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Determination of qualitative and quantitative characteristics of some lentil cultivars under organic farming conditions

Burak Önol

Department of Field crops, Faculty of Agriculture, Ankara University, 06110 Dışkapı, Ankara, Türkiye.
Corresponding author's e-mail: burakonol@gmail.com

The increasing population of the world is demanding enhanced agricultural production to fulfill the nutrient requirement of the growing population. However, higher inputs are required to get maximum agricultural production that is resulting higher prices of agricultural products. Therefore, organic farming could be alternative to fulfill the nutrient requirement of the common people with low inputs. Organic farming concepts use environment-friendly practices with low external inputs. The study aimed to check the performance of organically grown four lentil cultivars, namely Eure 20, Sazak 91, Kayı 91, and Sultan 1, to check if their performance was at par with the traditionally grown lentils. The results confirmed that the four genotypes had a high potential for adaptation in the organic farming system.
Keywords: Breeding, lentil, life quality organic farming, rainfed, seeds, yield.

INTRODUCTION

Hunger and the problem of providing a balanced diet to the people are increasing rapidly in parallel to limited production resources and increased pollution due to socio-cultural, and economic factors, increased greenhouse gasses resulting in adverse effects of climatic conditions (Magrini *et al.*, 2016, Fróna *et al.*, 2019). Consumption of lentils and their use in various diets is suggested among the top sustainable diets, which are suggested as a source of improving public health and their consumption is highly beneficial among health-conscious vegetarian societies (Duarte *et al.*, 2020). Lentil (*Lens culinaris* Medik.) was produced in Mesopotamia and Greece before 6000–5000 BCE (Hopf *et al.*, 1962). Lentil could provide and act as a source of a balanced diet with high nutritional value in terms of protein, energy, vitamins, and minerals (Migliozzi *et al.*,2015, Wallace *et al.*,2016). Lentil dried grains contain high protein (18-31.6%) depending on the species, genotype, environmental conditions, and growing models (Erman, 2021). These proteins contain valuable amino acids, vitamins A, B, C, and D, and minerals such as iron, magnesium, calcium, phosphorus, and potassium (Margier *et al.*,2018). Therefore, it could act as an important crop for organic agriculture. In addition to the nutrients, lentils have important effects in improving soil structure in terms of 5-20% nitrogen fixation and soil fertility (Alkharabsheh *et al.*, 2021). They also improve the soil's physical properties, such as aeration and water transmission (Torabian *et al.*, 2019). Therefore, it can be used as a plant in many crop rotation systems (Muehlbauer *et al.*, 2002).

Lentil is cultivated as a rainfed crop with an average yield of 1·03-1.9 t/ha (Prasai *et al.*, 2018, Islam *et al.*, 2019). There is a need to grow lentils using an organic farming system (Wolfe *et al.*, 2008) to improve the human lifestyle. Most of the lentil cultivars grown in the current organic agricultural system were bred through high-input breeding programs based on traditional farming systems. It is established that these cultivars produce lower yield adaptability in organic farming systems (Stanhill *et al.*, 1990, Kraska *et al.*, 2019). The major issue to be settled in organic farming systems is whether they are equally appropriate for traditional and organic farming systems (Burger *et al.*, 2008) or have an edge (Murphy *et al.*, 2007).

There is a consensus that the performance of lentil cultivars is genotype-dependent and may behave variably under different environmental conditions.

The main aim of the current study was to find the adaptability of 4 lentil cultivars bred under traditional breeding systems for morphological behavior of the crop as a low-input rainfed organic crop at Çubuk Ankara, Türkiye.

MATERIALS AND METHODS

***Seed material*:** Emre 20, Sazak 91, Kayı 91, and, Sultan 1 lentil cultivars were used in the study. They were obtained from the Field Crops, Central Research Institute, Yenimalhalle Ankara, Türkiye.

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Description of the experimental area**:** This experiment was conducted at a private organic farm (certificate No. MSR-3595-valid from 07.04. 2020) located at Eğriekin village of Çubuk county Ankara Turkiye (40.25 N, 32.97 E) during 2020, 2021.

Meteorological data**:** The data about monthly average air temperature (°C), monthly total precipitation (mm=kg/m²), monthly average relative humidity (%), monthly average sunshine duration (hours), and monthly average actual pressure (hPa) for the year for May to August 2020 and 2021 was taken from the directorate of Meteorology and belonged to the Ankara Esenboğa Airport, which lies at a distance of about 10 km from the study area. The data is given as a total monthly average.

Soil analysis**:** The soil structure of the organic farm was taken by collecting 4 random samples at depth of 30 cm. These were mixed thoroughly and sent for analysis to the Soil and Plant Nutrition Department of Ankara University for analysis.

No crop was sown in the experimental area for at least 20 years. The soil was plowed followed by the pulling of the cultivator. The experiments were set up during 2020-2021 with 3 replications, based on split plots divided into randomized blocks. The planting time (years) was the main factor, and the cultivars were the sub-factors. The size of each experimental plot was 7.60 ×5 m. The seeds of 4 cultivars were sown using a dibbler after maintaining an inter-row distance of 30 cm and plant distance of 20 cm. The seeds were sown at a depth of 1.5 to 2 cm below the soil on 1.5.2020 and 03.5.2021. No fertilizer and irrigation were applied to the plots. Each cultivar was separated by a distance of 100 cm. The data of external rows was not taken to avoid the margin effects.

No chemical fertilizer was added to any plot except the organically produced poultry fertilizer mixed with the soil using a scratch rake.

The following parameters were measured

1. Number of days to seedling emergence
2. Plant height (cm)
3. Number of days to first flowering
4. Number of days to pod formation
5. Number of seeds per pod
6. Number of days to pod maturity
7. Height of first bean (cm)
8. Number of branches per plant
9. 1000 seed weight (g)
10. Protein %
11. Yield (kg/ha)

Statistical analysis**:** The data obtained from the study were subjected to analysis of variance by the factorial experimental design in randomized blocks, and the grouping of the means was made according to the LSD test. IBM SPSS 26 computer package program was used in the calculation of statistical analysis.

RESULTS AND DISCUSSION

Meteorological data of the experimental area for 2020, 2021, and long years is given in Table 1. The temperature data for 2020, showed the minimum and maximum temperatures of 14.8 and 23.9 ˚C during May and July 2020. The minimum and maximum temperatures of 15.1 and 23.5 ˚C during May and July of the next year (2021). Long year's temperature data showed a minimum temperature of 14.1 C during May and a maximum temperature of 21.7 C during July and August. Long years temperature data showed decreased temperature compared to the general trend during 2020 and 2021.

The precipitation data showed the highest average precipitation of 1.16 mm during May and no precipitation during August 2020. Whereas, during 2021, the highest average precipitation of 1.28 mm and no precipitation during July was noted. The long years maximum and minimum precipitation range was 0.43 (for August) and 1.6 mm during August in the same order. The precipitation during the 2020-21 period was higher compared to the long year's average precipitation.

Table 1. Meteorological observations of the experimental area from May to August 2020, 2021, and Long years.

Average temperature (°C)	Year	**May**	**June**	**July**	**August**
	2020	14.8	18.6	23.9	23.2
	2021	15.1	18.5	23.5	22.8
	Long years	14.1	18.0	21.7	21.7
Total monthly Precipitation (mm=kg/m^2)	2020	1.16	1.39	0.05	0.00
	2021	1.23	1.28	0.08	0.00
	Long years	1.60	1.23	0.46	0.43
Monthly average relative humidity (%)	2020	56.7	59.7	45.7	38.1
	2021	59.1	60.9	45.2	38.2
	Long years	64.1	59.3	50.3	49.5
Monthly average sunshine duration (hour)	2020	8.30	8.80	11.4	10.6
	2021	8.40	9.10	11.1	10.9
	Long years	8.10	9.90	11.2	10.8
Monthly average air pressure (hPa)	2020	907.0	904.0	904.5	904.5
	2021	906.2	905.3	904.7	904.6
	Long years	905.8	905.7	904.9	905.6

Source: Directorate General of Meteorology Ankara, Turkiye

The monthly average relative humidity data showed the highest average relative humidity percentage of 59.7% during June and the minimum precipitation of 38.1% during August 2020. Whereas, in 2021, the highest average relative humidity of 60.9 and lowest relative humidity of 38.2% were noted during August 2021. The long years' maximum and minimum relative humidity were noted as 64.1 and 49.5% during May and August in the same sequence. The monthly average relative humidity of long years was higher than the average relative humidity of any month during –May-August period of 2020, and 2021. The monthly average relative humidity of long years was higher than the average relative humidity of any month during –May-August period of 2020 and 2021.

The monthly average sunshine duration during 2020 and 2021 ranged from 8.3 - 11.4 h and 8.4 -11.1 h respectively. The minimum and maximum sunshine duration were noted during May and July 2020 and 2021 in the same order. Whereas, in long years, the monthly average sunshine duration was 8.1 to 11.2 h during Mayıs and July respectively. The monthly average sunshine duration for long years was almost identical to the 2020 - 21 period.

The Average Air Pressure of the trial site showed the highest, and the lowest Average Air Pressure of 904 - 907 hPa was noted during 2020. Average Air Pressure of 904.6 - 906.2 hPa was noted in 2021. Average Air Pressure for long years remained at 904.9 to 905.8 hPa.

Soil analysis: The soil was made up of 58.02% sand, 21.00% clay, 20.98% silt. The soil had pH of 7.35 (mild saline), low EC value of 0.05 dS/m, 0.70% lime, low (2.40 %) organic matter, low (0.128 %) Nitrogen, appropriate (10.40 mg/kg) Phosphorus and high (166 mg/kg) Potasium (Table 2).

Table 2. Soil characteristics of the experimental area.

Soil structure	58.02% sand 21.00% clay 20.98% silt
pH	7.35
EC (dS/m)	0.05
Lime%	0.70
Organic matter%	2.40
Nitrogen%	0.128
Phosphorus mg/kg	10.40
Potassium mg/kg	166.00

Source: Department of Soil and plant nutrition, Ankara University, Ankara, Turkey

***Morphological and yield parameters number of days to seedling emergence*:** The number of days to seedlings emergence ranged from 11.37 d for cv. Kayı 91 to 13.51 d for cv. Sultan 1 during 2020 and 13.24 d for cv. Kayı 91 to 16.25 d for cv. Sazak 91 during 2021 (Table 3). The seed germination was independent of genotypes and was mainly affected by the amount of moisture in the soil and soil temperature. 1.16 mm and 1.23 mm precipitation was noted at or after sowing during 2020 and 2021 respectively before seedling emergence.

These affected the rate of seed germination and seedling emergence (Yıldız, 2020) also observed similar results for *Phacelia tanacetifolia*. The researcher noted that the soil, surface temperature, and soil moisture are the main parameters that affect seed germination and seed emergence from the soil.

***Plant height*:** The Plant height of the cultivars was affected by the soil and meteorological conditions and ranged from 28.2 (Kayı 91)-33.48 cm for cv. Sazak 91 during 2020. It ranged 31.46 (Emre 20) -34.99 cm for cv. Sazak 91 during 2021 (Table 3).

The plant height was genotype-dependent and was slightly affected by the meteorological conditions. High temperature, precipitation, and moisture level affected the plant growth in 2020 and 2021. These affected growth and achieving plant height. Lentil is a quantitative long-day species (Summerfield *et al.,*1985), besides genotypes, plant growth was fully or partially dependent on the environmental conditions (Bhat, et al 2020).

***Number of days to first flowering*:** The number of days to first flowering or vegetative period of growth are very important in the growth cycle of the plants (Table 3). They affect the subsequent generative growth period and yield. As most of photosynthesis occur during this period. The vegetative growth period of cultivars showed significant differences among cultivars. The results showed that each of the cultivars had its genotype-dependent specific growth period influenced by the meteorological conditions and the soil characters. The vegetative growth period from seed emergence ranged 79.37 cm for cv. Kayı 91 to 85.54 d for cv. Sultan 1 during 2020 and 82.15 d to 86.31 d for cv. Sultan 1 during 2021 (Table 1). High temperature, precipitation and moisture level affected the plant growth during 2020 and ended up increasing the vegetative growth period. Vegetative growth is influenced by the rate of photosynthesis and an improved photosynthesis rate increases total nitrogen uptake and nutrient accumulation in the plants as approved by Sinclair, *et al.,* (2019). These cultivars showed consistent,

Table 3. A comparison of different mophological and yield parameters during 2020 and 2021 in organic farming system (part 1).

Cultivars	Number of days to seed emergence		Plant height (cm)		Number of days to first flowering		Number of days to pod formation		Number of seeds per pod		Number of days to pod maturity	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
Emre 20	12.04b	13.35c	30.35b	31.46b	82.12b	85.58b	72.14c	73.31d	1.88a	1.93a	81.33c	87.55c
Sazak 91	12.33b	16.25a	33.48a	34.99a	83.17b	85.66b	83.26b	84.23b	1.45b	1.61b	93.35b	95.43b
Kayı 91	11.37c	13.24c	28.22c	31.84b	79.37c	82.15c	83.33b	83.65c	1.39c	1.54b	96.47a	97.52a
Sultan 1	13.51a	15.37b	30.46b	32.36b	85.54a	86.31a	84.37a	85.54a	1.41b	1.50b	95.99a	97.12a

accelerated flowering in response to long-day conditions during two experimental years with significantly different flowering times suggesting that flowering is strictly under the control of genotypes.

***Number of days to pod formation*:** Number of days to pod formation or 1st generative growth period have significant importance in the life cycle of the lentils (Table 3). They affect the yield of plants. The generative growth period of cultivars showed significant variations among cultivars. The results indicated that the generative phase of 4 cultivars was genotype-dependent with a specific generative growth period influenced by the temperature, relative humidity, and precipitation mildly influenced by the soil structure and its fertility level. The generative growth period from seed emergence changed from 72.14 d for cv. Emre 20 to 84.37 d for cv. Sultan 1 during 2020 and 73.31 d for Emre 20 to 85.54 d for cv. Sultan 1 during 2021 (Table 1). Although, the generative growth period of each cultivar was mainly genotype-dependent, they were affected by environmental parameters like drought, precipitation and temperature (Jorge *et al.*,2019). Water availability in lentils (*L. culinaris*) affects pod formation during the generative growth period (Jorge *et al.*, 2019).

***Number of seeds per pod*:** Number of seeds per pod ranged from 1.39 for cv. Kayı 91 to 1.88 for cv Sazak 91 during 2020 (Table 3). A slight increase in the seeds per pod was noted for 2021 and ranged from 1.50 for cv. Sultan 1 to 1.93 for cv Emre 20. Although, the number of seeds per pod is mainly genotype-dependent, they showed the effects of the environment like precipitation and temperature (Mclean *et al.*,1974) on pod formation.

***Number of days to pod maturity*:** Number of days to pod maturity or 2nd phase of generative period from emergence is an important parameter to measure the performance of genotypes under study (Table 3). The experimental data shows that the four genotypes took 81.33 d for Emre 20 to 96.47 d for Kayı 91 from emergence to maturity during 2020 and 87.55 d for Emre 20 to 97.52 d for Kayı 91 during 2021. The days from emergence to maturity showed that this parameter was purely genotype-dependent with induced plasticity due to environmental factors (Mclean *et al.*,1974, Jorge *et al.*, 2019). The genotypes were very stable in this parameter.

***Height of first bean (cm)*:** Different cultivars are affected variably by the height of first bean induction which is purely genotype-controlled character (Table 4). The height of the first bean from the soil surface changed from 12.21 cm for cv. Sultan 1 to 15.26 cm for cv. Sazak 91 during 2020. It ranged 13.20 cm for cv Sultan 1 to 15.24 cm for cv. Sazak 91 during 2021. The height of the first bean is a genotype-dependent factor (Albay, 2019) and showed variable height as affected by the environment.

***Number of branches per plant*:** Number of branches per plant ranged 3.24 for cv. Emre 20 - 3.61 for Sultan 1 during 2020 (Table 4). These branches induced differently during 2021 with a range of 3.42 for cv. Sazak 91 to 3.82 for cv. Sultan 1. The number of branches per plant is a genotype-dependent factor (Albay, 2019) and show variability in response to the prevalent environment.

***1000 seed weight (g)*:** The results of the study showed that the four cultivars had significantly different 1000 seed weights (Table 4). The seed weight ranged 32.57 g for cv. Sazak 91 to 59.98 g for Kayı 91 during 2020. These were affected by the environmental changes and changed from 33.27 g for Sazak 91 to 62.43 for cv. Sultan 1 during 2021. The 1000 seed weight is a genotype-dependent factor (Albay, 2019) that shows changes in response to the environment where grown.

***Protein %*:** The results of the study showed that the four cultivars had significantly different protein percentages (Table 4). The protein % ranged 25.00% for Emre 20 to 28.21% for cv. Sazak 91 during 2020 and 25.70% for Emre 20 to 34.33% for cv. Sazak 91 during 2021. The protein % is a genotype-dependent factor (Albay, 2019) that responds variably with little plasticity to environmental stress.

***Yield*:** The results of the study showed that the four cultivars had significantly different yields over two years (Table 4). The yield of 820.51 kg/ha for Emre 20 to 1243 kg/ha for cv. Kayı 91 during 2020 and 880.16 kg/ha to 1330 kg/ ha for Kayı 91 during 2021. However, the genotype was the main source of variation during 2020 and 2021 among the cultivars (Mclean *et al.*,1974, Jones *et al.*, 2010, Albay, 2019, Jorge *et al.*, 2019) also support the observations. They emphasize that superior genotypes should be selected for organic agriculture depending on specific environmental conditions (Nath *et al.*, 2014, Gahoonia *et al.*, 2006, Vlachostergios *et al.*, 2011). The effectiveness of single-plant selection at low density under an organic environment as nutrient management is the main

Table 4. A comparison of different mophological and yield parameters during 2020 and 2021 in organic farming system (part 2).

Cultivars	Height of first bean (cm)		Number of branches per plant		1000 seed weight (g)		Protein%		yield (kg/ha)	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
Emre 20	12.34c	13.33b	3.24c	3.58b	34.52b	36.21b	25.00b	25.7d	820.51c	880.16c
Sazak 91	15.26a	15.24a	3.33b	3.42b	32.57b	33.27b	28.21a	34.33a	1067.60b	1099.31b
Kayı 91	14.39b	13.83b	3.42b	3.62b	59.98a	61.78a	27.81a	29.21b	1200.43a	1330.11a
Sultan 1	12.21c	13.20bc	3.61a	3.82a	59.41a	62.43a	26.86a	27.37c	960.81b	980.38b

issue where hard and tolerant genotypes could survive (Debaeke *et al.*, 2021).

A comparison of the cultivars showed that the 4 lentil cultivars were equally suitable for cultivation under an organic farming system; however, their performance was genotype-dependent with plasticity dependent on environmental conditions without considerable loss in yield. It was further concluded and suggested that selection of superior genotypes for organic farming systems should be preferred as they have better adaptability under different climatic conditions.

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Conflict of interest**:** There is no conflict of interest between the author with any other person.

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