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Assessment and Evaluation of Seed Replacement Rate on Lentil (*Lens culinaris* Medik) Seed Yield in Ethiopia

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Abstract: The assessment and evaluation was done in major lentil growing areas of the country mainly in Oromia, Amhara and SNNP regions. Gimbichu, Adea, Moretina Jiru, Lume and Siyadebrna wayu were the districts involved for the study from the respective regions. Primery data was collected from the respondents of the selected districts. Lentil seed sample was collected from interviewed farmers based on the trend of seed replacement experiences which was intended for field experiment. Seed samples were bulked according to the identified replacement years and subjected to field experimentation The treatments were arranged based on the seed replacement rate of the farmers as 3years interval, 4 years interval, 5 years interval and basic seed of lentil variety Alemaya was used as standard check. The field experiment was conducted in a Randomized complete block design with three replications with plot size of 2m x 1.2m=2.4m^2 at Minjar, Chefe and Akaki sub-site. Both quantitative and qualitative data collected were subjected to SAS and SPSS statistical software. All the yield and yield related components were non- significant at 5% except for flowering date and straw yield. All yield and yield related parameters show significant differences at 5% for locations and the maximum seed yield was recorded at Chefe Donsa (901 kg/ha) followed by Minjar (589kg/ha and the lowest was from Akaki (301kg/ha). Regarding the seed replacement rate all yield and yield related parameters showed significant variations except for flowering date and plant height and the maximum seed yield was obtained at three years of seed replacement (695kg/ha) and the lowest is at fifth year seed replacement year (518kg/ha) which indicates the productivity of the varieties reduced as the replacement year increases due to genetic and physical deterioration and susceptibility to disease.

Keywords: Seed, Replacement Rate, Districts, Descriptive, Lentil

1. Introduction

Lentil (*Lens culinaris* Medik) is one of the most ancient annual food crops that have been grown as an important food source for over 8,000 years [6, 10] Nepal, India, Turkey, Australia, the United States, Iran, Syria, Ethiopia, Canada, China, are the uppermost lentil-producing county in the world [5]. Globally, it is the second pulse crop among the legumes [13].

Lentil plays a significant role in human and animal nutrition and in maintenance and improvement of soil fertility [6, 11]. Its cultivation enriches soil nutrient status by adding nitrogen, carbon and organic matter which promotes sustainable cereal based systems of crop production [11] The primary product of lentil is its seed which has relatively higher contents of protein, carbohydrate and calories compared to other legumes [4] The major lentil-growing countries of the world are Canada, India, Turkey, Australia, USA, Nepal, China, and Ethiopia. Out of the total increased volume of global production in recent years, the most is coming mainly from Canada and India.

Lentil is among the principal grain legumes in the highland Vertisols of Ethiopia mainly in tef, wheat, and barley-based crop rotation systems. In this cropping system, the function of yield increment of the following cereal crop is realized as a result of the predecessor lentil that fixes nitrogen, as well as breaks the life cycle of essential diseases, insect pests, and weed populations [7]. Lentil is grown and harvested primarily in Ethiopia's northern, central, and eastern highlands in the main season and to some extent during the short rainy season ('belg', February-May). In Ethiopia, lentil ranks 7th in terms of the number of growers; accounting for, 4.42% of total pulse growers, 0.05% of the total area under pulse crops and 0.04% of total pulse production [3].

Despite its popularity as a food crop, its productivity is very low (national average of about 1.34 tha^{-1}[3] mainly due to insufficient supply of quality seed, poor production practice and low genetic potential of the varieties as well as susceptibility to disease. Studies revealed that, regardless of its importance, lentil productivity is still very low in Ethiopia mainly due to little attention by the research [2] Use of high-quality seeds can enhance productivity by as much as 25% but low and stagnant yields have been attributed to the use of poor-quality seeds of local cultivars [1, 8, 14]. Most lentil producer farmers use their own saved seed for many years without changing the variety or the new seed from formal sources which has its own impact for the reduction of yield as well as the quality of the production due to physical and genetic contamination.

In Ethiopia, the effective demand for certified seed is not well identified that resulted in mismatch between supplies of early generation seed and demands for the majority of the crops in general and for lentil in particular [9].

In this context, this paper focuses on assessment and evaluation of the current seed replacement rate scenario of lentil in major producing areas of Ethiopia which is not yet studied with the objectives of to evaluate the impact of seed replacement rate on seed yield and to assess the experience of farmers in seed replacement rate.

2. Materials and Methods

The assessment was conducted in major lentil growing areas of the country mainly in Oromia, Amhara and SNNP regions. Gimbichu, Adea, Moretina Jiru, Lume and Siyadebrna wayu were the identified districts as major producers from the indicated regions. Structured questioner was developed and primary data was collected in relation to their experiences in lentil seed replacement rate and problems of production and productivity. Seed sample was collected from 15 farmers which were participated on the interviewee from each districts and the seed sample collection was based on the trend of farmers' replacement experiences which was intended for field experiment.

Seed samples collected from the selected districts were bulked according to the identified replacement years and subjected to field experimentation The treatments was arranged based on the seed replacement rate of the farmers as 3years interval, 4 years interval, 5 years interval and basic seed of lentil variety Alemaya was used as standard check. The field experiment was conducted in a Randomized complete block design with three replications with plot size of 2m x 1.2m =2.4m^2 at Minjar, Chefe and Akaki sub-site. The necessary yield and yield related data was collected as well as the number of off-type plants per plot recorded. The qualitative data obtained by the questionnaires, and the field experiment data was analyzed using SPSS and SAS software.

3. Result and Discussion

3.1. Agronomic Performance of Lentil

All the yield and yield related components of lentil collected from farmers were non- significant at 5% probability level except for flowering date and straw yield. The maximum straw yield was obtained from the sample collected from Gimbichu (2023 qt/ha) and the lowest straw yield was from Lume district (1820qt/ha). This shows that the performance of lentil collected from different districts is almost similar for the measured agronomic performances (table 3).

Table 1. *Mean values of yield and yield related parameters of lentil collected from different districts.*

Source Districts	Seed per pod,	No off Types,%	Flowering Date,	Maturity Date	Plant Height	Pod per Plant	Seed Yield (kg/ha)	Straw Yield (kg/ha)
Gimbich	1.20	4.26	59.50^{ab}	102.7	31.05	22.1	618	2023^{a}
Moretina Jiru	1.20	4.29	58.7^{C}	102.9	30.42	22.6	595	1931^{ac}
Ada'a	1.20	4.00	59.60^{ab}	102.5	30.31	22.3	616	1991^{ab}
Lume	1.18	4.06	59.80^{a}	102.3	30.74	21	575	1829^{C}
Seyadebrina wayu	1.15	4.26	59.00^{bc}	120.5	3037	23.1	591	1873^{bc}
Cv	15.66	15.64	2.11	1.9 6	9.6 7	18.95	14.76	13.13
HSD	0.09	0.346	0.66	1.06	1.56	2.23	46.9	134
F value	7.45	10.13	118.19	79.58	16.52	4.75	60.71	22.64

CV= Coefficient of variation, HSD= Minimum Significant Difference (Tukey).

Table 2. *Mean values of seed and seed related traits of lentil across different locations.*

Location	Seed per pod,	No off Types,%	Flowering Date,	Maturity Date	Plant Height	Pod per Plant	Seed Yield (kg/ha)	Straw Yield (kg/ha)
Akaki	1.23^{a}	4.00^{b}	55.10^{c}	93.00^{c}	24.60^{c}	18.16^{b}	308^{c}	1642^{b}
Chefe Donsa	1.29^{a}	4.07^{b}	64.30^{a}	114.00^{a}	32.40^{b}	24.30^{a}	901^{a}	2485^{a}
Minjar	1.04^{b}	4.45^{a}	58.60^{b}	100.00^{b}	34.50^{a}	24.30^{a}	589^{b}	1660^{b}
Cv	15.66	15.64	2.11	1.9 6	9.6 7	18.95	14.76	13.13
HSD	0.06	0.23	0.44	0.71	1.04	1.48	31.20	89.30
F value	7.45	10.13	118.19	79.58	16.52	4.75	60.71	22.64

CV= Coefficient of variation, HSD= Minimum Significant Difference (Tukey).

3.2. Performance of the Tested Samples Across Location

The analysis of variance for yield and yield related parameters tested across different locations showed significant different at 5%. The maximum mean value was recorded at Chefe- Donsa for all parameters except for the number of off types and plant height. The highest seed yield (901kg/ha) was recorded at Chefe - Donsa and the lowest seed yield was at Akaki((308kg/ha) (Table 4) which is lower than the national average 1.34t/ha [3]. This shows that location has an impact on the performance of the lentil (Table 2).

3.3. Seed Replacement Rate and Its Impact on Yield

According to the ANOVA result for lentil collected from farmers with different duration or rate of seed replacement and observed under field for two years, the yield and yield related parameters were significantly affected by duration. There is a significant difference at 5% for all measured traits except for seed per pod, flowering date and plant height. The highest mean value was recorded at 3years replacement rate for pod per plant (24.1), seed yield (695kg/ha) and straw yield (2065 kg/ha) and the lowest mean value was recorded for seed replaced at 5 years for pod per plant (20.2), seed yield (518kg/ha) and straw yield (1765 kg/ha). In the contrary the highest mean value for off types (5.49) was observed for the seed replaced at five years and lowest mean value for off types (2.95) was recorded for the seed replaced at third years which shows the level of contamination as the replacement years increased (table 3). Similar result was reported by [8] that Pulses have a seed renewal period of three to four years. The use of farm saved seeds for more than this stipulated period leads to a decline in genetic purity and an increase in susceptibility to pests and diseases. In addition [12] described that seed replacement should be accompanied by the adoption of correct crop management practices for increasing yield.

Table 3. *Mean values of lentil collected from farmers with different durations.*

Duration	Seed per pod,	No off Types,%	Flowering Date,	Maturity Date	Plant Height	Pod per Plant	Seed Yield (kg/ha)	Straw Yield (kg/ha)
3 years	1.19	2.95^{C}	59.4	102.3^{B}	30.8	24.1^{A}	695^{A}	2065^{A}
4 years	1.2	4.08^{B}	59.5	102.5^{AB}	30.7	22.4^{B}	584^{B}	1957^{B}
5 years	1.17	5.49^{A}	59.2	103^{A}	30.1	20.2^{C}	518^{C}	1765^{C}
Cv	15.66	15.64	2.11	1.9 6	9.6 7	18.95	14.76	13.13
HSD	0.06	0.23	0.44	0.71	1.04	1.48	31.2	89.3
F value	7.45	10.13	118.19	79.58	16.12	4.75	60.71	22.64

CV= Coefficient of variation, HSD= Minimum Significant Difference (Tukey).

The analysis of variance (ANOVA) result of the two-way interaction mean value (seed source districts * Duration of seed replacement rate) showed non-significant differences for all physiological parameters (Table 11). Even though it is not significant the highest seed yield was recorded at Gimbichu with three years of seed replacement (741.82kg/ha) and the lowest yield was at Moretina Jiru at five years of seed replacement interval (494.37kg/ha) (table 4).

Table 4. *Mean values of the two way interaction effect of seed source and duration on seed physiological parameters.*

WRD	SER	SP	Off types	FD	MD	PH	POP	SEY	SY
AD	3	1.19	2.87	60.13	102.25	30.45	25.72	695.74	2179.0
GM	3	1.23	3.16	59.94	102.19	30.41	23.65	741.82	2184.1
MJ	3	1.25	3.26	58.41	103.0	30.01	24.98	686.91	2148.6
SW	3	1.15	3.22	58.83	103.27	30.76	23.27	662.56	2113.8
LU	3	1.15	3.05	59.33	102.3	30.93	22.85	633.83	1851.7
AD	4	1.22	4.05	59.11	102.41	30.72	22.33	585.40	1998.5
GM	4	1.22	4.40	59.63	103.05	31.22	21.85	599.32	2067.1
MJ	4	1.15	4.18	58.88	102.8	30.83	22.08	601.35	1878.0
SW	4	1.16	4.11	59.27	101.75	30.16	23.30	582.59	1839.9
LU	4	1.22	3.88	60.58	102.16	31.16	21.55	570.57	1891.8
AD	5	118	5.06	59.80	103.02	29.75	18.95	569.28	1796.8
GM	5	1.17	5.22	59.08	103.05	31.76	20.31	519.92	1815.9
MJ	5	1.26	5.44	59.05	103.02	30.18	21.50	494.37	1770.1
SW	5	1.15	5.45	59.11	102.52	30.20	22.98	529.25	1665.6
LU	5	1.12	5.23	59.52	102.58	30.12	18.67	522.97	1743.9
CV		4.84	4.84	4.84	4.84	4.84	4.84	4.84	4.84
HSD		0.24	1.07	7.65	3.89	3.98	6.19	240.51	665.37
F value		7.45	10.13	118.19	79.58	16.12	4.75	60.71	22.64

4. Descriptive Analysis

Multistage purposive sampling techniques were used to collect a total of 92 samples from Amhara regional state 45 samples, Oromia regional state 47 samples. The highest sample percent (39.1%) were shared by Oromia regional state (51.1) whereas the lowest percent was shared by Amhara regional state

(48.9%). Regarding the seed source districts two of the districts were from Amahara region and the rest three were from Oromia. The average age of the respondents was 43 years with the maximum 69 and the minimum 21 (table 3) which indicates almost all respondents are in productive age which is directly related to accessing and utilization of agricultural technologies. In relation to the seed replacement rate about 30.40% (28) of the respondent replace their seed after three years and 29.30% (27) of the respondent households replace after four years. But more than 35% (32) of the households replace their lentil seed used for production after five years which means they use the seed received from any source for continuous five years without replacement. More than 5.40% (5) of the households respond that they did not replace the lentil seed for production for more than five years rather they use their own saved seed year after year for more than five years. In this practice the production potential of the variety is reduced and susceptibility to biotic as well as a biotic stresses increased. The result of the experiment also showed that the lowest mean value for seed yield and straw yield was obtained from the seed used continually for five years from own saved without replacement (table 3). Other finding also identified the unavailability of seeds of improved varieties as constraints to legume-based rotations [15]. Due to the lack of adequate amount and timely access to improved seed varieties, farmers relied on recycled seeds, which, contributes for yield reduction and additional year of re-use. All these factors combine to make them a risky crop compared to cereals. It is therefore imperative to focus on replacing farm-saved seeds with modern cultivars which are both high yielding and resistant to biotic and a biotic stresses. Weed management is another challenge in lentil production. According to the respondent farmers there is no recommended herbicide for the control of different weed types in lentil and most of them used hand weeding which is not effective. The maximum area allocated for lentil is 1.50 ha and the average is about 0.49 ha as indicted from the respondents (table 10). This indicates that the share of lentil is decreasing due to its production is challenged by many factors mainly due to disease prevalence and susceptibility of the seed/varieties the farmers used. Therefore replacing the old varieties and the seed used for many years with early generation seed and using the recommended technological packages has to get attention to tackle the production challenge of lentil.

Table 5. *Regional share of the respondent.*

Region	Ferequency	Percentage	Remark
Oromia	47.00	51.10	
Amahara	45.00	48.90	
Total	92.00	100	

Table 6. *Source districts and their share.*

Source Districts	Frequency	Percentage	Remark
Moretina jiru	25.00	27.10	
Siyadebrina wayu	20.00	21.70	
Adea	17.00	18.50	
Gimbichu	10.00	10.90	
Lume	20.00	21.70	
Total	92.00	100	

Table 7. *Age of the respondent household.*

	N	Maximum	Minimum	Average	Std. Deviation
Household Age	92	69	21	43	11.00

Table 8. *Seed replacement year trend of the respondents.*

Year	Frequency	Percent	Remark
3.00	28.00	30.40	
4.00	27.00	29.30	
5.00	32.00	34.80	
Others	5.00	5.40	
Total	92.00	100.00	

Table 9. *Important weeds of lentil.*

1	Major weeds	Frequency	Percentage	Remark
2	Seteria and broad leaf	14.00	15.20	
3	Phalaris	33.00	35.90	
4	phalaris and convelvules	14.00	15.20	
5	Avena	13.00	14.10	
6	Yelam chew	8.00	8.70	
7	Phalaris and avena	5.00	5.40	
8	Others	5.00	5.40	
	Total	92.00	100.00	

Table 10. *Area allocated for lentil production.*

No	No	Minimum	Maximum	Mean	St. divation
Total area	87	0.00	6.00	1.92	1.25
Area allocated for lentil	87	0.13	1.50	0.49	0.29
Total					

Table 11. *ANOVA table for Lentil seed yield and agronomic parameters.*

NO	Source	Df	Mean squares and significance level of the parameters							
			SP	Off types	FD	MD	PH	Pop	SEY	SY
1	WRD	4	0.03ns	1.00ns	11.96**	2.96ns	5.27ns	34.04ns	17631.97ns	348834.45***
2	DUR	2	0.02ns	146.57***	1.29ns	12.61*	13.4ns	347.87***	719200.44***	2085275.89***
3	YR	1	14.14***	0.51ns	2069.46**	5209.61***	6596..56***	248.24***	16448677.41***	9574379.22***
4	LOC	2	1.62***	5.27***	1944.57**	10960.95***	2447.63***	1134.94***	7933014.54***	20862635.62***
5	REP	2	0.19**	10.08**	3.14ns	28.78***	32.88*	27.38ns	6187.29ns	106870.33ns
6	WRD*DUR	8	0.01ns	0.25ns	5.5***	3.74ns	3.76ns	31.68ns	15883.74*	120880.79ns
7	YR*LOC	2	1.33***	7.01***	5359.75***	931.35***	380.64***	150.11***	302640.20***	29124748.64***
8	WRD*DUR*LOC*YR	70	0.04ns	0.70**	2.94***	4.39ns	10.41ns	53.57***	47351.53***	229413.43***
9	Error	176	0.034	0.42	1.57	4.06	8.73	17.82	7842.75	64238.9
10	Corrected total	269	29.86	469.74	17266.44	30149.96	14679	10880.69	44726496.51	143789288.3
11	Grand mean		1.19	4.17	59.39	102.62	30.58	22.26	599.72	1929.65
12	CV		15.66	15.64	2.11	1.96	9.66	18.95	14.76	13.13
	R^2		0.79	0.83	0.98	0.97	0.89	0.70	0.96	0.92
	F value		7.45	10.13	118.19	79.58	16.12	4.75	60.71	22.64

5. Conclusions

Lentil is among the principal grain legumes in the highland Vertisols of Ethiopia mainly in tef, wheat, and barley-based crop rotation systems. In this cropping system lentil plays a significant role in human and animal nutrition and in maintenance and improvement of soil fertility.

Despite its popularity as a food crop, its productivity is very low (national average of about 1.34 tha^{-1} [3] mainly due to insufficient supply of quality seed, poor production practice and low genetic potential of the varieties as well as susceptibility to disease. Use of high-quality seeds can enhance productivity by as much as 25% but low and stagnant yields have been attributed to the use of poor-quality seeds of local cultivars.

Most lentil producer farmers use their own saved seed for many years without changing the variety or the new seed from formal sources which has its own impact for the reduction of yield as well as the quality of the production due to physical and genetic contamination. As the result of this study reveled that more than 35% of the households replace their lentil seed used for production after five years which means they use the seed received from any source for continuous five years without replacement which as an impact on reducing the production potential of the variety and susceptibility to biotic as well as a biotic stresses increased. It is therefore important to focus on replacing farm-saved seeds with new varieties or seed of the varieties under production which are both high yielding and tolerant to biotic and a biotic stresses.

As indicated from this study; for self pollinated crops farmers has to replace their seed at three years so that they can maximize production by reducing physical and genetic contamination.

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