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EFFECTS OF ORGANIC AND INORGANIC FERTILIZERS ON YIELD AND YIELD COMPONENTS OF BARLEY

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Abstract: This study aimed to assess the impact of various organic and inorganic fertilizers on the yield and yield components of barley varieties. The research was conducted in the greenhouse of the Faculty of Agriculture of Dicle University in 2019-2020. Two barley varieties, Keçiburcu (six rows) and Önder (two rows), and 15 types of organic and inorganic fertilizers were used in this study. All organic fertilizers used in the study were applied at sowing, solid fertilizers were incorporated directly into the soil, and liquid fertilizers were diluted with water and then applied to the soil. Among the fertilizers used in this study, conventional fertilizer (1.48 g/plant) and sheep manure (1.05 g/plant) showed positive effects on grain yield and other traits. As a result, plants benefit from chemical fertilizers in a shorter period because they are absorbed and used more quickly than chemical fertilizers, which are part of traditional agriculture. In addition, organic fertilizers have a positive effect on plant development. For organic barley production, sheep manure is recommended, which yields results similar to those of conventional fertilizers.

Keywords: Barley, Conventional, Fertilizer, Organic, Yield

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1. Introduction

Barley, a member of the Poaceae family, was one of the first crops cultivated. Barley, which is an annual cereal, was initially used more for human consumption, but with the increase in the consumption of wheat and rice, its use as an animal feed and raw material for malt and beer has become more widespread. Barley is the fourth most important cereal in the world after wheat, maize, and rice. While the world barley production is 152 million tons, 5% of barley production is for human consumption, 67% for animal consumption, and 21% for the malting industry (FAO, 2022). Türkiye's barley production is 8.5 million tonnes, of which 86% is for animal feed and 14% for the malting and food industries (TÜİK, 2022).

In Türkiye, barley yield is generally reduced by factors such as decreasing agricultural land, lack of cultural practices, incomplete and incorrect fertilization, and inappropriate variety selection (Şener et al., 2020). Fertilization is an important factor in improving crop quality, reducing crop development time, and improving soil quality (Demirsoy and Aydın, 2020). The use of fertilizers is one of the most important reasons for the 50-75% increase in crop yield. Globally, there is a direct relationship between crop yield and fertilizer use (Polat, 2020). It has been reported in various sources that the unconscious and excessive use of chemical fertilizers in agricultural production from the past to the present has caused the soil organic matter content to decrease over time, which is harmful to soil organisms and human health (Karagöz, 2014; Aydın Can et al., 2019; Bozkurt, 2019). However, the use of organic fertilizers has been reported to increase soil organic carbon and soil fertility, resulting in higher yield trends compared to balanced chemical fertilizers (Zhang et al., 2014; Scaglia et al., 2016).

Organic fertilizers are obtained from different types of animal and plant wastes, such as compost, farm manure, barn manure, and green manure (Demirtaş et al., 2005). According to previous studies, organic fertilizers contain organic components and many beneficial microorganisms, along with plant nutrients (Soba, 2012). Alagöz et al. (2006) investigated the effect of organic matter addition on some chemical and physical properties of soil and reported that leonardite material applied at three different doses had an increasing effect on pH, organic matter, and total N content of soils. The effects of humic acid and different application on plant growth and nutrient uptake have been examined by researchers (Kolsarıcı et al., 2005; Demirkıran and Cengiz, 2010). Yılmaz and Alagöz (2005) investigated the effects of liquid humic acid application on aggregate formation and stability in soils, and reported that the liquid humic acid material used had 0.30% total N, 0.17% organic N, 0.41% CaO, 15% humic and fulvic acid, and 6.5% pH. Arslan (2021) reported that bat manure applied to the soil at different doses showed positive increases in plant height, plant fresh and dry weight, root fresh and dry weight, root length, chlorophyll content, and some microbiological characteristics of the root zone in barley and lentil. Altıntaş et al. (2005) emphasized that

organic and nutrient deficient soils can be made more fertile with the supplementation of bat manure.

Vermicompost, another source of organic fertilizer, facilitates nutrient uptake by plants, has a porous structure, good aeration, high water-holding capacity, and microbial effects (Yılmaz et al., 2017). Chicken manure, such as vermicompost, is an environmentally friendly, economical, and good soil conditioner that makes plants resistant to diseases (Bellitürk, 2016). Another preferred practice to increase the yield and quality of low-fertility soils is the addition of barnyard manure to the soil (Akkaya and Kara, 2018). Barn manure application increases the microbial activity of soil, improves its physical properties, and increases its water-holding capacity (Karayel et al., 2020). In addition, most plant nutrients in barnyard manure are in a water-soluble form that the plant can take up with its roots (Soyergin, 2003). This study aimed to determine the effects of different organic and inorganic fertilizers on the yield and yield components of barley.

2. Materials and Methods

This study was conducted in a greenhouse at the Faculty of Agriculture of Dicle University. The study used 15 organic and inorganic fertilizers and two barley varieties (Keçiburcu-6-row and Önder-2-row). The study was established on 05/12/2019 according to a randomized block design with four replications. The seeds of the varieties were sown in 8-litre pots with four plants in each pot. Table 1 lists the physical and chemical characteristics of the soils used in this study. All fertilizers (solid and liquid) used in this study were applied to pots with sowing. Solid fertilizers were mixed directly into the soil, while liquid fertilizers were diluted with water and applied to the soil. A control group, without fertilizer, was used to compare the fertilizer applied. The organic fertilizers used in this study and their contents are listed in Table 2. The temperature and humidity values under the greenhouse conditions are shown in Figure 1.

Table 1. Some physical and chemical properties of the soil used in the study

Saturation (%)	Salinity (dS/m)	Salt (%, TS 8334)	pH Degree	Lime (%)	Organic Matter (%)	Nitrogen (%)	Phosphorus (ppm)
63.00	0.92	0.04	8.11	11.24	0.71	0.04	4.00
Clay Loam	Without Salt	Without Salt	Light Alkaline	Middle	Low	Low	Low
Potassium (ppm)	Calcium (ppm)	Magnesium (ppm)	Sodium (ppm)	Iron (ppm)	Copper (ppm)	Manganese (ppm)	Zinc (ppm)
314.45	10717.9	471.78	26.65	9.29	1.61	16.5	0.08
High	Very High	Middle	Low	Very High	Middle	Middle	Low

Table 2. Fertilizer sources and contents used in the study

Code	Fertilizer Sources	Advised Dose	Given Fertilizer	Total Nitrogen (%)	Organic Content (%)
FS-1	Conventional Fertilizer (20-20-0)	12 kg/da	3.6 g/pot	20.0	-
FS-2	Commercial Organic Fertilizer-1	100-150 cc/100 lt water	1.5 ml/pot	2.0	30.0
FS-3	Commercial Organic Fertilizer-2	50-60 kg/da	1.2 g/pot	3.0	50.0
FS-4	Commercial Organic Fertilizer-3	50-60 kg/da	1.2 g/pot	7.0	50.0
FS-5	Organic Compost	120-150 kg/da	3 g/pot	2.0	65.0
FS-6	Organic Seed Coating	1000-2000 cc/da	0.004 g/pot	3.0	30.0
FS-7	Raw Leonardite	50-75 kg/da	5 g/pot	1.35	40.0
FS-8	Processed Leonardite	40-60 kg/da	5 g/pot	1.30	40.0
FS-9	Liquid Vermicompost Fertilizer	1000-2000 cc/da	0.004 g/pot	0.80	10.0
FS-10	Liquid Seaweed Fertilizer	2-3 lt/da	0.06 g/pot	0.30	10.0
FS-11	Bat Guano	50-100 kg/da	2 g/pot	5.65	26.4
FS-12	Solid Vermicompost Fertilizer	2000-3000 g/da	2 g/pot	1.50	40.0
FS-13	Farmyard Manure	2 tons	40 g/pot	3.82	61.59
FS-14	Sheep Manure	2 tons	40 g/pot	4.98	68.30
FS-15	Chicken Manure	500 kg/da	10 g/pot	4.09	57.89

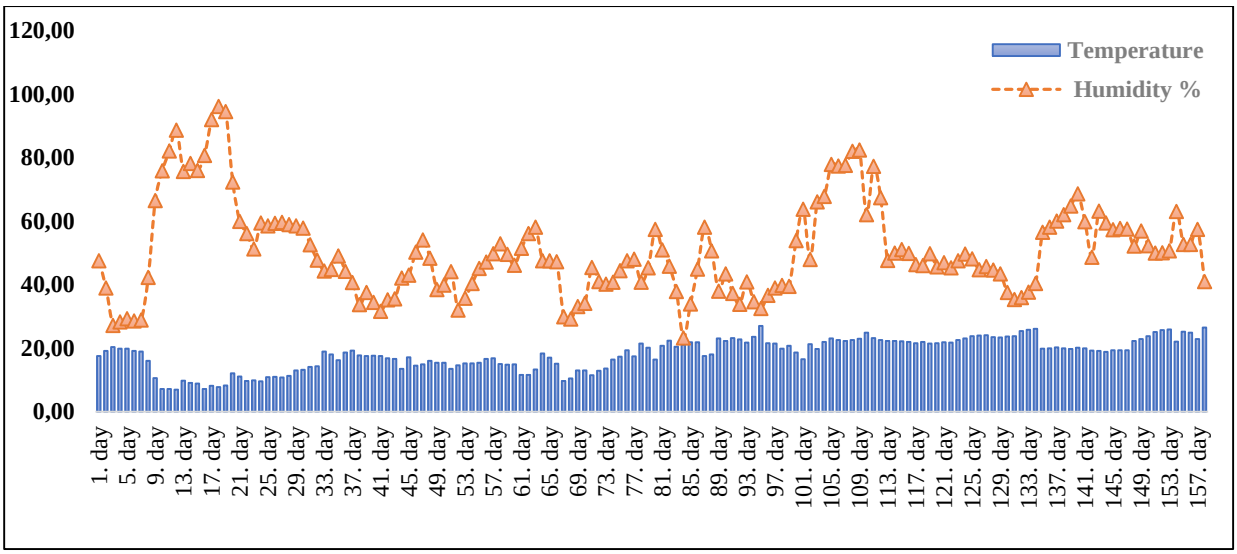


Figure 1. Temperature and humidity values for greenhouse conditions

A drip irrigation system was installed that could be controlled by timer solenoid valves. The traits measured in the study were heading time (days), plant height (cm), maturity time (days), stem diameter (mm), spike length (cm), number of spikelets per spike, number of grains per spike, grain weight per spike, grain yield (g/plant), and biomass (g/plant). The values of the study parameters were analyzed using the JMP Pro 13 statistical package, and statistical differences between the means were determined using the LSD test.

3. Results and Discussion

This study investigated the effects of 15 organic and inorganic fertilizers on the agronomic traits of Keçiburcu and Önder barley varieties grown under greenhouse conditions. The significance status of the traits investigated in the study and the mean values obtained are shown in the tables below.

When the effects of 15 different fertilizers on the heading and maturity times of barley cultivars were studied, no differences were observed between cultivars for maturity and heading time. Sheep manure on the Keçiburcu cultivar resulted in the earliest heading (90.67 days) and maturity (130.33 days) times. Notably, bat manure and processed leonardite delayed the heading and maturity stages of the genotypes (Figure 2-a and 2-b). Previous studies have reported values for days to heading varying from 55.3 to 61.0 days (Bayhan et al., 2022), 111.5 to 112.6 days (Özdemir et al., 2019), and 123.2 to 126.2 days (Akmaz, 2022). Similarly, days to maturity were reported in the range of 90.3 - 93.0 days (Bayhan et al., 2022) and 141.5 - 158.0 days (Akmaz, 2022). The values obtained in this study differ from those of previous studies, probably because of differences in the study conditions and application methods.

There were no significant differences in plant height between the varieties; however, fertilizer application resulted in increased plant height. The highest recorded plant height was obtained with sheep manure (87.00 cm). Among the fertilizer applications, commercial organic fertilizer-3 showed the highest value at 80.33 cm. Notably, processed leonardite, raw leonardite, organic compost, and bat manure did not have a significant effect on plant height (Figure 3-a). Plant height has been found to be affected by various factors such as environmental conditions, soil fertility, sowing density, and cultivar (Akıncı and Yıldırım, 2009; Yaraşır, 2018; Bayhan et al., 2019). Researchers have reported that in cool-climate cereals, increasing fertilizer doses can lead to an increase in plant height (Budaklı et al., 2005; Yang et al., 2008; Kon, 2019), and both organic and inorganic fertilizer applications have been shown to promote greater plant height in barley (Yolcu, 2008; Markoni et al., 2017; Özdemir et al., 2019).

Kiani et al. (2005) found that co-applying organic fertilizer with nitrogen resulted in increased plant height, while farmyard manure resulted in higher plant height values compared to the control group. Çiftçi (2019) found that organic fertilizers increased plant height in barley, with the highest height achieved using vermicompost. Özkan et al. (2021) found that chicken manure significantly increased plant height compared to other organic fertilizers.

The conventional fertilizer (NPK) resulted in a significant increase in stem diameter compared with the other fertilizers. Sheep and chicken manure also affected stem diameter. The mean values ranged from 1.64 to 3.44 mm, with the highest and lowest values observed in the Keçiburcu variety, sheep manure, and raw leonardite (Figure 3-b). Previous studies have reported that the stem diameter values obtained from organic farming are generally lower than those obtained from conventional farming (Bayhan and Yıldırım, 2021; Özkan and Akıncı, 2021). Yolcu (2008) reported stem diameter values ranging from 2.14 to 3.04 mm for barley varieties with farmyard manure application and 2.34 to 2.79 mm for the control group.

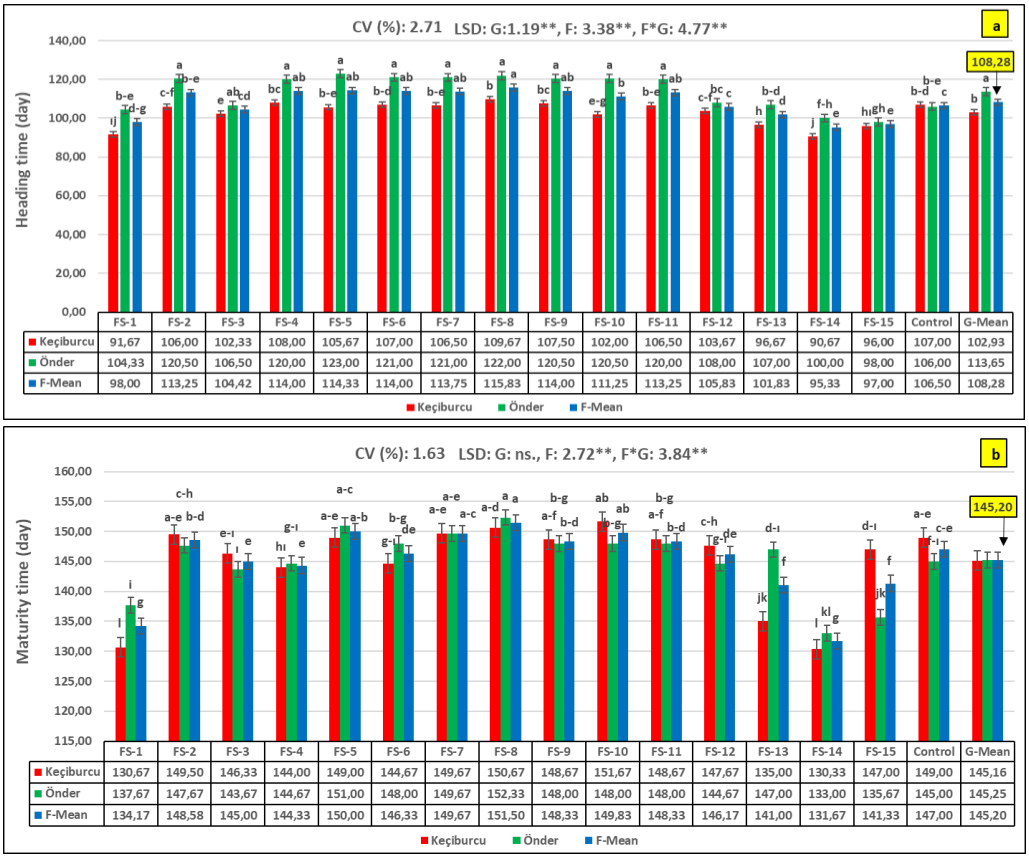


Figure 2. Mean values and groups of heading (a) and maturity (b) times analyzed in the study. ** Significant at P≤0.01, ns= not significant, CV= coefficient of variation, LSD= least significant difference, FS= fertilizer source and G= genotypes, Red= keçiburcu, Green= önder, Blue= fertilizer mean.

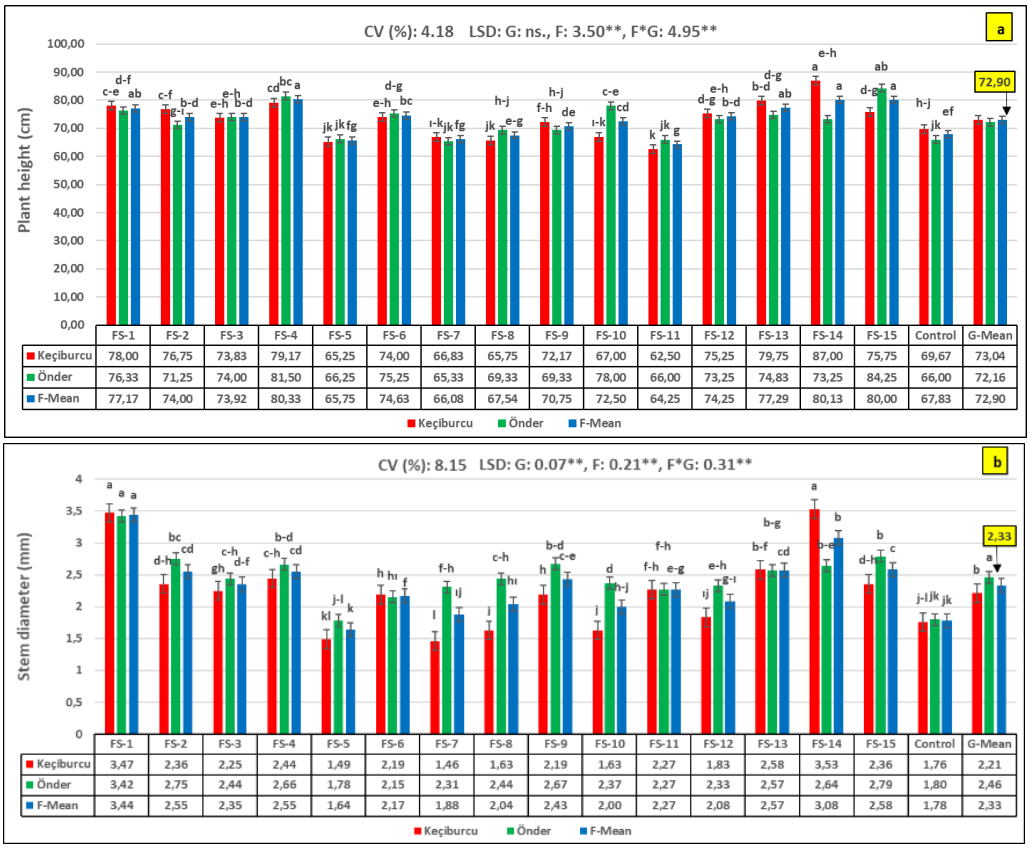


Figure 3. Mean values and groups of plant height (a) and stem diameter (b) analyzed in the study. ** Significant at P≤0.01, ns= not significant, CV= coefficient of variation, LSD= least significant difference, FS= fertilizer source and G= genotypes, Red= keçiburcu, Green= önder, Blue= fertilizer mean.

Significant differences between varieties were observed for all traits except the number of spikelets per spike when assessing the effect of organic and inorganic fertilizer application on spike characteristics in barley plants. In general, the highest values for these traits were obtained from treatments with conventional fertilizer and sheep manure (Figure 4-a, 4-b, 4-c, and 4-d). It is assumed that conventional fertilizer, with its readily available nitrogen and phosphorus in the soil, is more readily taken up by plants, whereas sheep manure is characterized by its high nutrient content. Many studies have reported that the use of organic fertilizers has a positive effect on crop yields and yield components (Ibrahim et al., 2008; Koutrobuas et al., 2016; Markoni et al., 2017). Additionally, vermicompost also increased biomass of plant (Fragaria x ananassa L.) according to the control and chemical fertilizer (Ateş et al., 2019).

İlker (2006) stated that spike length, which has significant direct and indirect effects on the grain yield in barley, can be used as a selection criterion. Gürsoy (2011) stated that the number of grains per spike has a direct effect on grain yield, which varies with spike length and number of spikelets per spike. Mutlu (2018) reported that the use of organic manure and organic manure combined with microbial fertilizer increased spike characteristics in barley, with the highest values obtained from cattle manure with liquid manure and compost with liquid manure. In line with the findings of the present study, other researchers have also reported that the maximum and minimum values of spike traits were attributed to the application of conventional manure and various organic manures (Hammad et al., 2011; Joshi et al., 2013; Kara and Gül, 2013; Aksu, 2017; Mazhar et al., 2018).

Both conventional and sheep manure applications have led to an increase in grain yield and biomass. The maximum and minimum values for both traits were obtained from conventional and sheep manure applications. Keçiburcu had the best yield (1.56 g/plant), while Önder had the highest biomass (3.74 g/plant). In the case of sheep manure, Keçiburcu was superior for both traits. In particular, compared with the control (no fertilizer), raw leonardite fertilizer had no positive effect on grain yield or biomass (Figure 5-a and 5-b). Based on these results, it can be suggested that readily available nitrogen and phosphorus applied to the soil through conventional fertilization are more easily taken up by plants, leading to increased yield. The main disadvantage of organic fertilizers in plant production is the inadequate supply of necessary nitrogen and other essential nutrients for plants. As a result, insufficient nitrogen and nutrient uptake by plants can lead to reduced grain yield. Organic fertilization has been reported to have lower levels of readily available nutrients than conventional fertilization (Hole et al., 2005). Furthermore, owing to the slow release and varying distribution of nutrients in organic fertilizers, yield reductions can occur. The organic nitrogen and phosphorus found in animal manure require mineralization to become readily available to plants (Havlin et al., 2014; Antille et al., 2014). Researchers have reported an increase in yield after 3-5 years of continuous organic fertilizer in the same field, and long-term organic fertilization has a positive impact on yield (Bulluck et al., 2002).

In many studies comparing conventional and organic farming practices have consistently reported lower yields from organic farming (Kaut et al., 2008; Özkan et al., 2021). For instance, Kodaş et al. (2015) found that the highest yield (329 kg/ha) was obtained through conventional farming, whereas the lowest yield (190 kg/ha) was observed in organic farming using farmyard manure. Özdemir et al. (2019) reported the highest grain yield of barley genotypes to be 524.5 kg/da with 160 kg/da vermicompost, while the lowest yield was obtained in the control group. Researchers have emphasized the need to supplement organic fertilizers with mineral fertilizers to enhance both soil fertility and grain yield (Wang et al., 2001; Gopinath et al., 2008). Mutlu (2018) reported a 50-56% increase in barley yield with the use of organic fertilizers in combination with microbial fertilizers. Previous studies have shown positive effects of sheep manure on certain plant nutrients (Hınıslı, 2014), parallel yield increases with increasing fertilizer (Elgin et al., 2006), and yields close to inorganic applications (Beşirli et al., 2004).

Based on the results of correlation analyses, no correlation was observed between ear length and heading time. However, there were significant negative correlations between heading time and the other traits. There were also significant positive correlations between plant height, stem diameter, spike length, number of spikelets per spike, number of grains per spike, grain weight per spike, grain yield, and biomass (Figure 6). These correlation results are consistent with similar results reported in previous barley studies (Akdeniz et al., 2004; Özkan and Akıncı, 2021; Bayhan et al., 2022).

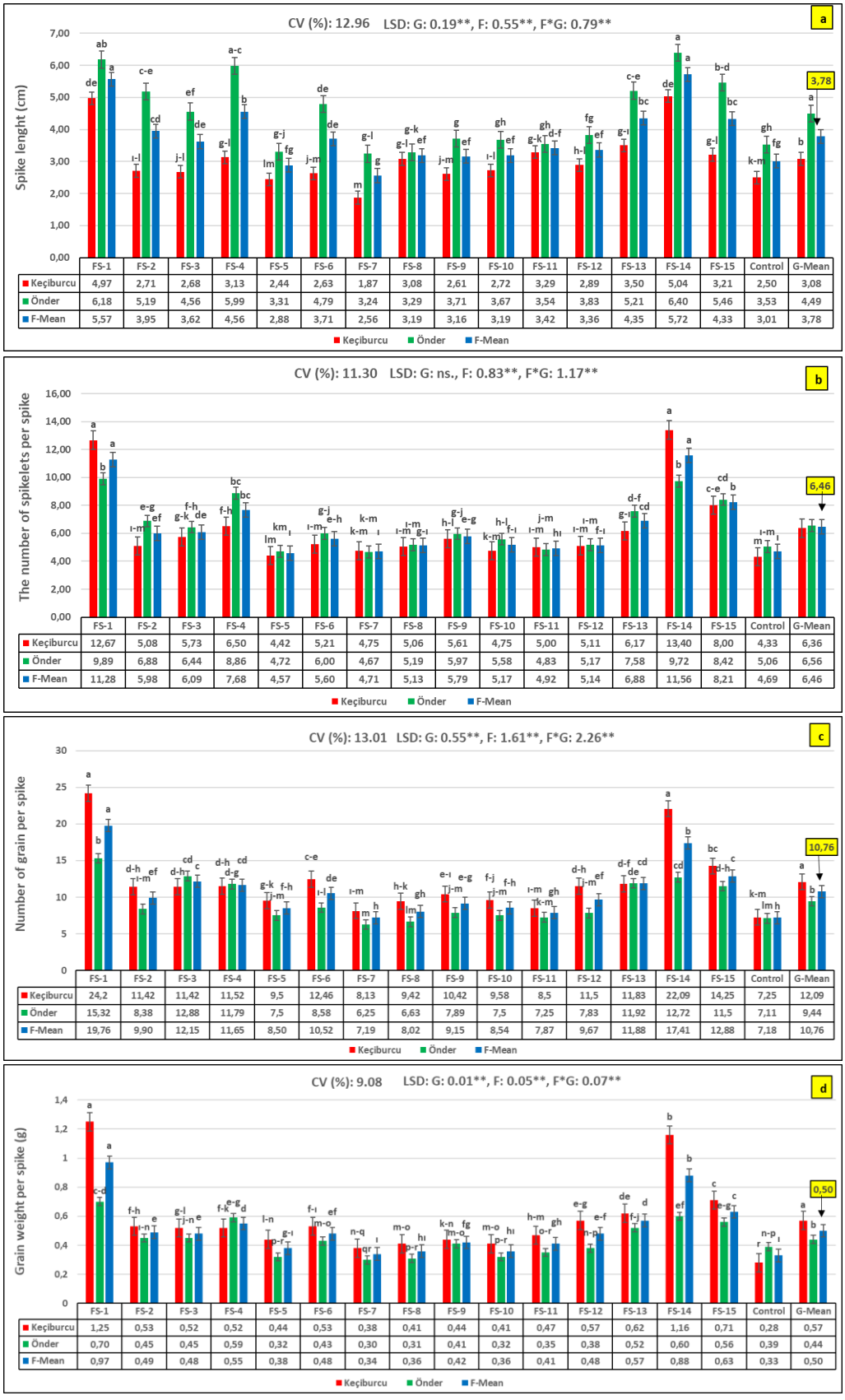
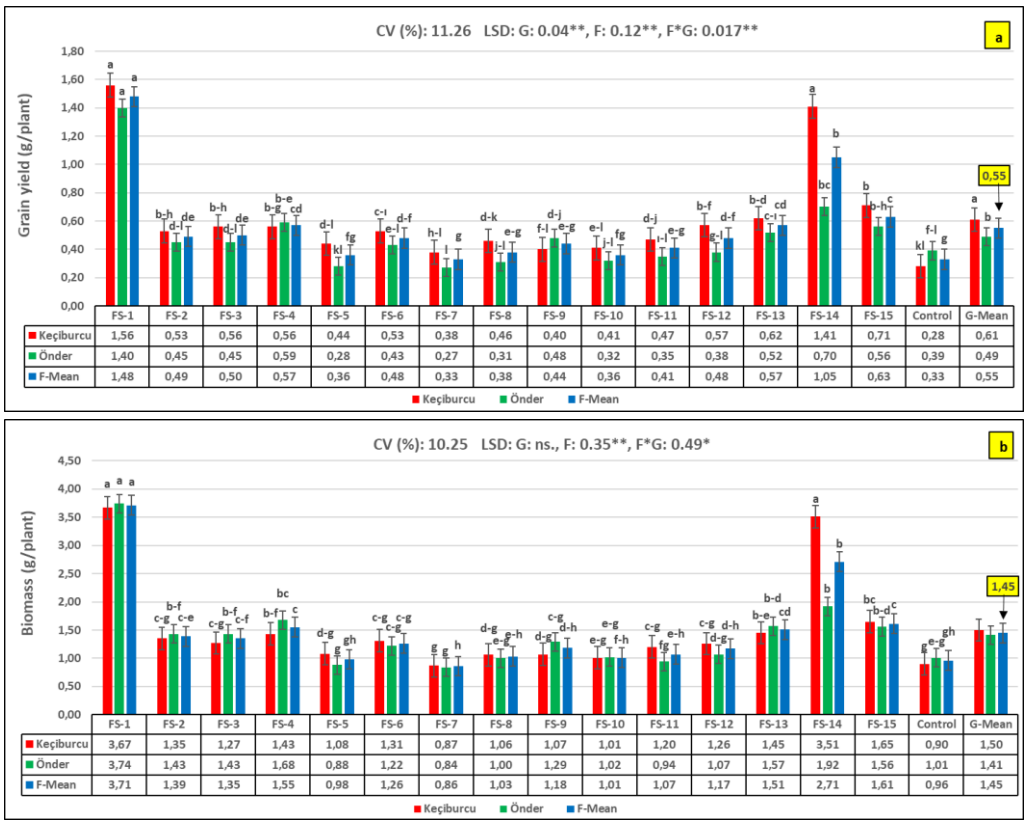


Figure 4. Mean values and groups of spike length (a), number of spikelets per spike (b), number of grains per spike (c), and grain weight per spike (d) analyzed in the study. ** Significant at P≤0.01, ns= not significant, CV= coefficient of variation, LSD= least significant difference, FS= fertilizer source and G= genotypes, Red= keçiburcu, Green= önder, Blue= fertilizer mean.



	FS-1	FS-2	FS-3	FS-4	FS-5	FS-6	FS-7	FS-8	FS-9	FS-10	FS-11	FS-12	FS-13	FS-14	FS-15	Control	G-Mean
Keçiburcu	1,56	0,53	0,56	0,56	0,44	0,53	0,38	0,46	0,40	0,41	0,47	0,57	0,62	1,41	0,71	0,28	0,61
Önder	1,40	0,45	0,45	0,59	0,28	0,43	0,27	0,31	0,48	0,32	0,35	0,38	0,52	0,70	0,56	0,39	0,49
F-Mean	1,48	0,49	0,50	0,57	0,36	0,48	0,33	0,38	0,44	0,36	0,41	0,48	0,57	1,05	0,63	0,33	0,55

	FS-1	FS-2	FS-3	FS-4	FS-5	FS-6	FS-7	FS-8	FS-9	FS-10	FS-11	FS-12	FS-13	FS-14	FS-15	Control	G-Mean
Keçiburcu	3,67	1,35	1,27	1,43	1,08	1,31	0,87	1,06	1,07	1,01	1,20	1,26	1,45	3,51	1,65	0,90	1,50
Önder	3,74	1,43	1,43	1,68	0,88	1,22	0,84	1,00	1,29	1,02	0,94	1,07	1,57	1,92	1,56	1,01	1,41
F-Mean	3,71	1,39	1,35	1,55	0,98	1,26	0,86	1,03	1,18	1,01	1,07	1,17	1,51	2,71	1,61	0,96	1,45

Figure 5. Mean values and groups of grain yield (a) and biomass (b) analyzed in the study. * Significant at P≤0.05, ** Significant at P≤0.01, ns= not significant, CV= coefficient of variation, LSD= least significant difference, FS= fertilizer source and G= genotypes, Red= keçiburcu, Green= önder, Blue= fertilizer mean.

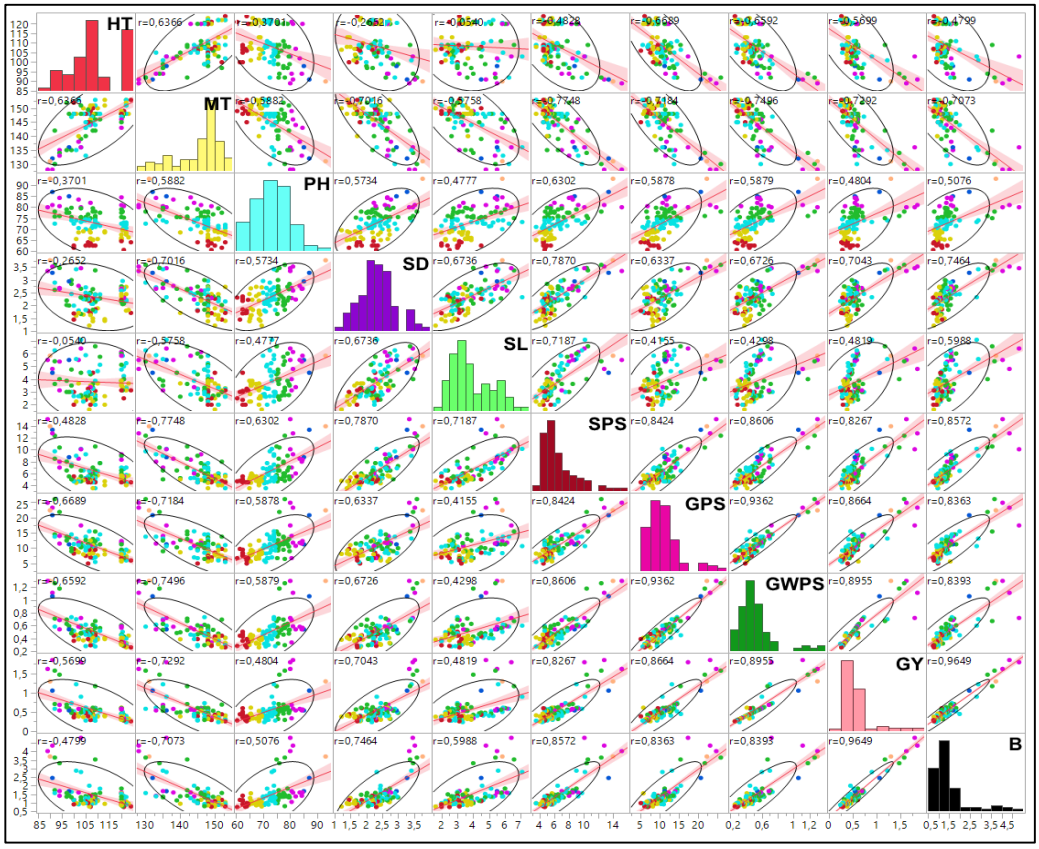


Figure 6. Correlation analysis results of the parameters examined in the study. HT= heading time, MT= maturity time, PH= plant height, SD= stem diameter, SL= spike length, SPS= spkilets per spike, GPS= grain per spike, GWPS= grain weight per spike, GY= grain yield, B= biomass

4. Conclusion

This study determined the effects of different organic fertilizers on the yield and yield components of barley varieties that can be used in organic barley production. In particular, sheep manure competed with conventional fertilizer and led to successful results. In addition, chicken manure also showed a positive increase compared to that of other fertilizers, although not very high. It was concluded that the application of conventional fertilizer, which is part of the conventional production system, is an effective source of fertilizer due to its rapid uptake and use by the crop, and that the application of organic fertilizer has a positive effect on crop development. In addition, it was found that sheep manure, which gives comparable results to conventional fertilizer, can be recommended for organic barley production and that the Keçiburcu variety, which gives promising results, can be used. It was concluded that different doses of sheep manure or the use of sheep manure together with conventional fertilizer should also be tested in future studies on this subject.

Author Contributions

The percentage of the author contributions is presented below. The author reviewed and approved the final version of the manuscript.

	R.Ö.
C	100
D	100
S	100
DCP	100
DAI	100
L	100
W	100
CR	100
SR	100
PM	100
FA	100

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The author declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because of there was no study on animals or humans. The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to.

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