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The Study of Lentil Samples from Global Collection in Different Agroclimatic Conditions of Ararat and Gegharkunik Regions

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ABSTRACT

Lentil (Lens culinaris Medik.), is a valuable and accessible source of plant proteins. Thanks to their symbiosis with nitrogen-fixing bacteria, they help in the accumulation of nitrogen in the soil. In the climatic conditions of the Ararat and Gegharkunik regions, lentil samples from ICARDA collection were studied, including: plateflat forms Flip2006-4L, Flip2007-12L, Flip2007-15L, Flip2006-10L, Flip2007-3L, Flip2007-30L; drought-resistant Bilsen-365, EP-54; early-maturing Flip2005-42L, Flip 2005-53, Sellfrom LL1 767, Flip2006-79L; frost-resistant Flip2003-30L, Flip 2007-26L, AKM-46, Flip2005-25L. For the lentil samples, the climatic conditions of the Gegharkunik region proved to be more favorable, and the samples Flip2007-12L, Flip 2007-15L, and Flip2007-3L demonstrated 21 %, 35 %, and 14 %, higher yields compared to the Ararat region, respectively. In the Ararat region, the highest yield among all studied samples was shown by the drought-resistant Ep-54. The mentioned varieties are recommended for use in breeding work and production sowings.

Introduction

Lentil (Lens culinaris Medik.) is one of the oldest legume crops cultivated by humanity. In many developing countries with food insecurity, it serves as a vital source of nutrition (Pugliese, et al., 2024). Lentil is a drought-resistant crop that is an excellent source of food-grade protein and starch, making it ideal for everyday consumption, while in its green form, it is also a valuable animal feed (Moezalislam, et al., 2012; Minhao, et al., 2023). As a legume crop, lentil stands out for its high protein content, which ranges from 22-30 % in the seeds (Shaboyan, et al., 2024).

The root system of lentil forms a symbiotic relationship with nitrogen-fixing bacteria, thereby enriching the soil with nitrogen (Mukherjee, et al., 2023). When included in crop rotation as a preceding crop, lentil significantly increases the yield of subsequent crops (20-30 %) (Ali, et al., 2022). The introduction of new, high-yielding, erectness, disease- and pest-resistant lentil samples, suitable for mechanical harvesting, is an important and current priority in agricultural development (Barbaryan, et al., 2020).

According to statistical data from the Republic of Armenia, in 2023, lentil was grown on 123 hectares, with total harvested crop 1772 c. Lentils are primarily cultivated in the Kotayk, Shirak, Armavir, and Gegharkunik regions (Sown Areas of Agricultural Crops, Planting Area of Permanent Crops, Gross Harvest and Average Crop Capacity for 2022). The low crop areas and yields of lentil are mainly due to the lack of high-yielding, erectness, disease-resistant varieties suitable for mechanical harvesting, as well as improper choices of sowing methods, timing, and areas (Anil, et al., 2022).

Both abiotic and biotic factors have a strong negative impact on the physiology of lentil plants, in particular pod and lentil production; environmental conditions and both abiotic and biotic stresses affect the potential response of plants to caffeine when used as a potential ingredient for biostimulant formulations (Jené, et al., 2022).

In 2008-2009, 101 lentil samples from the ICARDA global collection were studied in the climatic conditions of the Ararat and Gegharkunik regions based on yield data. Among these, 25 were plate-shape, 25 were drought-resistant, 34 were early-maturing, and 17 were frost-resistant samples. From 2019 to 2021, we selected and studied 16 relatively high-yielding samples from this collection for further evaluation based on their biological and agronomic particularities, with the aim of including them in future breeding programs.

Materials and methods

The studies conducted between 2019-2021 were carried out in the climatic conditions of the Ararat and Gegharkunik regions at the experimental farm of the Scientific Center for Vegetable and Technical Crops of the Ministry of Agriculture of the Republic of Armenia, located in the Darakert community, which has irrigated meadow gray soils. The region is situated at an altitude of 850-1000 meters above sea level. The average temperature in January is −2.6°C, and in July, it is 26.2°C. The annual average precipitation is 289 mm. In the Martuni community of the Gegharkunik region, at the farm of Grigori Khlyghatyan the crops were grown in irrigated gray meadow soils. The experimental plot was located at an altitude of 1800-2000 meters above sea level, with an average temperature of −6.0°C in January and 22.0°C in July. The annual average precipitation is approximately 350 mm.

Seeding in Darakert was carried out in the last decade of April, while in Martuni, it was done in the first decade of May. The following lentil samples were studied:

Plate-shaped: Flip2006-4L, Flip2007-12L, Flip2007-15L, Flip2006-10L, Flip2007-3L, Flip2007-30L; Drought-resistant: BILSEN-365, EP-54; Early-maturing: Flip2005-42L, Flip2005-53, Sellfrom1767L, Flip2006-79L; Frost-resistant: Flip2003-30L, Flip2007-26L, AKM-46, Flip2005-25L. The accepted sowing norm for lentil is 2.5-3 million viable seeds per hectare, determined through multiple years of trial data, or 80-100 kg/ha (Ansari, et al., 2015).

The trials were conducted with three replications, each in 16.6 m² plots. The sowing was carried out using the (15+15) x15 cm scheme, with each variety planted at a density of 22 plants per m². The seed germination rate for all the studied samples ranged between 97-98 %. The plant lodging until the end of the vegetation period averaged 4%. Yield data were calculated based on the average yield per plant in each replication within a 50 m² plot, which was then extrapolated to a per-hectare basis. Agronomic practices were carried out according to accepted agricultural standards, ensuring the normal growth and development of the plants. The studies were conducted in accordance with the methodology for state variety testing of agricultural crops (Methodology for State Variety Testing of Agricultural Crops, 1975).

The samples were evaluated based on the average data from five randomly selected plants in each replication. The local Talin-6 was used as a control variety. Measurements included the height of formation of the first node, plant height, erectness, the mass of the pods per plant, the mass of seeds per plant, and overall yield. The yield was calculated using the harvesting and weighing method. The profitability level of all the promising samples was also determined. The price of seed was set as 600 drams. The cultivating cost per hectare was also calculated. In the Ararat region, during the vegetation period, the plants were irrigated four times, while in the Gegharkunik region, cultivation took place under dryland conditions. The costs included expenses for irrigation, sowing, seed purchase, weed control, and harvesting.

The data were subjected to statistical analysis using the ANOVA method with a significance level of $P \leq 0.05$.

Results and discussions

The effect of different ecological conditions on yield and yield components of lentil has been investigated. The economically valuable data for the lentil samples in the conditions of the Ararat region, are presented in Table 1, while the data for the Gegharkunik region are shown in Table 2. According to the study results, among the plate-shaped samples, those with the best erectness were Flip 2006-4L, Flip 2007-3L, and Flip 2007-30L (Table 1), while in the Gegharkunik region, only Flip 2007-3L exhibited notable erectness (Table 2). Overall, in the Ararat region, the plate-shaped samples were more erect than in the Gegharkunik region.

The plant height in both regions ranged from 31 to 56 cm. In Ararat Marz, plate-shaped samples were 2-11 cm taller than the standard. The tallest were Flip20064L (11 cm taller) and Flip20610L (2 cm taller). Only Flip2007-3L was shorter than the control. Drought-resistant samples, like BILSEN-365, surpassed the control by 3 cm in plant height. The early-maturing sample Sellfrom 767L had a height similar to the control, with no significant difference. Other samples were 7-14 cm shorter, with Flip2006-79L being the shortest. Frost-resistant samples were 5 cm taller than the control, except for Flip2003-30L, which showed no significant difference. In Gegharkunik Marz, plant height of all plate-shaped samples was similar to that of Ararat Marz, except for Flip2007-3L, which was 5 cm shorter than in Ararat Marz and 7 cm shorter than the control. Height differences were only observed in frost-resistant samples Flip2007-26L and AKM-46, which were 2-3 cm shorter in Gegharkunik Marz compared to Ararat Marz.

Table 1. Economically valuable traits of lentil samples in the conditions of the Ararat region*

Samples	Erectness, unit	Height, sm		Per plant, g		Yeild, g/m^2
		plants	formation of first pods	pods mass.	grains mass	
Talini 6 (control)	3	45±0.3	20±0.1	4.7±0.3	4.4±0.2	198±1.4
Plate shape						
Flip2007-15L	3	50±0.3	19±0.2	4.6±0.1	4.2±0.3	189.0±1.2
Flip2007-12L	4	48±0.2	25±0.1	5.6±0.2	5.2±0.1	234.2±1.3
Flip2006-4L	5	56±0.3	25±0.1	5.1±0.5	4.8±0.1	216.0±0.9
Flip2006-10L	4	47±0.4	9.5±0.2	4.8±0.1	4.5±0.4	202.1±0.6
Flip2007-15L	5	43±0.3	18±0.1	6.8±0.1	6.5±0.3	292.2±2.2
Flip2007-30L	5	55±1.1	28±0.2	6.6±0.2	6.3±0.4	283.2±1.4
$LSD_{0.05}$		1.2	1.5	0.2	1.4	4.2
Drought-resistant						
BILSEN-365	4	48±1.1	25±0.1	4.9±0.3	4.6±0.5	207.2±1.3
EP-54	5	43±0.2	12±0.1	6.8±0.1	6.1±0.2	274.4± 2.1
$LSD_{0.05}$		2.1	2.2	2.1	1.1	21.4
Early-maturing						
Flip2005-42L	5	32±0.9	11±0.1	3.3±0.2	2.8±0.2	126.1±1.2
Flip2005-53L	4	38±0.5	12±0.2	3.6±0.3	3.0±0.2	135.3±1.7
Sellfrom 1767L	5	44±1.2	9±0.1	6.2±0.2	5.5±0.2	247.2±2.1
Flip2006-79L	5	31±1.4	13±1.3	4.6±0.1	4.1±0.2	184.1±1.4
LSD0.05		1.2	1.1	0.4	0.3	3.2
Frost-resistant						
Flip2003-30L	5	44±0.4	20±1.1	4.4±0.1	4.1±0.4	184.2±2.1
Flip2007-26L	5	50±0.3	33±1.0	2.5±0.1	2.1±0.2	115.2±2.5
AKM-46	4	50±0.5	12±1.3	2.8±0.1	2.6±0.2	115.2±1.2
Flip 2005-25L	5	50±0.4	27±0.8	2.6±0.1	2.2±0.3	119.6±1.2
$LSD_{0.05}$		2.4	1.5	0.6	0.8	4.2

*Composed by the author.

For the mechanical harvesting of lentils, one of the key indicators is the height of formation of the first node.

In the Ararat region, the first node height ranged from 9.0 to 33 cm, with the highest in Flip2007-26L and the lowest in Sellfrom 1767L. In Gegharkunik Marz, the first node ranged from 9.5 to 30 cm. Most drought-resistant and plate-shaped samples formed pods at similar heights in both regions, except Flip2007-3L, which formed pods 6 cm higher in Gegharkunik. Early-maturing Sellfrom 1767L formed pods 3 cm higher, while frost-resistant Flip2007-26L formed pods 3 cm lower in Gegharkunik.

In the Ararat region, pod mass per plant ranged from 2.5g to 6.8g. Plate-shaped samples exceeded the control by 0.4g to 2.1g. The heaviest pods were in Flip2007-3L and drought-resistant EP-54 (6.8 g). Sellfrom 1767L, an early-maturing sample, surpassed the control Talini 6 variety by 1.5 g in pod mass per plant. Frost-resistant samples had a pod mass per plant of 2.5g to 4.4 g, which was 0.3g to 2.2g lower than the control.

In the Gegharkunik region, pod mass per plant ranged from 1.7 g to 8.8g, with plate-shaped samples exceeding the control by 1.6g to 3.3g, except for Flip2007-15L (2.5 g lighter) and Flip2006-10L (equal to control). Drought-resistant samples had a pod mass 2.3g to 3.1g heavier than the control variety Talini 6. Early-maturing samples Flip2005-42L and Sellfrom 1767L surpassed the control by 1.1g and 0.6g, respectively. Pod mass in all frost-resistant samples was lighter than the control.

Table 2. Economically Valuable Traits of Lentil Samples in the Conditions of the Gegharkunik Region*

Samples	Erectnes, unit	Height, sm.		Per plant, g		Yeild, g/m^2
		plants	of formation first pods	Pods mass.	Grains mass	
Talini 6 (control)	4	45±0.9	19±1.0	5.5±0.2	5.0±0.1	230±1.5
Plate shape						
Flip2007-15L	4	50±0.8	19±0.8	3.0±0.4	2.6±0.2	117±2.2
Flip2007-12L	3	48±0.5	25±0.5	7.1±0.1	6.6±0.2	297±1.7
Flip2006-4L	3	56±1.1	25±0.7	8.1±0.3	7.5±0.5	337±1.1
Flip2006-10L	4	47±0.9	9.5±0.5	5.5±0.4	5.0±0.2	230±1.2
Flip2007-3L	5	38±0.3	24±0.7	8.8±0.2	7.6±0.1	342±1.5
Flip2007-30L	4	55±03	28±0.7	8.4±0.2	7.4±0.2	331±1.1
$LSD_{0.05}$		0.6	2.1	1.2	1.8	5.4
Drought-resistant						
BILSEN-365	4	48±03	25±1.2	7.8±0.7	7.4±0.1	333±1.4
EP-54	5	43±03	12±1.0	8.6±0.4	7.8±0.2	351±1.75
$LSD_{0.05}$		1.0	1.4	0.5	0.6	8.2
Early-maturing						
Flip2005-42L	5	32±0.4	11±0.2	6.6±0.4	5.0±0.3	225±1.2
Flip2005-53L	4	38±1.0	12±0.1	4.8±0.3	4.0±0.2	180±2.4
Sellfrom1767L	5	44±0.8	12±0.3	6.1±0.2	5.7±0.4	259±3.2
Flip2006-79L	5	31±0.7	13±0.1	5.1±0.2	4.8±0.2	202±1.2
$LSD_{0.05}$		1.2	0.5	0.3	1.1	15.2
Frost-resistant						
Flip2003-30L	5	44±07	20±0.3	5.1±0.3	4.6±0.1	207±3.2
Flip2007-26L	5	48±0.5	30±0.5	1.7±0.2	1.6±0.1	72±1.2
AKM-46	4	47±0.8	14±0.2	2.8±0.1	2.6±0.3	117±2.3
Flip2005-25L	5	50±0.5	27±0.3	3.1±0.1	2.9±0.2	130±3.0
$LSD_{0.05}$		2.2	4.1	0.9	0.2	10.2

*Composed by the author.

There is a direct correlation between pod mass and grain mass per plant. In the Ararat region, only Flip2007-15L from plate-shaped samples had lighter grains, while others were 0.3g to 2.1g heavier than the Talini 6 variety. Per heavy grains mass drought-resistant samples and early maturing sample Sellfrom 1767L were selected.

In the Gegharkunik region, grain mass per plant ranged from 1.6g to 7.6g. Plate-shaped samples exceeded the control by 1.6g to 2.6g, except for Flip2007-15L (2.4g lighter) and Flip2006-10L (equal to control). Drought-resistant samples had 2.4g to 2.8g heavier grain mass than the control Talini 6, while early-maturing Sellfrom 1767L surpassed the control by 2.4g. All frost-resistant samples had lighter grain mass than the control.

In the Ararat region, the highest yields were obtained from the plate-shaped samples Flip 2007-3L, Flip 2007-30L, and Flip 2007-12L, which surpassed the control variety by 1.4, 1.4, and 1.2 times, respectively. The drought-resistant sample EP-54 also outperformed the control variety by 1.3 times (Table 1).

Table 3. Economic Efficiency of the Studied Lentil Varieties in the Climatic Conditions of the Gegharkunik and Ararat Regions*

Sample	Marketable yield, q/ha	Income, thousand drams	Production costs, per ha (thousand drams)	Cost price per 1 kg, drams	Net profit, thousand drams	Profitability level, %
Gegharkunik Region						
Talini 6 (control)	23.0	1380	372	161.7	1008	271.0
Plate shape						
Flip 2007-30L	33.1	1986	385	116.3	1601	415.8
Flip 2007-3L	34.2	2052	400	116.9	1652	413.0
Flip 2007-12L	29.7	1782	378	127.2	1404	371.4
Flip 2006-4L	33.7	2022	385	114.2	1637	425.2
Drought-resistant						
EP-54	35.1	2106	410	116.8	1696	413.7
Bilsen365	33.3	1998	385	115.6	1613	419.0
Early-maturing						
Sellfrom1767L	25.9	1554	380	146.7	1174	308.9
Ararat region						
Talini 6(control)	19.8	1188	447	225.7	741	165.8
Plate shape						
Flip 2007-30L	28.3	1698	475	167.8	1223	257.5
Flip 2007-3L	29.2	1752	453	155.1	1299	286.8
Flip 2007-12L	23.4	1404	460	196.6	944	205.2
Flip 2006-4L	21.6	1296	485	224.5	811	167.2
Drought-resistant						
EP-54	27.4	1644	480	175.1	1164	242.5
Bilsen365	20.7	1242	455	219.8	787	173.0
Early-maturing						
Sellfrom1767L	24.7	1482	460	186.2	1022	222.2

*Composed by the author.

The drought-resistant EP-54 sample stood out for its high yield, surpassing the control variety by 2.6 times in the Ararat region and by 1.3 times in the climatic conditions of the Gegharkunik region. The first node of the EP-54 sample formed at a lower height in both regions compared to the tested BILSEN-365 sample, but it exceeded the control variety in terms of pod and seed mass.

The early-maturing Sellfrom1767L sample provided higher yields than the control variety in the climatic conditions of the Gegharkunik region, producing 1.2 times higher yield than in the Ararat region. The Sellfrom1767L sample also surpassed the control variety in terms of pod and seed mass per plant.

In the Gegharkunik region, the Flip 2007-3L sample provided 1.1 times higher yield than that of in the climatic conditions of the Ararat region.

As seen from the data in the table, lentils in the conditions of the Gegharkunik region provide a high level of profitability, which ranges from 308.9 % to 425.2 %, exceeding the control variety by 37.9 % to 154.2 %. In the climatic conditions of the Ararat region, the profitability level ranged from 167.2 % to 286.8 %. The highest profitability in Gegharkunik regions was provided by the Flip 2006-4L sample ,in Ararat region Flip 2007-3L.

Conclusion

The study results conclude that ecological conditions significantly impact the economically valuable traits of the samples. In the Gegharkunik region, conditions are more favorable for lentil samples than in the Ararat region, highlighting the importance of selecting more adaptive samples for each region.

Based on the findings, the lentil varieties Flip2007-3L, Flip2007-12L, and Flip2006-4L are recommended for further breeding programs due to their high yield and favorable economic returns in both the Ararat and Gegharkunik regions. Drought-resistant variety EP-54 and early-maturing Sellfrom1767L also showed promising results, particularly for areas with limited irrigation resources. The study emphasizes the importance of selecting varieties that are well-adapted to local climatic conditions to maximize both yield and profitability.

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Declarations of interest

The author declare no conflict of interest concerning the research, authorship, and/or publication of this article.

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