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Effect of Different Organic Fertilizers on Bread Wheat (*Triticum aestivum L.*) Productivity

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Abstract

Organic fertilizers are the basis of sustainable agriculture and an important resource in plant nutrition as well. The research was conducted in the greenhouse conditions at the Dicle University Faculty of Agriculture, Diyarbakır, Turkey in 2020. The effects of 14 different organic fertilizers on grain yield, yield components, morphology and physiology properties of bread wheat (*Triticum aestivum* L) were examined. It was found that sheep manure, among other used fertilizers has a greater effect on both the growth and yield components of wheat in comparison with other organic fertilizers. The grain yield and biomass yield obtained from sheep manure have been determined to be competitive with commercial fertilizers. It was revealed that certain organic fertilizers had no effect on grain yield or biomass yield as compared to the control level of no fertilizers. According to the research results, it would be appropriate to use chicken and sheep manure in order to obtain an optimal wheat yield in the organic farming system.

Keywords: Organic fertilizers, Wheat, Yield, Morphology, Physiology

Introduction

Bread wheat (*Triticum aestivum* L.) is grown almost everywhere in the world due to its nutritional importance. Corn, rice, and wheat are the world's top three most-produced grains (Byerlee and Polanco, 1983). Wheat grain is consumed in various ways in many industries. It is also a cheaper feed source for livestock and poultry.

Overuse of chemical fertilizers has devastating effects on soil fertility. Moreover, even if chemical fertilizers are used in a balanced way, they negatively affect soil health in the long term. Nowadays scientists are trying to develop an agricultural system that not only reduces the cost of agricultural production but also protects natural resources (Abbas et al., 2012).

Organic farming is a production system that limits or largely eliminates the use of synthetic or inorganic fertilizers, pesticides, and hormones (Reddy, 2005). Using poultry and livestock wastes in organic agriculture makes this system a part of the integrated production system. The biggest obstacles to using these wastes are the insufficiency of waste-processing and the storage problem. However, due to the affordable cost of bio-resources, the demand for these resources is increasing day by day (Deksissa et al., 2008).

Turkish agricultural soils are deficient in organic matter and nitrogen, with only 6% having enough of these nutrients to support crop growth (Aygün and Acar, 2019). Using organic fertilizers in agriculture to eliminate plant nutrition and organic matter deficiency is of great importance.

Intensive farming applications cause a decrease in plant

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nutrients in the soil. If these decreasing plant nutrients are not recompensed by mineral and organic fertilizers, a serious decrease in agricultural production occurs. Each year about 6 million tons of chemical fertilizers and 38 thousand tons of plant protection products and hormones are used in agriculture in Turkey (Aygün and Acer, 2019). Unconscious use of these chemicals causes an increase in soil salinity and has a negative impact on soil pH and corruption of soil structure. Organic fertilizers should be utilized to maintain the soil's natural balance, improve its structure, increase yield and quality, and produce healthy products.

Using waste mushroom compost in bread wheat production has been found to be an alternative to conventional methods and if the compost is made from organic materials, it can be used as a fertilizer by organic farmers (Aydın et al., 2010). In a study using 3 different organic fertilizers and 8 bread wheat varieties, more yield was obtained in conventional cultivation and a 27% lower yield was observed in green manure application compared to conventional, but this difference could be covered by the price difference in organic (Kodaş et al. 2015).

It was the goal of this research to find out the effects of various organic fertilizers on wheat growth and potential yield.

Materials and Methods

The study was conducted in the greenhouse of Dicle University Faculty of Agriculture in 2020. In the study, 15 fertilizers (Table 1) and DZ7-59 bread wheat varieties were used as materials. The study was established on December 5, 2019, with 3 replications according to the randomized block experimental design. Bread wheat line was grown under greenhouse conditions in 8 liter pots with 4 plants per pot. The soil material used in the study was obtained from a field where no agricultural activity was carried out for a long time. Some physical and chemical contents of soil are given in Table 2. Seeds that were not exposed to any chemical treatment were used as plant material. All fertilizers were added to the pots at the time of sowing, solid fertilizers were mixed with the soil and liquid fertilizers were diluted with water and applied to the soil. Control pots with no fertilizer were created in order to compare the fertilizer applications. A drip irrigation system, controlled by a timer-based solenoid valve, had been set up for the precise application of irrigation. Each pot was irrigated to the field capacity at 2 days intervals. The name of organic fertilizer and their contents are given in Table 1.

Table 1. Fertilizer Sources and Contents

Fertilizer	Advised Dose	Applied Fertilizer	Total Nitrogen (%)	Organic Content (%)	Other Content
NPK	12 kg/da	3.6 g/pot	20	-	Phosphorus Pentaoxide 20%
COF-1	100-150 cc/100 lt su	1,5 ml/pot	2	30	Humic + Fulvic% 20; Potassium Oxide% 2; Phosphorus Pentaoxide% 0,4
COF-2	50-60 kg/da	1,2 g/pot	3	50	Humic + Fulvic% 12,5; Phosphorus Pentaoxide% 0,6; Potassium Oxide% 1,3; Kalsiyum Oxide% 0,3
COF-3	50-60 kg/da	1,2 g/pot	7	50	Humic + Fulvic Acid% 18; Phosphorus Pentaoxide% 1; Potasyum Oxide% 1
OC	120-150 kg/da	3 g/pot	2	65	Potassium Oxide% 2; Alginic Acid% 0,3
OSC	1000-2000 cc/da	0,004 g/pot	3	30	Humic + Fulvic% 24; Potassium Oxide% 5;
RL	50-75 kg/da	5 g/pot	1,35	40	Humic + Fulvic% 40
PL	40-60 kg/da	5 g/pot	1,3	40	Humic + Fulvic% 40
LV	1000-2000 cc/da	0,004 g/pot	0,8	10	Organic Carbon% 12; Potassium Oxide% 1
LSF	2-3 lt/da	0,06 g/pot	0,3	10	Humic + Fulvic% 6; Potassium Oxide% 1; Phosphorus Pentaoxide% 0,2
BG	50-100 kg/da	2 g/pot	5,65	26,4	Humic + Fulvic% 30; Potassium Oxide% 1; Phosphorus Pentaoxide% 1
SV	2000-3000 g/da	2 g/pot	1,5	40	Humic + Fulvic% 15; Phosphorus Pentaoksit% 3
FM	2 tons	40 g/pot	3,82	61,59	Organic Carbon% 25; Phosphorus Pentaoxide %4; Iron %0,3; Humic + Fulvic % 25
SM	2 tons	40 g/pot	4,98	68,3	Phosphorus Pentaoxide% 0,03
CM	500 kg/da	10 g/pot	4,09	57,89	Phosphorus Pentaoxide% 0,03

Table 2. Some physical and chemical properties of the soil used in the study

Analysis Results							
Results				Evaluation			
Analysis Name				Low	Middle	High	Very High
Saturation (%)	:	63,00	Clay loam				
Salinity (Saturation Sludge) (dS / m)	:	0,92	Without salt				
% Salt (by calculation) TS 8334	:	0,04	Without salt				
pH (Saturation Sludge)	:	8,11	Light Alkali				
Lime (Calcimetric) (%)	:	11,24	Middle				
Organic Matter (Walkley Black) (%)	:	0,71	Low				
Nitrogen (%)	:	0,04	Low				
Phosphorus (Olsen Spectrometer) (ppm)	:	4,00	Low				
Potassium (A. Acetate-ICP) (ppm)	:	314,45	Very High				
Calcium (A. Acetate-ICP) (ppm)	:	10717,89	Very High				
Magnesium (A. Acetate-ICP) (ppm)	:	471,78	Middle				
Sodium (A. Acetate-ICP) (ppm)	:	26,65	Low				
Iron (DTPA-ICP) (ppm)	:	9,29	Very High				
Copper (DTPA-ICP) (ppm)	:	1,61	Middle				
Manganese (DTPA-ICP) (ppm)	:	16,50	Middle				
Zinc (DTPA-ICP) (ppm)	:	0,08	Low				

Measurement and Statistical Analysis

Heading time (day): It represents the number of days between the date of the plant emergence and the date when the spike appeared on the flag leaf at the rate of 1/2, in 50% of the plants in the pot.

Plant height (cm): It was determined by measuring the length from above ground soil to the tip of the top spike.

Maturity time (day): It represent the number of days between the date of plant emergence and the date when the spike and upper stem of the plants in pots turn yellow by 90%.

SPAD value: It was measured by using the SPAD 502 Chlorophyll-Meter at the heading time of the plant, in the middle of the flag leaf.

Stem diameter (mm): The average value was calculated at the first node of the main stem with a digital caliper.

Spike length (cm): The length of the spikes from each pot was measured.

The number of spikelets per spike: The number of spikelets of the spikes from each pot was counted.

Number of Grain per Spike: The grains of spikes from each pot were counted.

Grain weight per spike: Spikes taken during the harvest period were threshed and weighed by precision scale.

Grain yield (g/plant): The grains acquired from the harvested plants were determined by weighing.

Biomass (g/plant): The weights of all plant parts taken from the pot were determined by weighing after drying.

The values obtained from the investigated parameters were analyzed by the JUMP Pro 13 statistical package program, and the statistical differences between the averages were determined by the LSD test.

Results and Discussion

The significant levels and the average values of the observations which show the effects of various organic fertilizers on the morphological, physiological, yield, and yield investigated parameters of bread wheat are given in Table 3.

The effects of fertilizers on all traits (except maturity time) of bread wheat were found to be statistically significant ($p < 0.01$).

While fertilizer applications significantly affected the heading time, they did not affect the maturity time. The average values ranged between 97 - 108 days for heading time, and 136.33 - 146 days for maturity time. Among the organic fertilizers, sheep manure encouraged earliness, whereas the control and OSC application extended the heading time and maturity time (Figure 1). In the study conducted by Subhan et al. (2017), the maximum heading time was determined as 115 days in the control treatment (no fertilizer). The minimum heading time was determined as 88.5 days in the NPK application.

Chicken manure application significantly increased plant height compared to the other treatment (Figure 1). Average values ranged between 62.83 - 80.67 cm for plant height. The maximum plant height was obtained in chicken manure application, while the minimum plant height was obtained in the control treatment. The previous studies stated that when organic fertilizers are used regularly and at appropriate doses, there may be improvements in plant growth parameters (Dixit and Gupta, 2000, Selvakumari et al., 2000, Khoshgoftarmanesh and Kalbaşı, 2002). Delden (2001) reported that the plant height in wheat can be increased by the application of organic and inorganic fertilizers. Aksu (2017) found that farmyard manure application before wheat sowing in autumn had a positive effect on plant height.

Average values ranged between 27.70 - 47.83 for SPAD, 3.68 - 6.87 cm for spike length, 8.48 - 17.83 for the number of spikelets per spike, 8.05 - 22.22 for the number of grains per spike, 0.29 - 1.05 g for grain weight per spike. Maximum values for these parameters were obtained from conventional fertilizer (NPK) application, followed by sheep and chicken manure applications. The minimum values were obtained from the control treatment (no fertilizer). It was determined that sheep and chicken manure application increased plant height, spike length, chlorophyll content, number of spikelets, grains per spike, and grain weight per spike compared to the other treatment (Figure 1-2). It can be said that the main reason for this is the rich content of the sheep and chicken manure. Similar results were obtained in previous studies (Chattha et al. 2019; Joshi et al. 2013; Mazhar et al.2018). Hammad et al., 2011, obtained the highest spike length (9.28 cm) in traditional fertilizer application, while they reported the highest number of spikelets per spike (14.9) and the number of grain per spike (49.25) from the combination of different organic fertilizers. Kara and Gül (2013) reported that the highest results belonged to conventional fertilizer (NPK) practice and the lowest results was found liquid seaweed fertilizer in a two-year study. Aksu (2017) stated that the combination of nitrogen dose and farmyard manure can reach even higher levels of grain number per spike.

Grain yield, biomass yield, and stem diameter increased significantly with sheep manure and conventional fertilizer applications compared to the other treatment. Average values ranged between 1.09 - 3.56 g / plant for grain yield, 2.69 - 8.04 g / plant for biomass, 1.81 - 3.48 mm for stem diameter. The highest values of these parameters were obtained from the sheep manure and conventional fertilizer (NPK) application in the same statistical group, while the minimum values were obtained from the control treatment (no fertilizer) (Figure 3). The grain yield and biomass yield obtained from sheep manure among organic fertilizers have been determined to be competitive with commercial fertilizers. It was revealed that certain organic fertilizers had no effect on grain yield or biomass yield as compared to the control level of no fertilizers. According to these results, it can be said that nitrogen and phosphorus applied to the soil with conventional fertilization is taken by the plant more easily and accordingly it causes an increase in the yield value. The biggest disadvantage of organic fertilizers is the low nitrogen and other nutrients that the plant needs. Therefore, grain yield decreases as the plant cannot get enough nitrogen and other nutrients. Organic fertilizers can differ due to their slow decomposition (mineralization, transformation from organic form to inorganic form) in the soil and the variable distribution of nutrients they contain (Ameeta and Chetani, 2017). It has been reported that the application of nitrogen-rich organic fertilizers tends to high yield in wheat and increases biomass yield (Camara et al., 2003). Hole et al. (2005) reported that the available nutrients in organic fertilization are lower than in conventional fertilization. Hiltburunner et al. (2005), reported that farmyard manure increases the stem diameter during the grain filling period of wheat and higher protein is obtained due to the high nutrient accumulation in the stem. Öztürk et al., (2011), reported that farmyard manure increased the grain yield of wheat by improving the fertility of the soil. The results we obtained in the study have similarities with the results of the previous studies (Khanam et al., 2001; Rees and Castle, 2002; Ghosh et al., 2004; Sarwer et al., 2008; Reddy et al., 2005). Abbas et al. (2012) found that maximum grain yield was obtained when the appropriate dose of NPK was given with 6 t ha^{-1} chicken manure application. Jamal and Fawad (2018, 2019) stated that chicken manure significantly increased biomass yield. Phullan et al., (2017) concluded that farmyard manure at 6 tons ha^{-1} coupled with mineral fertilizer rate of 120-90 kg N-P_2O_5 ha^{-1} was the best source for sustainable soil health and wheat production. Aydın et al., (2010), reported that the highest grain yield was obtained as 3716 kg/ha with the application of 72.0 kg/ha spent mushroom compost and additionally grain yield obtained from conventional practice 27.69 kg/ha, 19.54 kg/ha of organic agriculture application respectively. Kodaş et al., (2015), found that the highest yield was obtained from conventional with 3290 kg/ha, the lowest yield was 1900 kg/ha obtained from farmyard manure.

Conclusion

According to the findings of this research, sheep manure treatment increased grain production and biomass capacity to levels comparable to commercial fertilizer. By overcoming the primary disadvantage of organic agriculture, low yield, the use of sheep manure may contribute to the expansion of organic farming areas. Encouragement of sheep manure production and application to agriculture will be critical in this regard. Given the scarcity of fertilizer in areas where sheep are primarily grazed, it is possible to recommend a mixture of chicken manure and sheep manure, which ranks second in terms of grain yield after sheep manure. From the organic fertilizers tested in this study, it was discovered that only sheep and chicken dung could be used successfully in organic agriculture. More testing will be essential to bring these findings into practical use by supporting them with further trials.

Compliance with Ethical Standards

Conflict of interest

The authors declared that for this research article, they have no actual, potential or perceived conflict of interest.

Author contribution

Remzi Özkan designed the study and collected the data with Levent Yorulmaz. Remzi Özkan, Merve Bayhan, Muhammet Öner and Mehmet Yıldırım made the statistical analysis and wrote the original draft of the article. All the authors read and approved the final manuscript. All the authors verify that the Text, Figures, and Tables are original and that they have not been published before.

Ethical approval

Not applicable.

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Data availability

Not applicable

Consent for publication

Not applicable.

Table 3. Average values examined traits and theirs

Fertilizers	Heading time (day)	Maturity time (day)	SPAD value	Plant height (cm)	Spike Length (cm)
FM	98,00 d-f	138,67	31,00 e-g	78,50 a-c	5,90 bc
LSF	103,67 a-c	142,33	30,35 e-g	68,00 d-g	4,38 d-g
RL	104,33 a-c	141,33	32,40 d-f	65,17 e-g	3,77 g
PL	105,67 a-c	143,33	33,60 de	65,50 e-g	3,96 fg
SM	96,67 f	136,33	41,83 b	79,33 ab	6,87 ab
OC	101,33 c-f	137,33	29,10 fg	64,83 e-g	4,17 e-g
COF-1	102,33 b-e	144,00	32,75 d-f	73,33 a-d	5,40 cd
COF-2	102,33 b-e	139,67	32,20 d-f	73,67 a-d	5,00 c-f
COF-3	105,67 a-c	142,67	39,45 bc	74,50 a-d	4,67 d-g
LV	103,33 a-c	144,00	31,85 ef	71,00 c-f	4,50 d-g
SV	105,00 a-c	145,67	32,40 d-f	63,83 fg	4,17 e-g
CM	97,00 f	136,67	35,97 cd	80,67 a	6,13 bc
CF	97,67 ef	140,67	47,83 a	75,17 a-d	7,94 a
OSC	107,00 ab	146,67	40,90 b	72,00 b-e	5,25 c-e
BG	103,00 a-d	142,33	32,67 d-f	68,67 d-g	3,83 fg
Control	108,00 a	146,00	27,70 g	62,83 g	3,68 g
Average	102,56	141,73	34,5	71,06	4,97
%CV	2,94	2,88	6,93	6,37	10,77
LSD (P<0.05)	5,01	no	3,98	7,55	1,22

no: not important, **FM:** Farmyard manure, **LSF:** liquid Seaweed Fertilizer, **RL:** RawLeonardite, **PL:** Processed Leonardite, **SM:** Sheep Manure, **OC:** Organic Compost, **COF-1:** Commercial Organic Fertilizer-1, **COF-2:** Commercial Organic Fertilizer-2**, COF-3:** Commercial Organic Fertilizer-3, **LVF:** Liquid Vermicompost Fertilizer, **SVF:** Solid Vermicompost Fertilizer, **CM:** Chicken Manure, **CF:** Conventional Fertilizer (NPK). **OSC:** Organic Seed Coating, **BG:** Bat Guano.

Table 3. Average values examined traits and theirs (contunied)

Fertilizers	Number of spikelet per spike	Number of grains per spike	Grain weight per spike	Grain yield (g/plant)	Biomass yield (g/plant)	Stem diameter (mm)
FM	15,78 ab	13,75 b-d	0,40 cd	1,43 de	4,80 b-d	2,72 b-d
LSF	10e.g. cd	10,58 d	0,38 cd	1,51 b-e	3,52 e-g	2,13 d-f
RL	8,61 d	8,19 d	0,30 d	1,30 de	3,14 fg	2,08 d-f
PL	8,69 d	8,69 d	0,31 d	1,14 e	2,74 fg	1,95 ef
SM	16,10 ab	17,63 a-c	0,78 ab	3,56 a	8,04 a	3,48 a
OC	9,67 cd	8,42 d	0,30 d	1,19 e	2,94 fg	1,87 f
COF-1	13,03 bc	12,61 b-d	0,61 bc	2,19 bc	4,88 bc	2,63 c-e
COF-2	12,92 bc	10,67 d	0,38 cd	1,51 c-e	3,74 d-g	2,3 c-f
COF-3	11,72 cd	13,67 b-d	0,52 b-d	1,91 b-d	4,29 b-e	2,28 c-f
LV	10,92 cd	10,92 cd	0,39 cd	1,57 b-e	3,80 c-f	2,30 c-f
SV	9,67 cd	10,33 d	0,38 cd	1,53 b-e	3,40 e-g	1,96 ef
CM	15,58 ab	18,00 ab	0,71 b	2,20 b	5,21 b	2,90 a-c
CF	17,83 a	22,22 a	1,05 a	3,70 a	8,23 a	3,41 ab
OSC	11,17 cd	13,83 b-d	0,55 b-d	1,63 b-e	3,81 c-f	2,48 c-f
BG	8,70d	9,68 d	0,33 d	1,41 de	3,26 e-g	1,81 f
Control	8,48 d	8,05 d	0,29 d	1,09 e	2,69 g	1,81 f
Average	11,83	12,32	0,48	0,49	4,28	2,38
%CV	9,26	10,85	11,79	9,23	11,19	8,07
LSD (P<0.05)	3,79	6,75	0,28	0,68	1,09	0,71

no: not important,

FM: Farmyard manure, **LSF:** liquid Seaweed Fertilizer, **RL:** RawLeonardite, **PL:** Processed Leonardite, **SM:** Sheep Manure, **OC:** Organic Compost, **COF-1:** Commercial Organic Fertilizer-1, **COF-2:** Commercial Organic Fertilizer-2**, COF-3:** Commercial Organic Fertilizer-3, **LVF:** Liquid Vermicompost Fertilizer, **SVF:** Solid Vermicompost Fertilizer, **CM:** Chicken Manure, **CF:** Conventional Fertilizer (NPK). **OSC:** Organic Seed Coating, **BG:** Bat Guano.

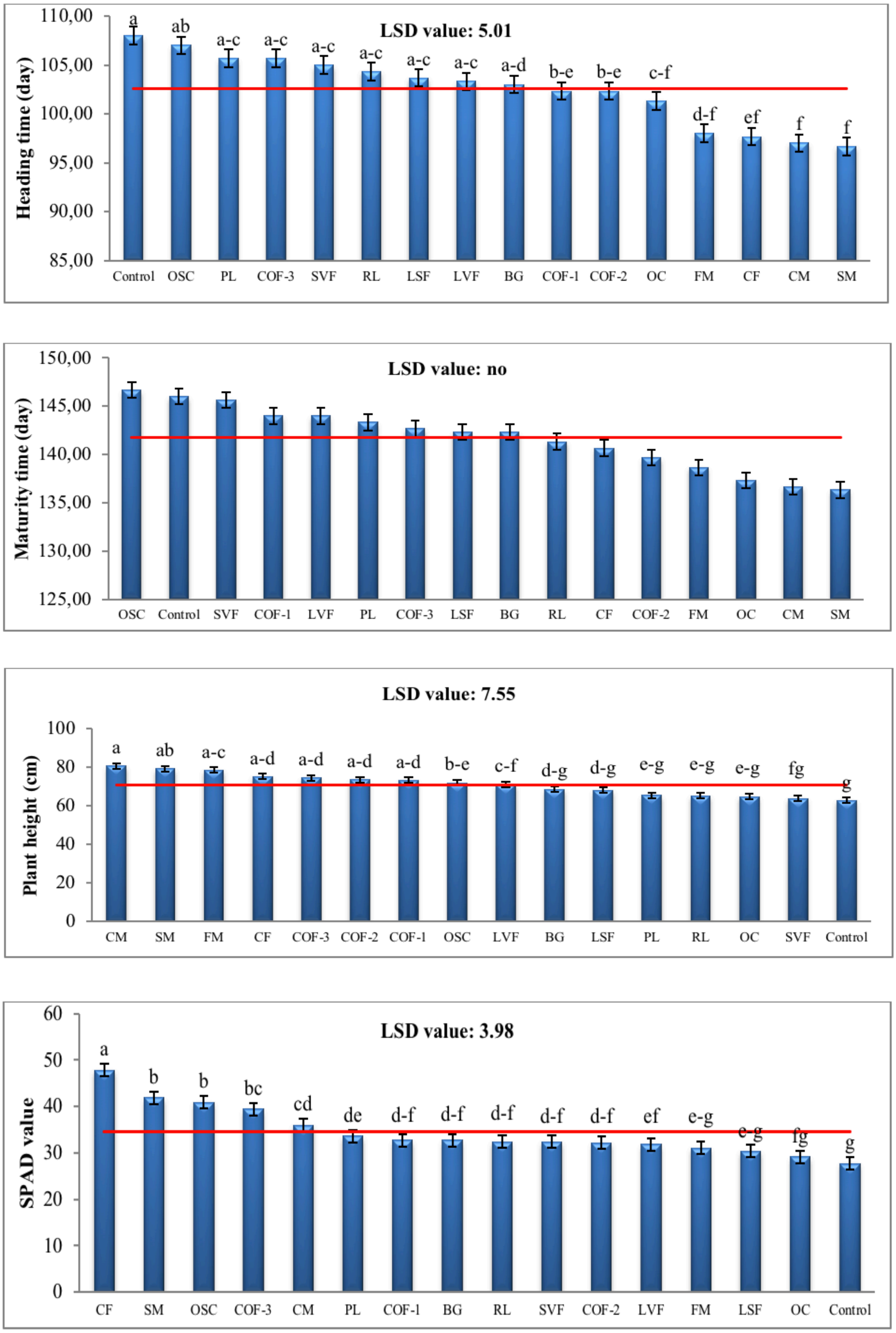

Figure 1. The effect of different organic fertilizers on the heading time (day), maturity time (day), plant height (cm), SPAD value in wheat. **Red line:** General Mean, **FM:** Farmyard manure, **LSF:** liquid Seaweed Fertilizer, **RL:** RawLeonardite, **PL:** Processed Leonardite, **SM:** Sheep Manure, **OC:** Organic Compost, **COF-1:** Commercial Organic Fertilizer-1, **COF-2:** Commercial Organic Fertilizer-2**, COF-3:** Commercial Organic Fertilizer-3, **LVF:** Liquid Vermicompost Fertilizer, **SVF:** Solid Vermicompost Fertilizer, **CM:** Chicken Manure, **CF:** Conventional Fertilizer (NPK), **OSC:** Organic Seed Coating, **BG:** Bat Guano

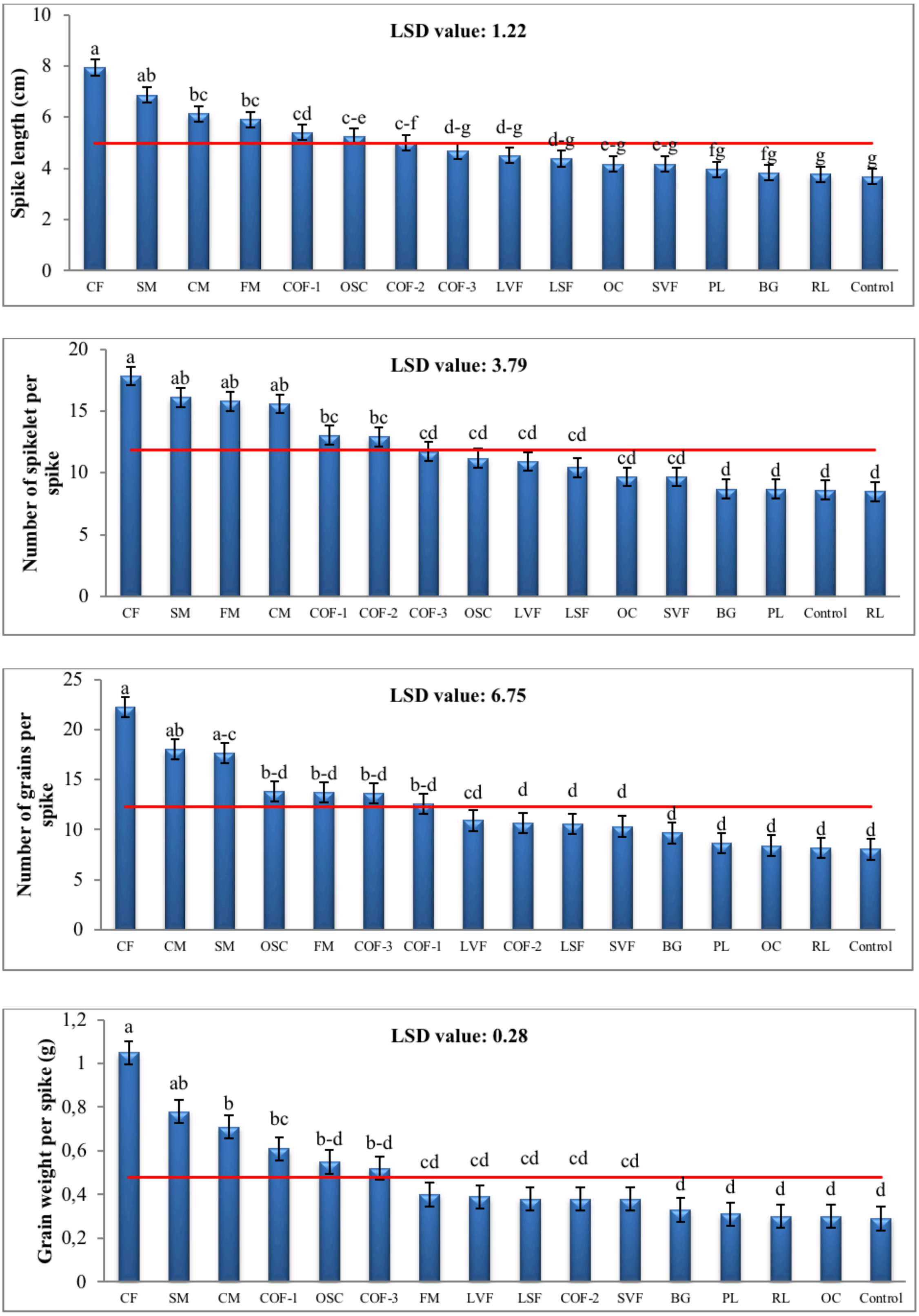

Figure 2. The effect of different organic fertilizers on the spike length (cm), and the number of spikelets per spike, number of grains per spike, grain weight per spike in wheat. **Red line:** General Mean, **FM:** Farmyard manure, **LSF:** liquid Seaweed Fertilizer, **RL:** RawLeonardite, **PL:** Processed Leonardite, **SM:** Sheep Manure, **OC:** Organic Compost, **COF-1:** Commercial Organic Fertilizer-1, **COF-2:** Commercial Organic Fertilizer-2**, COF-3:** Commercial Organic Fertilizer-3, **LVF:** Liquid Vermicompost Fertilizer, **SVF:** Solid Vermicompost Fertilizer, **CM:** Chicken Manure, **CF:** Conventional Fertilizer (NPK), **OSC:** Organic Seed Coating, **BG:** Bat Guano

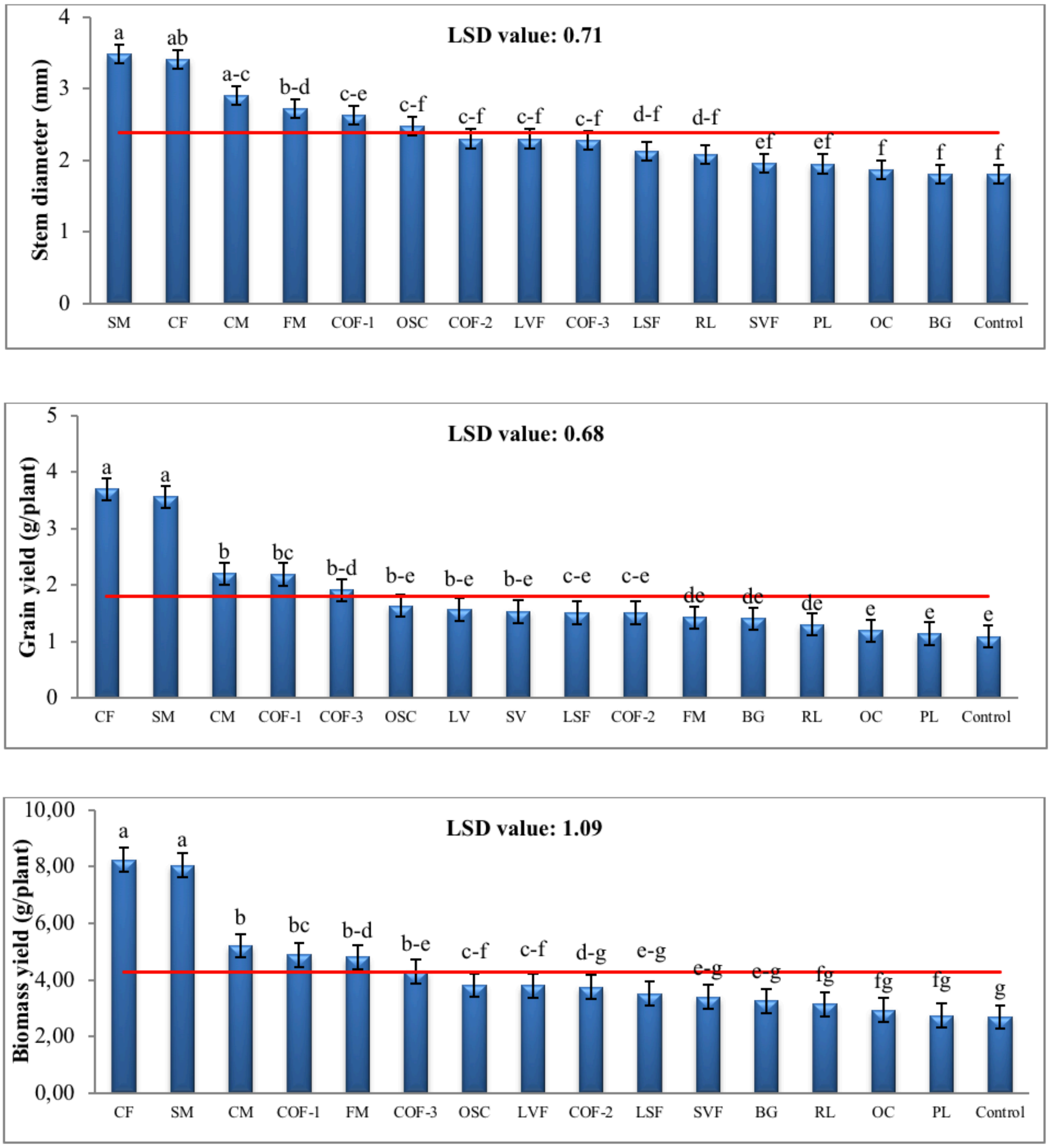

Figure 3. The effect of different organic fertilizers on the stem diameter (mm)and biomass yield (g/plant) in wheat. **Red line:** General Mean, **FM:** Farmyard manure, **LSF:** liquid Seaweed Fertilizer, **RL:** RawLeonardite, **PL:** Processed Leonardite, **SM:** Sheep Manure, **OC:** Organic Compost, **COF-1:** Commercial Organic Fertilizer-1, **COF-2:** Commercial Organic Fertilizer-2**, COF-3:** Commercial Organic Fertilizer-3, **LVF:** Liquid Vermicompost Fertilizer, **SVF:** Solid Vermicompost Fertilizer, **CM:** Chicken Manure, **CF:** Conventional Fertilizer (NPK), **OSC:** Organic Seed Coating, **BG:** Bat Guano

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