.10	1.53	2963.00	827.31	46.67
Derash	57	99	31.97	3.33	97.20	1.67	3611.10	1121.30	45.00
Danbi	59	101	29.33	2.93	69.30	1.67	3166.70	1094.07	35.00
Local	56	89	26.73	2.87	37.10	1.60	2037.00	746.30	31.67
Means	56	96	28.24	2.85	57.23	1.58	2983.22	792.42	40.62
LSD	3.1 **	2.8 **	3.5 *	0.4 **	9.3 **	NS	NS	187.97 **	7.67 **
CV	4.23	3.64	7.14	8.65	9.26	11.88	21.26	13.55	10.78

*Where:—DF = days to flowering, DM = days to maturity, PH = plant height, BRP = primary branches per plant, PDP = pods per plant, SPD = seeds per pod, BM = biomass in kg ha-1, GY = grain in kg ha-1, ** = highly significant, * = significant and NS = nonsignificant, LSD = list significant difference, coefficient of variance.*

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reported that significant difference among recently released lentil varieties for yield, plant height, number of pods and hundred seed weight, days to flowering and days to maturity. The mean number of pods per plant ranged from 35.87 to 97.2. The varieties Derash, Danbi, and Alemaya had a higher number of pods per plant than other tested varieties (Table 1). This finding is in line with Stoilova and Pereira (1999) who reported that the number of pods per plant was showing remarkable variation in their lentil lines. Derash (1121.30 kg ha^{-1}), Danbi (1094.07 kg ha^{-1}), and Alemaya (1024.07 kg ha^{-1}) had a maximum mean grain yield (Table 1). Yasin (2015) also reported that grain yield had a wide variation (from 943.6 to 1239 kg ha^{-1}) in tested lentil materials. This result pointed out that grain yield potential in lentil may be varied from variety to variety.

As per the selection criteria set farmers ranked Derash (59.33), Danbi (57.00) and Checol (56.17) at the first, second and third position but Gudo (32.17) was the lowest (Table 2). Farmers' exposure to evaluate and select new varieties is an advantage to exploit their potential knowledge of identifying adapted varieties that best meets their interest. Our finding agrees with Yasin (2015) who reported that farmers had deep knowledge to identify adapted varieties that best meets their interest. According to Joshi, Sthapit, and Witcombe (2001) varieties developed for specific niches may be capable of spreading to other distant and different environments; in many cases, they are unlikely to spread as readily as varieties that have specifically been developed to have wide adaptation. The present study also demonstrated this.

3.2. Agronomic traits of mother trial and farmer's variety evaluation at dehana

Agronomic traits, i.e., days to flowering, days to maturity, plant height, number of primary branches per plant, number of pods per plant, number of seeds per pod, Biomass, grain yield, and hundred seed weight, were analyzed (Table 3). The varieties significantly ($p \leq 0.05$) varied for days to flowering, highly significant differences ($p \leq 0.01$) were also observed among varieties for plant height, pods per plant, grain yield, and 100 seed weight. Edossa, Tesfaye, and Endashaw (2011) also reported that the number of pods, number of secondary branches, plant height, and grain yield except for hundred seed weight.

The mean days to flowering ranged from 65 days to 72 days (Table 3). The findings of this study disagree with Erskine (1983) who found days to flowering ranged from 118 to 162 days. Significant variations were observed among varieties for plant height. Plant height varied from 22.13 to 29.40 cm. It was determined that Checol variety was the shortest, and Teshale was the tallest among tested varieties (Table 3). Piergiovanni (2000) reported that plant height varied from 28 to 41 cm in their material. Derash scored the highest number of pods per plant (58.40) followed by Checol (48.97) and Danbi (41.60) but Teshale scored the lowest (29.60). With the finding of Yasine (2015) was also indicated that number of pods per plant was showing remarkable variation in their lentil lines. Derash had a maximum mean grain yield (1 455.55 kg ha^{-1}) followed by Danbi (1 347.22 kg ha^{-1}) and Checol (1 333.22 kg ha^{-1}) but Teshale (851.26 kg ha^{-1}) was the lowest yielder. At the same time, Derash (55.14) scored the highest mean value based on farmers perception followed by Checol (52.34) and Danbi (51.34) but Teshale (29.64) scored the lost value (Table 4).

3.3. Agronomic traits of mother trial and farmer's variety evaluation at Hamusite

Agronomic traits, i.e., days to flowering, days to maturity, plant height, number of primary branches per plant, number of pods per plant, number of seeds per pod, biomass, grain yield, and hundred seed weight, were analyzed (Table 5). The Varieties significantly ($p \leq 0.05$) varied for days to flowering and the number of seeds per pod. Highly significant differences ($p \leq 0.01$) were also observed among varieties for days to maturity, number of pods per plant, bio-mass, grain yield, and 100 seed weight. This finding agrees with the result reported by Edossa, Tesfaye, and Endashaw (2010) in Ethiopian lentil landraces for the number of pods, number of secondary branches, plant height, and seed yield except for hundred seed weight. Derash scored the highest number of pods per plant (40.25) followed by Danbi (35.58) and Alemaya (37.24) but Alemtena scored the lowest (22.50). The maximum grain yield ((1064.8 kg ha^{-1}) was recorded in variety

Table 2. Mean of farmers selection criteria and ranking of lentil varieties at Lalibela

Variety	Farmers criteria						Total	Mean	Rank
	PES	OAP	VG	PS	ER	LO			
Teshale	44	33	32	32	60	22	223	37.17	5th
Gudo	30	21	22	22	33	65	193	32.17	8th
Local	30	33	49	30	32	22	196	32.67	7th
Alemtena	33	37	34	37	33	37	211	35.17	6th
Derash	66	69	69	69	46	37	356	59.33	1st
Alemaya	65	66	63	64	26	49	333	55.50	4th
Checol	63	64	58	61	26	65	337	56.17	3rd
Danbi	66	60	56	64	46	50	342	57.00	2nd

Where: PES = plant Establishment OAP = Overall performance VG = Vigoursity, PS = pod setting ER = earliness LO = lodging

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Table 3. Agronomic traits of lentil at Dehana

Varieties	DF	DM	PH (cm)	BRP	PDP	SPD	BM (kgha^{-1})	GY (kgha^{-1})	SW(gm)
Checol	66	101	22.13	6.65	41.97	1.67	1.06	1333.22	30.33
Gudo	67	102	24.57	5.90	37.33	1.70	0.93	1099.07	34.83
Alemaya	71	102	23.70	6.63	34.70	1.73	1.02	1008.33	32.67
Alemtena	67	101	25.07	6.53	32.97	1.67	1.08	945.07	40.40
Teshale	66	102	29.40	5.87	29.60	1.67	1.12	851.26	40.17
Derash	72	104	22.87	5.93	58.40	1.53	1.08	1455.55	31.37
Danbi	66	102	21.47	5.73	48.60	1.60	1.08	1347.33	30.53
Local	65	104	26.43	6.00	39.55	1.47	0.96	1224.59	34.58
Means	67	102	24.45	6.16	40.38	1.63	1.04	1158.05	34.36
LSD	4.07*	NS	1.86**	NS	1.89**	NS	0.09 **	83.57 **	5.73 **
CV	4.45	4.79	5.35	14.43	3.68	10.36	5.12	5.12	9.52

*Where: DF = days to flowering, DM = days to maturity, PH = plant height, BRP = primary branches per plant, PDP = pods per plant, SPD = seeds per pod BM = biomass, GY = grain, ** = highly significant, * = significant and NS = nonsignificant.*

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Table 4. Mean of farmers selection criteria and ranking of lentil varieties at Dehana

Variety	Farmers criteria						Total	Mean	Rank
	PES	BM	BR	PS	ER	LO			
Alemtena	46	40	40	38	44	22	230	38.34	7th
Teshale	33	22	22	22	33	46	178	29.64	8th
Derash	59	55	58	59	56	44	331	55.14	1st
Local	48	42	48	48	40	52	278	46.34	5th
Alemaya	54	46	52	50	44	44	290	48.34	4th
Checol	58	52	58	56	48	42	314	52.34	2nd
Danbi	54	48	54	50	46	56	308	51.34	3rd
Gudo	48	46	42	42	42	46	266	44.34	6th

Where: PES = plant establishment BM = biomass Br = branches, PS = pod setting, ER = earliness, Lo = lodging

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Table 5. Agronomic characters of Lentil at Hamusite

Varieties	DF	DM	PH (cm)	BRP	PDP	SPD	BM (kgha^{-1})	GY (kgha^{-1})	SW(gm)
Checol	53	79	31.9	6.1	29.98	1.7	1703.7	787.0	20.3
Gudo	56	82	31.1	5.3	26.75	1.4	1527.8	694.4	36.3
Alemaya	51	80	27.5	4.5	35.58	1.9	2157.4	935.2	26.0
Alemtena	54	78	29.7	5.7	22.50	1.4	1287.0	657.4	28.6
Teshale	54	79	29.1	4.3	22.64	1.7	1398.1	685.2	31.7
Derash	55	80	34.6	5.4	40.25	2.0	2518.5	1064.8	29.5
Danbi	57	80	32.8	5.1	37.24	1.6	2083.3	1027.0	24.0
Local	55	73	33.1	4.3	29.08	1.4	1713.0	712.9	22.5
Means	54	79	31.23	5.09	20.50	1.66	1798.61	821.76	27.38
LSD	3.21*	1.81**	NS	NS	1.71**	0.38*	2.14**	127.77**	3.14**
CV	4.37	3.31	8.31	24.62	5.77	13.29	16.77	8.88	6.55

**Where: DF = days to flowering, DM = days to maturity, PH = plant height, BRP = primary branches per plant, PDP = pods per plant, SPD = seeds per pod, BM = biomass, GY = grain, ** = highly significant, * = significant and NS = nonsignificant.*

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Table 6. Mean of farmers selection criteria and ranking of lentil varieties at Hamusite

Variety	Farmers criteria						Total	Mean	Rank
	PES	OAP	PH	PS	ER	SS			
Alemaya	47	46	46	47	35	26	247	41.17	2nd
Gudo	30	25	22	26	28	48	179	29.83	6th
Alemtena	30	28	25	26	27	22	158	26.33	7th
Local	40	38	34	37	31	37	217	36.17	4th
Derash	49	50	47	50	33	40	269	44.83	1st
Teshale	28	26	26	22	21	46	169	28.17	8th
Checol	32	32	30	32	33	48	207	34.50	5th
Danbi	46	44	40	44	28	42	244	40.67	3rd

**Where: PES = plant establishment, OAL = overall performance, PH = plant height, ps = pod seating, Er = earliness, SS = seed size*

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Derash followed by Danbi (1027.0 kg ha^{-1}) and Alemaya (935.2 kg ha^{-1}) but Alemtena was the lowest yielder (657.4 kg ha^{-1}). Erksine (1983) reported that grain yield had a wide variation (from 10 to 3257 kg ha^{-1}) in his lentil materials. Simultaneously, farmers had selected Derash (44.83), Alemaya (41.17) and Danbi (40.67) as the first, second and third best promising varieties, respectively, but variety Teshale (28.17) had scored the last rank (Table 6).

The promising varieties Derash and Danbi were selected as first and second top ranking varieties at all three tested locations. Plant establishment, overall performance, plant height, pod seating, earliness and seed size were the criterias for evaluating the performance varieties. The same varieties had better performance and found to be promising from the analysis of researchers collected data. The current selection process also demonstrated that farmers were capable of selecting important traits for grain yield (yield components) and based on those traits demonstrated to identify superior varieties adapted to their locality. The study showed that participatory approaches played a significant role which is equivalent with conventional plant breeding (*http:// site resources. World bank.org/INTWDR 2008/Resources/W DR_00_book.pdf)*

4. Conclusion and recommendation

Incorporating farmers' preferences in the selection of varieties in the breeding process may increase the adoption of new varieties. Farmers' exposure to evaluate and select new varieties provide an advantage to exploit their potential knowledge of identifying adapted varieties, that best meets their interest. From this finding improved varieties such as; Derash and Danbi were found highly adapted and yielding to the testing areas and can increase production and productivity of lentil by 50% and 46.5% over the local check and 57.6% and 53.8% over the CSA data at Lalibela, respectively. Similarly, the varieties Derash and Danbi had a grain yield advantage of 18.86% and 10.07% over Local variety, respectively, at Dehana. At the same time varieties, Derash and Danbi showed 49.36 % and 44.05 % yield advantage over Local variety at Hemusite. The same varieties had better performance and selected as top ranking according to farmers perception. Therefore, based on Researchers and farmers' preference, varieties Derash and Danbi are recommended for production for Wag-lasta areas and similar agro-ecologies.

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Author details
Yirga Kindie[1]
E-mail: ykindie2007@gmail.com
Zinabu Nigusie[1]
E-mail: zinabu1221@gmail.com
[1] Sekota Dryland Agricultural Research Center, Amhara Regional Agricultural Research Institute (ARARI), Crop Technology Supply Research Directorate, Sekota, Ethiopia.

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