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Determination of the Effects of Organic and Chemical Fertilization on Grain Yield and Some Agricultural Characteristics of Pea

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HIGHLIGHTS

- Pea (*Pisum sativum* L.) is used as a vegetable for fresh consumption as well as frozen, canned, or dried and processed and consumed as a dry grain.
- Organic fertilizers are used to meet the nutrient needs of plants, enrich the soil, and increase productivity.

Abstract

Pea (*Pisum sativum* L.) plant, a legume species, is used as a vegetable for fresh consumption and frozen, canned or dried and processed and consumed as dry grain. The effects of organic fertilization, which is important for plant nutrition and soil fertility in pea cultivation, on grain yield and some agricultural characteristics were investigated. The experiment was carried out in the experiment field belonging to Selçuk University, Faculty of Agriculture, Prof. Dr. Abdülkadir AKÇİN Research and Application Station in 2021 according to the "Split Plots Experiment in Randomized Blocks" design with 3 replications. In the research, fertilizers were randomly placed in the main plots and varieties were randomly placed in the sub-plots. In the experiment, high yielding 16002, 16011, 16018, 16022 and Ultrello x Rondo genotypes suitable for fresh consumption and registered Betagreen pea variety were used as materials. Grain yield, some agronomic traits, protein yield and protein ratio were analyzed in the study. It was determined that the effects of chemical fertilizer and some organic fertilizer applications on all other traits examined in peas were statistically significant. According to the results of the research, the number of branches in pea plants was 3.18 pieces/plant (control) and 4.13 pieces/plant (chemical fertilizer), plant height was 45.89 cm (sheep manure) and 49.51 cm (chemical fertilizer), the number of pods was 14.31 pieces/plant (control) and 25.90 pieces/plant (chemical fertilizer), the number of grains in pods was 4.90 pieces (control) and 6.64 pieces (chemical fertilizer), the number of grains per plant was 70. 03 (control) to 172.20 (chemical fertilizer), hundred seed weight 29.30 g (control) to 33.22 g (chemical fertilizer), grain yield 128.75 kg da^{-1} (control) to 300.38 kg da^{-1} (chemical fertilizer), protein content 22.49% (control) to 23.12% (sheep manure) and protein yield 28.96 kg da^{-1} (control) to 67.91 kg da^{-1} (chemical fertilizer). The responses of genotypes to organic fertilizer applications showed differences. As a result, it was determined that organic fertilization in peas gave less grain yield than those grown with chemical fertilization, but protein content had higher values. This showed that organic fertilization is a sustainable and environmentally friendly option for pea cultivation.

Keywords: Chemical fertilizer; pea; organic fertilizers; seed yield

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1. Introduction

The pea (*Pisum sativum* L.) plant, a legume species, is used as a vegetable for fresh consumption, as well as processed as frozen, canned, or dried and consumed as dried grains. It can also be used as animal feed. Pea plant is a very important place in crop rotation due to its soil enrichment feature (Ceyhan 2004).

Pea production may vary from year to year, depending on various factors. Factors such as weather conditions, agricultural policies, and changes in cultivation areas can affect the amount of production. In addition, consumer demand is also an essential factor in determining the amount of production. One point that should be remembered is the impact of agriculture on the environment and ecosystem. In pea production worldwide and Türkiye, it is extremely important to pay attention to sustainable agricultural practices and the conservation of natural resources. This will contribute to maintaining soil fertility, sustainable use of water resources and the balance of ecosystems (Ceyhan 2004).

Organic fertilizers are fertilizers derived from natural sources and composed of organic materials. Such fertilizers are used to meet the nutrient needs of plants, enrich the soil and increase productivity. Organic fertilizers contain nutrients such as nitrogen (N), phosphorus (P), and potassium (K), which are essential nutrients needed by plants. They also contain micronutrients and other beneficial elements. In this way, plants grow in a healthy and balanced way. Organic fertilizers improve the structural properties of the soil. Organic matter increases the water-holding capacity of the soil and promotes better root growth through aeration (Yolcu 2010; Göksu 2012; Kahraman and Ceyhan2022; Küçük and Ceyhan 2022).

Organic fertilizers improve the structural properties of the soil. Organic matter increases the soils water-holding capacity the water-holding capacity of the soil and promotes better root growth by providing aeration. Organic fertilizers provide plants with a long-term source of nutrients because they contain slowly soluble compounds. This meets the nutritional needs of plants over a longer period and leaves less waste without accumulating in the soil. Unlike chemical fertilizers, organic fertilizers, pollute the soil and the environment less, break down and return to nature through natural processes and do not harm water resources (Kahraman and Ceyhan2022; Küçük and Ceyhan 2022).

The disadvantages of organic fertilizers are their lower nutrient content than chemical fertilizers and the slower dissolution rate of some nutrients such as nitrogen. For this reason, chemical fertilizers may be preferred in situations requiring quick action or urgent nutrient deficiencies. However, when considering soil health and environmental protection in the long term, organic fertilizers are a more sustainable and environmentally friendly option (Yolcu 2010; Göksu 2012; Kahraman and Ceyhan2022; Küçük and Ceyhan 2022).

Chemical fertilizers can negatively affect the life of microorganisms and other beneficial organisms in the soil. In long-term use, they can reduce soil fertility and disrupt the natural structure of the soil. Excessive use of chemical fertilizers can be carried into water sources through rainwater or irrigation and cause water pollution. When misused or applied in excessively, chemical fertilizers can cause burning, leaf spots and other harmful effects on plants. They can also contribute to the spread of plant diseases due to mineral imbalances. The production, distribution and use of chemical fertilizers can generate environmentally harmful waste and greenhouse gas emissions. This can contribute to climate change and environmental pollution (Yolcu 2010; Göksu 2012; Kahraman and Ceyhan2022; Küçük and Ceyhan 2022).

Considering the above-mentioned harms of chemical fertilizers, alternatives such as the transition to sustainable agricultural practices and organic fertilizers should be preferred. Organic fertilizers support the natural structure of the soil, cause less water pollution and are a more suitable option for a healthy ecosystem. However, the type of fertilizer to be used in each case may vary depending on factors such as soil characteristics and the geographical region where agriculture is carried out. In this study, the effects of cow and sheep manure as organic fertilizers on grain yield and some agronomic characteristics in pea production were tried to be determined.

2. Materials and Methods

High yielding 16002, 16011, 16018, 16022, and Ultrello x Rondo genotypes and registered Betagreen variety developed by Prof. Dr. Ercan CEYHAN and suitable for fresh consumption were used as materials in the research.

Some properties of sheep manure used as material in the study were moisture 10.35%, organic matter 74.1%, pH 7.53, nitrogen 1.63%, water-soluble P_2O_5 0.17%, water-soluble K_2O 3.26%, water-soluble Zn 1.60 ppm and water-soluble Fe 4.80 ppm. Some properties of cow manure were moisture 2.96%, organic matter 76.67%, pH 7.38, nitrogen 1.55%, water-soluble P_2O_5 0.16%, water-soluble K_2O 3.00%, water-soluble Zn 2.40 ppm and water-soluble Fe 29.60 ppm (Kahraman and Ceyhan2022; Küçük and Ceyhan 2022).

According to the 17-year meteorological observations made in Konya province during the vegetation period in the year, the trials were established, the 17-year average temperature, total precipitation, and average relative humidity were 22.5 ^{0}C, 80.1 mm and 40.8%, respectively. In 2021, when the experiment was established, it was realized as 21.8 ^{0}C, 105.2 mm and 42.2%.

The previous crop in the research area was wheat. After the wheat plant was harvested, the soil was deeply plowed in October, allowing it to spend the winter in this way. In March, the experimental area was ploughed and parceled, and organic fertilizers (cow and sheep manure) were applied to the main plots. Control (no fertilizer), nitrogen 50 kg ha^{-1} as pure matter from chemical fertilizer (urea), cow manure 30000 kg ha^{-1}, sheep manure 20000 kg ha^{-1} were randomly placed in the main plots. According to the experimental design, control (no fertilizer), 0.72 kg of urea fertilizer, 195 kg of cow manure, and 130 kg of sheep manure were applied to the main plots. The organic fertilizers and chemical fertilizers, previously weighed for each main plot, were evenly distributed into the plots with the help of a shovel and rake and mixed into the soil with a hand hoe rotavator.

The experiment was established on May 2, 2021, in the experimental field of Selçuk University, Faculty of Agriculture, Prof. Dr. Abdülkadir AKÇİN Research and Application Station on tempered soil with 3 replications according to the "Split Plots Experiment in Randomized Blocks" design. In the research, fertilizers were randomly placed in the main plots, and varieties were randomly placed in the sub-plots. The sub-plots were 5.0 m x 2.5 m = 12.5 m2. Seeds were sown by hand to a depth of 3 cm in the rows opened with a marker, with 50 cm between rows and 10 cm above rows. Five rows were sown in each plot.

During the plant growth period, hoeing was performed twice to clean the test plots from weeds, and irrigation was performed 3 times to meet the water needs of the pea plant depending on the climatic conditions. The first irrigation was done when the plants were 10-15 cm after emergence due to lack of rainfall, the second irrigation was done at flowering time and the last at the pod filling period. Harvesting was done manually between July 20 and 25, 2021. Harvesting was done when all plants were mature in each genotype.

Each agricultural traits examined in the experiment was subjected to statistical analysis separately. The differences of the averages calculated for each treatment were grouped according to the "LSD test", some at 1% and some at 5%. Statistical analyses were performed by using the MSTATC software program.

3. Results and Discussion

3.1. Number of Branches per Plant

The difference between fertilizer treatments and genotypes, and fertilizer treatments x genotype interactions were found to be statistically significant at a 1% level in terms of branch number values of pea cultivars (Table 1). Göksu (2012); Ceyhan et al. (2005); Ceyhan et al. (2012) reported that there were statistically significant differences between the genotypes in their study.

As can be seen from the examination of Table 2, when the fertilizer treatments of the varieties are compared with each other in terms of the number of branches, it is seen that they produce different results. As the average of the varieties, the highest number of branches was obtained in chemical fertilizer application with 4.13 number/plant. This was followed by cow manure (3.96 number/plant) and sheep manure (3.57 number/plant) treatments in descending order. The lowest number of branches was obtained from the plants grown in the control treatment with 3.18 number/plant. In general, fertilization treatments positively affected on the number of branches compared to the control (Göksu 2012).

According to the averages of fertilizer treatments, the number of branches of the varieties varied between 3.32 - 4.25 number/plant. The highest number of branches was obtained in 16011 and the lowest number was obtained in Betagreen variety. The number of branches of other varieties was between these values. It was determined that the varieties gave different reactions according to the fertilizer type. If the number of branches is high, the pods formed and therefore as the number of seeds per plant will also increase, the yield also increases (Ceyhan et al. 2005; Göksu 2012; Ceyhan et al. 2012; Al-Bayati et al. 2019).

The highest number of branches was obtained in genotype 16011 with 5.11 number/plant in chemical fertilizer. In contrast, the lowest number of branches was determined in the Betagreen variety with 2.56 number/plant in the control treatment. These results show that although the number of branches is a cultivar trait, fertilizer application also highly affects it. Some researchers also reported that different fertilizer applications increased the number of branches in some plants (Göksu 2012).

3.2. Plant Height

As shown in Table 1, the difference among fertilizer treatments, genotypes and fertilizer treatments x genotype interaction was statistically significant at 1% level in terms of plant height values. In previous studies, Gopinath et al. (2009); Göksu (2012) Al-Bayati et al. (2019) reported that there were statistical differences among fertilizer treatments in terms of plant height, while Ceyhan et al. (2008) reported that there were statistical differences among genotypes in terms of plant height.

According to the average of genotypes, the highest plant height was obtained from cow manure treatment with 47.67 cm, while the lowest plant height was determined in sheep manure treatment with 45.89 cm. These results show that plant height is significantly affected by chemical and organic fertilizer applications as well as cultivar characteristics (Gopinath et al. 2009; Bulut 2013; Al-Bayati et al. 2019; Kahraman and Ceyhan 2022; Küçük and Ceyhan 2022).

In pea plant, the highest plant height was measured in the Ultrillo x Rondo variety with 51.79 cm as the average of fertilizer treatments. This was followed by Betagreen (48.71 cm), 16011 (48.15 cm), 16022 (45.89 cm) and 16018 (45.43 cm) in descending order. The lowest plant height was measured from genotype 16002 with 43.84 cm (Table 2). The genetic structure of the cultivars is the most determining factor on plant height in pea (Ceyhan 2004; Ceyhan et al. 2008). Many previous studies reported that the stature of pea varieties was different (Ceyhan 2004; Ceyhan et al. 2008; Ceyhan et al. 2012; Avcı and Ceyhan 2013).

Table 1. Analysis of variance for the traits examined in pea genotypes treated with organic and chemical fertilizers.

Sources of Variance	df	Number of Branches per Plant	Plant Height	Number of Pods per Plant
Total	71			
Replication	2	0,051	2,272	0,786
Fertilizer Treatments (FT)	3	3,248**	50,109**	406,165**
Error1	6	0,128	2,797	0,615
Genotypes (G)	5	1,508**	96,821**	33,865**
FT x G Interaction	15	0,387**	16,921**	4,772**
Error2	40	0,100	6,116	0,564
Sources of Variance	**df**	**Number of Seeds per Pod**	**Number of Seeds per Plant**	**Hundred-Seed Weight**
Total	71			
Replication	2	0,078	1,927	0,343
Fertilizer Treatments (FT)	3	9,706**	31639,800**	47,210**
Error1	6	0,083	64,243	0,230
Genotypes (G)	5	1,028**	1977,180**	232,899**
FT x G Interaction	15	0,095*	300,572**	2,357**
Error2	40	0,047	32,250	0,254
Sources of Variance	**df**	**Seed Yield**	**Protein Content**	**Protein Yield**
Total	71			
Replication	2	61,184	0,025	2,240
Fertilizer Treatments (FT)	3	93024,700**	1,383**	4835,620*
Error1	6	119,120	0,004	6,489
Genotypes (G)	5	2763,770**	2,170**	147,916*
FT x G Interaction	15	161,238	0,239**	8,790
Error2	40	87,000	0,018	4,809

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Table 2. Means and LSD groups of the number of branches per plant, plant height and number of pods per plant of pea genotypes treated with organic and chemical fertilizers.

Genotypes	Chemical and Organic Fertilizers				
	Control	Chemical Fertilizer	Cow Manure	Sheep Manure	Mean
			Number of Branches per Plant		
16002	3,67 c-g	3,72 c-g	3,33 fgh	3,52 d-g	3,56 b
16011	3,31 fgh	5,11 a	4,92 ab	3,66 c-g	4,25 a
16018	3,15 ghı	3,88 c-f	3,90 c-f	3,40 efg	3,58 b
16022	2,67 hı	4,06 cde	3,78 c-g	3,56 d-g	3,52 b
Betagreen	2,56 ı	3,92 c-f	3,50 d-g	3,30 fgh	3,32 b
Ultrello x Rondo	3,73 c-g	4,11 cd	4,33 bc	3,97 c-f	4,04 a
Mean	3,18 c	4,13 a	3,96 ab	3,57 bc	3,71
	$\text{Lsd}_{\text{Çeşit x Gübre}}$: 5,461; $\text{Lsd}_{\text{Çeşit}}$: 2,730; $\text{Lsd}_{\text{Gübre}}$: 2,067				
			Plant Height (cm)		
16002	40,89 h	46,96 c-g	44,81 e-h	42,71 fgh	43,84 d
16011	49,56 a-e	49,56 a-e	48,70 b-e	44,79 e-h	48,15 bc
16018	44,71 e-h	47,36 c-f	46,42 d-g	43,22 fgh	45,43 cd
16022	41,66 gh	49,96 a-e	46,82 c-g	45,11 e-h	45,89 cd
Betagreen	45,74 e-h	54,00 ab	47,71 c-f	47,38 c-f	48,71 b
Ultrello x Rondo	54,30 a	49,22 a-e	51,55 a-d	52,10 abc	51,79 a
Mean	46,14 b	49,51 a	47,67 ab	45,89 b	47,30
	$\text{Lsd}_{\text{Çeşit x Gübre}}$: 1,658; $\text{Lsd}_{\text{Çeşit}}$: 0,8292; $\text{Lsd}_{\text{Gübre}}$: 0,9691				
			Number of Pods per Plant		
16002	14,84 fg	28,51 b	21,30 d	19,81 de	21,12 b
16011	14,78 fg	30,78 a	24,25 c	23,54 c	23,34 a
16018	14,40 fg	24,59 c	20,27 de	19,19 e	19,61 c
16022	15,22 f	23,14 c	19,40 e	19,21 e	19,24 c
Betagreen	13,26 g	24,28 c	19,86 de	19,18 e	19,15 c
Ultrello x Rondo	13,35 g	24,11 c	20,08 de	19,09 e	19,16 c
Mean	14,31 c	25,90 a	20,86 b	20,00 b	20,27
	$\text{Lsd}_{\text{Çeşit x Gübre}}$: 0,3578; $\text{Lsd}_{\text{Çeşit}}$: 0,2394; $\text{Lsd}_{\text{Gübre}}$: 0,3560				

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The highest plant height average was 54.30 cm in the Ultrillo x Rondo genotype in the control treatment and the lowest was 40.89 cm in 16002 genotype in the control treatment (Table 2). Plant height of the genotypes used in the study showed differences according to fertilizer applications (Gopinath et al. 2009; Göksu 2012; Bulut 2013; Al-Bayati et al. 2019; Kahraman and Ceyhan 2022; Küçük and Ceyhan 2022).

3.3. Number of Pods per Plant

Fertilizer treatments, genotypes and fertilizer treatments x genotype interaction were statistically significant at 1% level (Table 1). While it was reported by Gopinath et al. (2009); Göksu (2012); Al-Bayati et al. (2019) that fertilizer applications affected the number of pods in pea, it was also reported by Ceyhan (2004); Ceyhan et al. (2008); Gopinath et al. (2009); Ceyhan et al. (2012); Göksu (2012); Avcı and Ceyhan (2013) that there were significant differences among cultivars in terms of pod number.

According to the mean of the varieties, the highest number of pods was obtained from chemical fertilizer application with 25.90 number/plant. This was followed in descending order by cow dung application (20.86 pcs/plant) and sheep dung application (20.00 number/plant). The lowest number of pods was found in the control treatment with 14.31 number/plant. Gopinath et al. (2009); Göksu (2012); Bulut (2013); Al-Bayati et al. (2019); Kahraman and Ceyhan (2022); Küçük and Ceyhan (2022) reported that organic fertilizer applications increased the number of pods.

The mean values for the number of pods of pea varieties are given in Table 2. According to the averages of fertilizer treatments, the number of pods of the varieties varied between 19.15 - 23.34 number/plant. Among the varieties, the highest number of pods was determined in genotype 16011 and the lowest number of pods was determined in the Betagreen variety. Similar results were obtained in many previous studies (Ceyhan 2004; Ceyhan et al. 2008; Gopinath et al. 2009; Ceyhan et al. 2012; Göksu 2012; Avcı and Ceyhan 2013).

When the varieties were compared with each other in terms of number of pods in terms of fertilizer applications, it was observed that they produced different results. The highest number of pods was obtained from genotype 16011 in chemical fertilizer treatment with 30.78 number/plant, while the lowest number of pods was obtained from the Betagreen variety in control treatment with 13.26 number/plant. This shows that although the number of pods is a cultivar characteristic, it is also highly affected by fertilizer applications (Gopinath et al. 2009; Göksu 2012; Bulut 2013; Al-Bayati et al. 2019; Kahraman and Ceyhan 2022; Küçük and Ceyhan 2022).

3.4. Number of Seeds per Pod

The difference between fertilizer treatments and genotypes regarding of the number of seeds in pods was statistically significant at 1% level, while the fertilizer treatment x genotype interaction was statistically significant at 1% level (Table 1). It was reported in previous studies that the effects of organic fertilizer applications on the number of grains in pods were statistically significant in pea (Gopinath et al. 2009; Göksu 2012; Al-Bayati et al. 2019) and bean (Kahraman and Ceyhan 2022; Küçük and Ceyhan 2022). In previous studies, many researchers reported that there were statistical differences between varieties in terms of the number of grains in pods (Ceyhan 2004; Ceyhan et al. 2008; Gopinath et al. 2009; Ceyhan et al. 2012; Göksu 2012; Avcı and Ceyhan 2013).

According to the mean of the varieties, the highest number of seeds in pods was determined in chemical fertilizer application with 6.64. This was followed by cow manure application (6.13 number/pod) and sheep manure application (5.90 number/ pod) in decreasing order. The lowest number of seeds per pod was obtained from the control treatment with 4.90 (Table 2). It was determined that fertilizer applications increased the number of seeds in pods of peas (Gopinath et al. 2009; Göksu 2012; Al-Bayati et al. 2019) and beans (Kahraman and Ceyhan 2022; Küçük and Ceyhan 2022).

According to the averages of fertilizer applications, the number of seeds per pod of the varieties varied between 5.64 (Betagreen) and 6.43 (16018 genotype). The number of seeds per pod of other varieties were between these values. Similar results were also reported by Ceyhan (2004); Ceyhan et al. (2008); Gopinath et al. (2009); Ceyhan et al. (2012); Göksu (2012); Avcı and Ceyhan (2013) who conducted studies on this subject.

Table 3. Means and LSD groups of the number of seeds per pods, number of seeds per plant and hundred-seed weight of pea genotypes treated with organic and chemical fertilizers.

Genotypes	Chemical and Organic Fertilizers				
	Control	Chemical Fertilizer	Cow Manure	Sheep Manure	Mean
			Number of Seeds per Pod		
16002	4,67 j	6,70 b	6,18 efg	5,92 fgh	5,87 bc
16011	5,01 ıj	6,60 bcd	6,26 def	5,91 fgh	5,94 b
16018	5,21 ı	7,48 a	6,77 b	6,26 def	6,43 a
16022	4,89 ıj	6,07 e-h	5,85 gh	5,74 h	5,64 cd
Betagreen	4,93 ıj	6,68 bc	5,95 fgh	5,85 gh	5,85 bcd
Ultrello x Rondo	4,66 j	6,33 cde	5,79 h	5,73 h	5,63 d
Mean	4,90 c	6,64 a	6,13 b	5,90 b	5,89
	$Lsd_{Çeşit\ x\ Gübre}$: 12,54; $Lsd_{Çeşit}$: 6,270, $Lsd_{Gübre}$: 9,905				
			Number of Seeds per Plant		
16002	69,29 hı	190,98 ab	131,74 ef	117,30 g	127,33 b
16011	73,83 hı	203,07 a	151,60 cd	138,98 e	141,87 a
16018	75,11 h	183,96 b	137,20 e	120,03 fg	129,08 b
16022	74,54 hı	140,44 de	113,38 g	110,30 g	109,67 c
Betagreen	65,22 hı	162,14 c	118,26 g	112,28 g	114,47 c
Ultrello x Rondo	62,18 ı	152,58 cd	116,31 g	109,32 g	110,10 c
Mean	70,03 d	172,20 a	128,08 b	118,03 c	122,09
	$Lsd_{Çeşit\ x\ Gübre}$: 1,113; $Lsd_{Çeşit}$: 0,5564; $Lsd_{Gübre}$: 0,5927				
			Hundred-Seed Weight (g)		
16002	22,61 ı	25,71 gh	23,60 ı	22,92 ı	23,71 d
16011	24,96 h	32,08 cde	26,98 f	26,27 fg	27,57 c
16018	32,34 cde	35,99 a	34,71 b	35,24 ab	34,57 a
16022	32,41 cde	35,33 ab	34,36 b	34,31 b	34,10 a
Betagreen	31,47 e	34,81 b	32,95 cd	32,95 cd	33,05 b
Ultrello x Rondo	32,00 de	35,42 ab	32,88 cd	33,15 c	33,36 b
Mean	29,30 c	33,22 a	30,91 b	30,81 b	31,06
	$Lsd_{Çeşit}$: 10,30; $Lsd_{Gübre}$: 13,49				

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The highest number of seeds in pods was determined in genotype 16018 in chemical fertilizer treatment with 7.78, while the lowest number of seeds in pods was obtained in Ultrillo x Rondo genotype in control treatment with 4.66. The highest number of seeds in pods was obtained in the chemical fertilizer treatment. Similar results were also reported by Kahraman and Ceyhan (2022); Küçük and Ceyhan (2022) in beans.

3.5. Number of Seeds per Plant

As shown in Table 1, fertilizer treatments, genotypes and fertilizer treatments x genotype interaction were found to be statistically significant at 1% level. It was reported by many researchers that there were significant differences among fertilizer treatments in terms of the number of seeds per plant in pea (Göksu 2012; Al-Bayati et al. 2019). Ceyhan (200) and Ceyhan (2003) found significant differences among varieties in the number of seeds per plant.

In this study, the highest number of grains per plant was obtained from chemical fertilizer application with 172.20 and the lowest number of seeds per plant was obtained from control application with 70.03. The number of grains per plant was 128.08 in cow manure and 118.03 in sheep manure treatment (Table 2). These results show that the number of grains per plant is significantly affected by fertilizer applications as well as genetic structure (Göksu 2012; Al-Bayati et al. 2019).

As the average fertilizer treatments, the highest number of grains per plant was determined in genotype 16011 with 141.87. This was followed by 16018 (129.08 number), 16002 (127.33 number), Betagreen (114.47) and Ultrillo x Rondo (110.10) genotypes in descending order. The lowest number of seeds per plant was obtained from genotype 16022 with 109.67 number (Table 2). In many previous studies, it was reported that the number of seeds per plant of pea genotypes were different (Ceyhan 2004; Ceyhan et al. 2008; Ceyhan et al. 2012; Göksu 2012; Avcı and Ceyhan 2013; Al-Bayati et al. 2019).

In the study, the highest number of seeds per plant was determined in genotype 16018 in chemical fertilizer treatment with 203.07 number, while the lowest number of seeds per plant was determined in the Ultrello x Rondo genotype in control treatment with 62.18 number. The chemical fertilizer treatment determined the highest number of seeds per plant. The number of seeds per plant of pea cultivars was affected differently by organic and chemical fertilizer applications. Similar results were also reported by Al-Bayati et al. (2019).

3.6. Hundred-Seed Weight

The effect of fertilizer treatments, genotypes and fertilizer treatments x genotypes interaction on hundred-seed weight was found statistically significant at 1% level (Table 1). In many studies, researchers have stated that there are significant differences among varieties in terms of hundred-seed weight in peas (Ceyhan 2004; Ceyhan et al. 2008; Ceyhan et al. 2012; Göksu 2012; Avcı and Ceyhan 2013).

As the average of the varieties used in the study, the highest hundred-seed weight was determined in chemical fertilizer treatment with 33.22 g. The lowest hundred-seed weight was determined in the control treatment with 29.30 g. In this study, the hundred-seed weight was 30.91 g in cow manure and 30.81 g in sheep manure application (Table 2). As in other plants, thousand-seed weight, which is one of the most important agricultural traits affecting seed yield in peas (Göksu 2012) and bean (Kahraman and Ceyhan 2022; Küçük and Ceyhan 2022), is highly affected by fertilizer applications.

According to the average of fertilizer treatments, the highest hundred-seed weight was obtained from genotype 16018 with 34.57 g, followed by genotypes 16022 (30.10 g), Ulltrillo (33.36 g), Betagreen (33.05 g) and 16011 (27.57 g) in descending order. The lowest hundred-seed weight was found in genotype 16002 with 23.71 g (Table 2). The facial grain weight values obtained in this study are similar to the results of similar studies conducted on the subject by Ceyhan (2004); Ceyhan et al. (2008); Ceyhan et al. (2012); Göksu (2012); Avcı and Ceyhan (2013).

Table 4. Means and LSD groups of the seed yield, protein content and protein yield of pea genotypes treated with organic and chemical fertilizers.

Genotypes	Chemical and Organic Fertilizers				
	Control	**Chemical Fertilizer**	**Cow Manure**	**Sheep Manure**	**Mean**
			Seed Yield (kg/da)		
16002	115,07	288,04	218,36	208,97	207,61 d
16011	114,90	294,43	250,59	217,62	219,39 bc
16018	139,74	325,03	273,19	245,07	245,76 a
16022	136,37	292,55	242,13	235,89	226,73 b
Betagreen	121,10	287,83	235,91	215,86	215,18 cd
Ultrello x Rondo	145,31	314,37	271,85	237,18	242,18 a
Mean	128,75 d	300,38 a	248,67 b	226,77 c	226,14
	$Lsd_{Çeşit}$: 10,30; $Lsd_{Gübre}$: 13,49				
			Protein Content (%)		
16002	22,28 gh	22,18 h	23,09 bcd	22,29 gh	22,46 d
16011	22,42 gh	23,17 bcd	23,22 bcd	23,27 bc	23,02 b
16018	22,14 h	22,26 gh	22,21 gh	22,98 cde	22,40 d
16022	23,19 bcd	23,33 b	23,38 b	24,13 a	23,51 a
Betagreen	22,48 fg	22,32 gh	22,39 gh	22,93 de	22,53 d
Ultrello x Rondo	22,42 gh	22,43 gh	22,73 ef	23,13 bcd	22,68 c
Mean	22,49 d	22,62 c	22,84 b	23,12 a	22,77
	$Lsd_{Çeşit\ x\ Gübre}$: 0,2963; $Lsd_{Çeşit}$: 0,1481; $Lsd_{Gübre}$: 0,07816				
			Protein Yield (kg/da)		
16002	25,64	63,88	50,42	46,58	46,63 c
16011	25,75	68,23	58,21	50,64	50,71 b
16018	30,94	72,35	60,68	56,32	55,07 a
16022	31,62	68,26	56,60	56,92	53,35 a
Betagreen	27,23	64,24	52,83	49,50	48,45 bc
Ultrello x Rondo	32,57	70,51	61,79	54,85	54,93 a
Mean	28,96 d	67,91 a	56,76 b	52,47 c	51,52
	$Lsd_{Çeşit}$: 2,421; $Lsd_{Gübre}$: 3,148				

[1] Tables may have a footer.

This study determined the highest hundred-seed weight was in genotype 16018 in chemical fertilizer treatment with 35.99 g. In comparison, the lowest hundred-seed weight was determined in genotype 16002 in the control treatment with 22.61 g. The chemical fertilizer treatment determined the highest hundred-seed weights of the varieties.

3.7. Seed Yield

The differences between fertilizer treatments and genotypes regarding seed yield in pea genotypes were statistically significant at a 1% level, while the location x genotype interaction was found statistically insignificant (Table 1). Similar to our results, Gopinath et al. (2009); Göksu (2012); Al-Bayati et al. (2019) reported that there were significant differences among fertilizer treatments and Ceyhan (2004); Ceyhan et al. (2008); Gopinath et al. (2009); Ceyhan et al. (2012); Göksu (2012); Avcı and Ceyhan (2013) reported that there were significant differences among pea varieties in terms of seed yield.

As can be seen from the examination of Table 2, the seed yield of the genotypes used in the research, which was 128.75 kg/ha in the control treatment, increased to 226.77 kg/ha in sheep manure treatment, 248.67 kg/ha in cow manure treatment and 300.38 kg/ha in chemical fertilizer treatment. The seed yields of the genotypes varied between 114.90 (16011) - 145.31 kg (Ultrillo x Rondo) in the control treatment, 208.97 (16002) - 245.07 kg (16018) in the sheep manure treatment, 218.36 (16002) - 273.19 kg (16018) in the cow manure treatment and 292.55 (16022) - 325.03 kg (16018) in the chemical fertilizer treatment. Many traits form seed yield in peas as in all other plants, and many factors such as growing conditions and cultural practices (irrigation, sowing frequency and fertilizer etc.) besides the genetic structure of the plant affect the yield (Ceyhan 2004; Ceyhan et al. 2008; Ceyhan et al. 2012). The application of manure and chemical fertilizer increased the yield of peas. The differences between manure and chemical fertilizers show differences in their effects on seed yield as the nutrients they provide to plants differ (Jannoura et al. 2014; Kahraman and Ceyhan 2022; Küçük and Ceyhan 2022). In many previous studies, it was reported that fertilizer applications significantly increased grain yield in legume crops including peas (Gopinath et al. 2009; Göksu 2012; Al-Bayati et al. 2019; Kahraman and Ceyhan 2022; Küçük and Ceyhan 2022).

The mean values and groups of seed yields of the genotypes used in the study are given in Table 2. According to the mean values of the locations, the highest seed yield was determined in genotype 16018 with 245.76 kg/da and the lowest seed yield was determined in genotype 16002 with 207.61 kg/da (Table 2). The other genotypes used in the study were Ultrillo x Rondo (242.18 kg/da), 16022 (226.73 kg/da), 16011 (219.39 kg/da) and Betagreen (215.18 kg/da) in descending order (Table 2). The seed yield values of the varieties in this study were in agreement with the grain yields obtained by Ceyhan (2004); Ceyhan et al. (2008); Gopinath et al. (2009); Ceyhan et al. (2012); Göksu (2012); Avcı and Ceyhan (2013); Al-Bayati et al. (2019).

3.8. Protein Content

Fertilizer treatments, genotypes and fertilizer treatments x genotype interaction were found to be statistically significant at 1% level in terms of the protein content of pea genotypes used in the experiment (Table 1). Differences among fertilizer treatments in terms of protein content were reported by Göksu (2012) and differences among genotypes were also reported by Ceyhan (2004); Göksu (2012); Harmankaya et al. (2010); Ceyhan and Şimşek (2021).

As the average of the genotypes, the protein content was determined as 22.46% in the control treatment, 22.62% in the chemical fertilizer treatment, 22.84% in the cow manure treatment and 23.12% in the sheep manure treatment. In the study, protein contents were higher in organic fertilizer treatments than in control and chemical fertilizer treatments. Manure and chemical fertilizers are one of the most effective factors causing changes in plant protein content and improved crop quality (Göksu 2012; Kahraman and Ceyhan 2022; Küçük and Ceyhan 2022).

The highest protein ratio was obtained from genotype 16022 with 23.51%, followed by genotypes 16011 (23.02%), Ultrillo x Rondo (22.68%), Betagreen (22.53%) and 16002 (22.46%). The lowest protein content value was found in genotype 16018 with 22.40%. The protein content in peas is closely related to the genetic structure of the genotypes and the cultivation technique (Ceyhan 2004; Harmankaya et al. 2010). The results obtained in this study are very similar to the results obtained by Ceyhan (2004); Ceyhan et al. (2005); Harmankaya et al. (2010); Ceyhan and Şimşek (2021).

The highest protein content was determined in genotype 16022 with 24.13% in the sheep manure treatment, while the lowest protein content was determined in genotype 16018 with 22.14% in the control treatment. In terms of protein content, the responses of the genotypes to the fertilizer treatments were very different (Table 2).

3.9. Protein Yield

While the differences among fertilizer treatments and genotypes in terms of protein yield were statistically significant at 1% level, the location x genotype interaction was statistically insignificant (Table 1). Similar to our results, Önder et al. (2001); Ceyhan et al. (2008) reported significant differences among fertilizer treatments and Önder et al. (2001); Ceyhan et al. (2008) reported significant differences among pea varieties in terms of protein yield.

As the average of the genotypes used in the study, protein yield, which was 28.96 kg/ha in the control treatment, increased to 52.47 kg/ha in sheep manure treatment, 56.76 kg/ha in cow manure treatment and 67.91 kg/ha in chemical fertilizer treatment. Ceyhan (2004) reported that fertilizer applications significantly increased protein yield.

According to the mean values of the locations, the highest protein yield was determined in genotype 16018 with 55.07 kg/da and the lowest was in genotype 16002 with 46.63 kg/da (Table 2). The other genotypes used in the study were Ultrillo x Rondo (54.93 kg/da), 16022 (53.35 kg/da), 16011 (50.71 kg/da) and Betagreen (48.45 kg/da) in descending order (Table 2). The protein yields of the varieties in this study agreed with the protein yields reported in previous studies (Ceyhan 2004).

4. Conclusions

Peas grown with organic fertilization give less grain yield than those grown with chemical fertilization. However, considering it provides a more long-term and sustainable nutrient source, it can be easily used in pea cultivation. In addition, it was determined that the protein content of peas grown with organic fertilization had higher values than those grown with chemical fertilization.

The study results showed that organic fertilization is a sustainable and environmentally friendly option for pea cultivation. Organic fertilization offers long-term productivity and nutritional value advantages by maintaining soil health. Therefore, preferring organic fertilization methods by considering environmental impacts will be an extremely important step for the future of agriculture.

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References

Al-Bayati HJM, Ibraheem FFR, Allela WBAM, Al-Taey DKA (2019). Role of organic and chemical fertilizer on growth and yield of two cultivars of pea (*Pisum sativum* L.). *Plant Archives*, 19(1): 1249-1253.

Avcı MA, Ceyhan E (2013). Determination of some agricultural characters of pea (*Pisum sativum* L.) genotypes. *Journal of Animal and Veterinary Advances*, 12(7): 798-802.

Bulut N (2013). Aşılı aşısız koşullarda fasulyede *(Phaseolus vulgaris L.*) organik gübrelerin verim ve verim öğeleri üzerine etkisi. Master Thesis, *Yüzüncü Yıl University (Unpublished), Türkiye.*

Ceyhan E (2004). Determination of some agricultural characters and their heredity through line x tester method in pea parents and crosses. Ph.D. Thesis, *Selcuk University (Unpublished), Türkiye.*

Ceyhan E, Avcı MA, Mcphee KE (2005). The determination of grain yield and some agronomical characters as winter cultivation of pea genotypes in Konya ecological conditions. *The University of Selcuk Journal of Faculty of Agriculture*, 19 (37): 6-1.

Ceyhan E, Avci MA, Karadas S (2008). Line x tester analysis in pea (*Pisum sativum* L.): Identification of superior parents for seed yield and its components. *African Journal of Biotechnology* 7: 2810-281.

Ceyhan E, Kahraman A, Ates MK, Karadaş S (2012). Stability analysis on seed yield and its components in peas. *Bulgarian Journal of Agricultural Science,* 18(6): 887-893.

Ceyhan E, Şimşek D (2021). Inheritance of some quality characters in canned pea population. *Türk Tarım ve Doğa Bilimleri Dergisi*, 8(1): 188–195.

Göksu E (2012). The effects of chemical, organic and microbial fertilization on yield and yield properties of pea (*Pisum sativum* L.). Ph.D. Thesis, *Uludağ University (Unpublished), Turkey.*

Harmankaya M, Özcan MM, Karadaş S, Ceyhan E (2010). Protein and mineral contents of pea (*Pisum sativum* L.) genotypes grown in Central Anatolian region of Turkey. *South Western Journal of Horticulture, Biology and Environment*, 1(2): 159-165.

Jannouraa R, Joergensena RG, Bruns C (2014). Organic fertilizer effects on growth, crop yield, and soil microbial biomass indices in sole and intercropped peas and oats under organic farming conditions. *European Journal of Agronomy*, 52: 259–270.

Savur O, Ceyhan E (2011). Melezleme yöntemiyle elde edilen yemeklik bezelye (*Pisum sativum* L.) hatlarının bazı tarımsal özelliklerinin belirlenmesi. *Selçuk Tarım ve Gıda Bilimleri Dergisi*, 25(2): 17-23.

Yolcu M (2010). The organic agriculture dissertations on pepper plants. Master Thesis*, Dumlupınar University (Unpublished), Türkiye.*