COMPARISON OF ORGANIC AND CHEMICAL FERTILIZER USE: THE CASE OF MURATLI DISTRICT OF TEKİRDAĞ PROVINCE

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ABSTRACT

The industrial revolution, which followed the green revolution, increased the use of synthetic fertilizers while increasing the yield from the unit area. According to the 2019 data of the Ministry of Agriculture and Forestry, the pure plant nutrients (N, P_2O_5, K_2O) used in Turkey as of the end of 2018 decreased by 18.15% compared to the previous year and became 2,164,158 tons. Intensive use of inorganic fertilizers in agriculture causes health problems and irreversible environmental pollution. The research carried out is to review the effects of organic and inorganic fertilizers on various aspects of plants, and to reach the proportional values of unconscious chemical fertilizer use in order to increase the yield despite the low amount of organic matter in the Thrace region. It is to create statistical values in this area, evaluate it with the socio-cultural effects of the region, and determine what needs to be done and what to do. As a result of the research, it was determined that about 72% of the population is at primary education level, about 89% of the producers determine the amount of fertilizers based on the advice of friends and their own experiences, and only 11% of the producers have soil analysis, even if it is irregular, in the field of fertilizer consumption. The reason for not complying with 50% of the fertilizer analysis data is the thought that it is incomplete. Considering the organic fertilizer knowledge level of the producers, approximately 86% of them have some knowledge. According to the data we received from our survey; In order to increase the efficiency of fertilizer use, it is important to popularize the use of organic and organomineral fertilizers in addition to chemical fertilizers, to support farmers in terms of education and to raise awareness.

Keywords: Organic matter, Organic fertilizer, Chemical fertilizer, Soil

ORGANİK VE KİMYASAL GÜBRE KULLANIMININ KARŞILAŞTIRILMASI: TEKİRDAĞ İLİ MURATLI İLÇESİ ÖRNEĞİ

ÖZET

Yeşil devrimi izleyen sanayi devrimi, bitkisel üretimde birim alandan verim artışına neden olurken, tarımda sentetik gübre kullanımını artırmıştır. Tarım ve Orman Bakanlığı 2019 verilerine göre Türkiye'de 2018 sonu

itibariyle kullanılan saf bitki besin maddesi (N, P_2O_5, K_2O) bir önceki seneye oranla %18,15 azalarak 2.164.158 ton olmuştur. Toplam işlenen tarım alanı miktarı ise 23.185.463 hektardır. Tarımda yoğun inorganik gübre kullanımı sağlık sorunlarına ve geri dönüşü olmayan çevre kirliliğine neden olmaktadır. Yapılan araştırma organik ve inorganik gübrelerin bitkilerin çeşitli yönleri üzerindeki etkisini gözden geçirmek, Trakya bölgesindeki toprakların organik madde miktarının azlığına rağmen verimi artırmak adına genel olarak bilinçsiz kimyasal gübre kullanımının oransal değerlerine ulaşmaktır. Bu alanda istatistiksel değerler oluşturup bölgenin sosyokültürel etkileriyle değerlendirmek ve yapılması gereken ve yapılacakları belirlemektir. Araştırma sonucunda elde edilen veriler gübre tüketimi konusunda kitlenin yaklaşık %72'si en çok ilköğretim seviyesinde ve üreticileri yaklaşık %89'u arkadaş tavsiyesi ve kendi tecrübelerine göre gübre miktarlarını belirlediği, incelenen işletmelerde düzensizde olsa üreticilerin sadece %11 oranında toprak analizi yaptırdıkları saptanmıştır. Gübre analizi verilerine %50'sinin uymama nedeni eksik geldiği düşüncesidir. Üreticilerin organik gübre bilgi seviyelerine bakıldığında yaklaşık olarak %86'lık kısmı biraz bilgi sahibidir. Yaptığımız anketten aldığımız verilere göre; gübre kullanımı etkinliğinin artırılması amacıyla kimyasal gübrelerin yanında organik ve organomineral gübre kullanımının yaygınlaştırılması, çiftçilerin eğitimsel açıdan desteklenmesi ve bilinçlendirilmesi önem arz etmektedir.

Anahtar Kelimeler: Organik madde, Organik gübre, Kimyasal gübre, Toprak

1.INTRODUCTION

For centuries, the use of organic fertilizers has been a common practice in China to maintain soil fertility and crop yields (Yan and Gong, 2010). With the increasing availability of chemical fertilizers since the late 1970s and rising labor costs since the 1980s, organic fertilizer use has declined significantly (Zhu and Chen, 2002). Large amounts of chemical fertilizers have been applied to arable land in the last few decades to prevent worldwide food shortages and maximize crop yields (Savcı, 2012). However, excessive use of chemical fertilizers has led to various problems such as severe soil degradation, nitrogen leaching, soil compaction, reduction in soil organic matter and soil carbon loss. In addition, the effectiveness of chemical fertilizers on crop yield decreases over time (Nkoa, 2014). Intensive use of land and water in the agricultural sector also forms the basis of the green economy. Misuse of natural resources is important for the sustainability of the ecosystem (Hurma, 2014). The agricultural sector itself is a source of pollution and is the sector most affected by pollution factors (Hurma, Demirkol and Yılmaz, 2016). The deterioration in the ecological system and natural resources is one of the primary factors affecting the health of living things and the quality of life of people (Hurma, 2007). Agricultural production will gain greater value in the future when insufficient water resources are added with the decrease in agricultural areas per capita as a result of the misuse and misuse of agricultural lands around the world, as well as the effect of irregular precipitation as a result of climate changes (FAO, 2015a; FAO, 2015b).

The aim of this paper is to review the effects of organic and inorganic fertilizers on various aspects of plants, to reach the proportional values of unconscious chemical fertilizer use in order to increase the yield despite the low amount of organic matter in the Thrace region. It is to create statistical values in this area, evaluate it with the socio-cultural effects of the region, and determine what needs to be done and what to do. The completion of the aforementioned questionnaire is face-to-face, and the primary data obtained from the face-to-face survey studies were formed with the producers dealing with agricultural production in Muratlı district and neighborhoods of Tekirdağ province. Detailed information on the agricultural structure, producers and land existence in the region was obtained from the public institutions in the

research region. Foreign and domestic literature on the subject was used as a secondary data source.

2.MATERIAL AND METHOD

The main material used in the research; It was obtained from the data collected from the producers in the Thrace region within the framework of the "Fertilizer Use Questionnaire in the Thrace Region". Survey studies were carried out to a total of 100 producers in Edirne, Kırklareli and Tekirdağ provinces. Survey studies were carried out by face-to-face interviews. The survey forms applied in the region are basically:

• Demographic information of the producers,

• Land presence, production information,

• Employee information of the enterprise,

• Availability of tools and equipment, and

• It included questions of different nature in order to compile information about the fertilization process. The questionnaire form is given in Appendix 1. The survey questions were prepared in accordance with the literature.

The completion of the aforementioned questionnaire is face-to-face, and primary data obtained from the producers in the Muratlı district of Tekirdağ province and its neighborhoods were created. Some detailed information such as the land availability and structural features of the research area were obtained from the producers or public institutions in the region. As a secondary data source, domestic and foreign literature on the subject was used.

The descriptive statistics of the answers obtained from the survey study were calculated and the results were presented by supporting with tables and graphics. SPSS (Statistical Package for Social Sciences) for Windows 25.0 program was used in the analysis of the data. MS Excel program was used to turn the results into graphs. While evaluating the data, descriptive statistical methods (number, percentage, mean, standard deviation) were used.

3.RESEARCH FINDINGS AND DISCUSSION

The parameters (fertilizer access, price, yield, advertisement, habits, trust) and perspective that the producers pay attention to when evaluating chemical and organic fertilizers are evaluated by performing cluster analysis in Table 1. The data obtained in this chart are the average data of farmer evaluations.

Table 1. Evaluation of concepts according to given qualifications

	Access to fertilizer	**Price**	**Yield**	**Advertisement**	**Habit**	**Confidence**
Chemical fertilizers	**4,15**	**1,09**	4,07	4,09	4,13	4,14
Organomineral Fertilizer	3,02	1,9	2,96	2,86	2,61	2,56
Vermicompost	3,34	1,91	3,35	3,15	2,99	3,01

Farm Fertilizer	3,34	1,7	3,61	3,59	3,63	3,61
Green Fertilizer	2,82	**2,11**	2,75	2,63	2,38	2,34

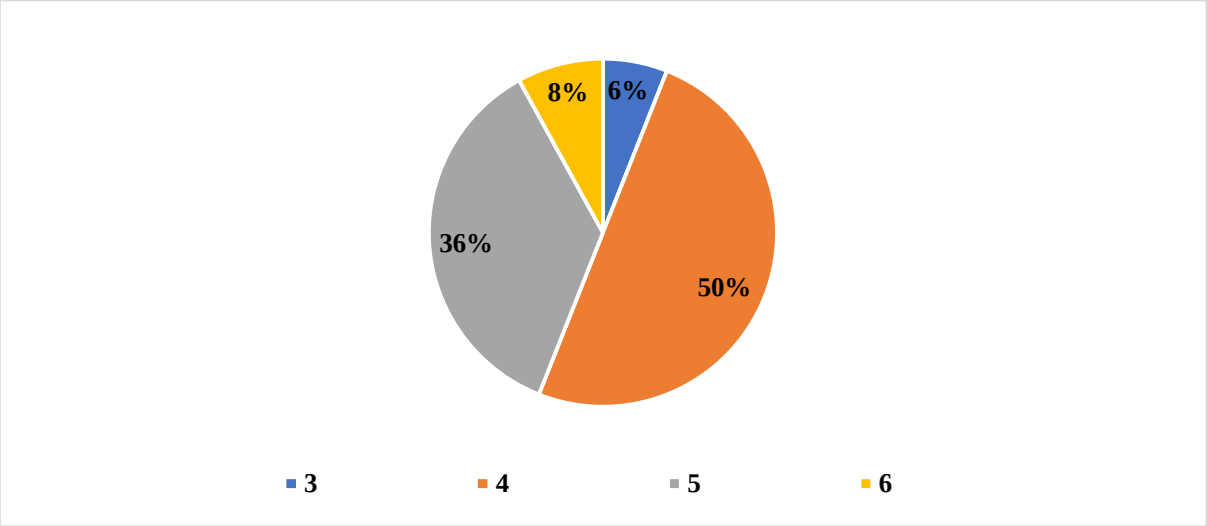

Figure 1. Family size distribution of producers

While the number of family members of approximately 50% of the producers of the examined enterprises is 4, the second largest ratio right after this is a family of 5 with 36%, a family of 6 with a ratio of 8%, a family of 6 with a ratio of 6%. family of 3 is followed by this ratio (Figure 1).

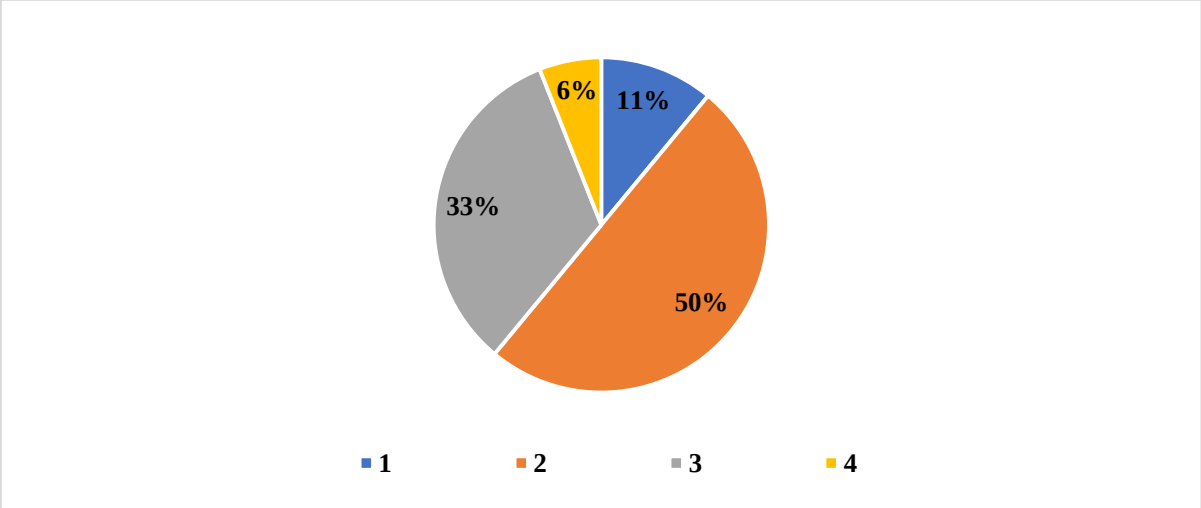

Figure 2. Distribution of producers by the number of people in the enterprise

While the producers of the examined enterprises have 2 people, the second largest ratio is 33%, a 3-person business with a ratio of 11%, a family of 1 with a ratio of 11%, and 6%. It is followed by a 4-person enterprise with a ratio of 3% (Figure 2).

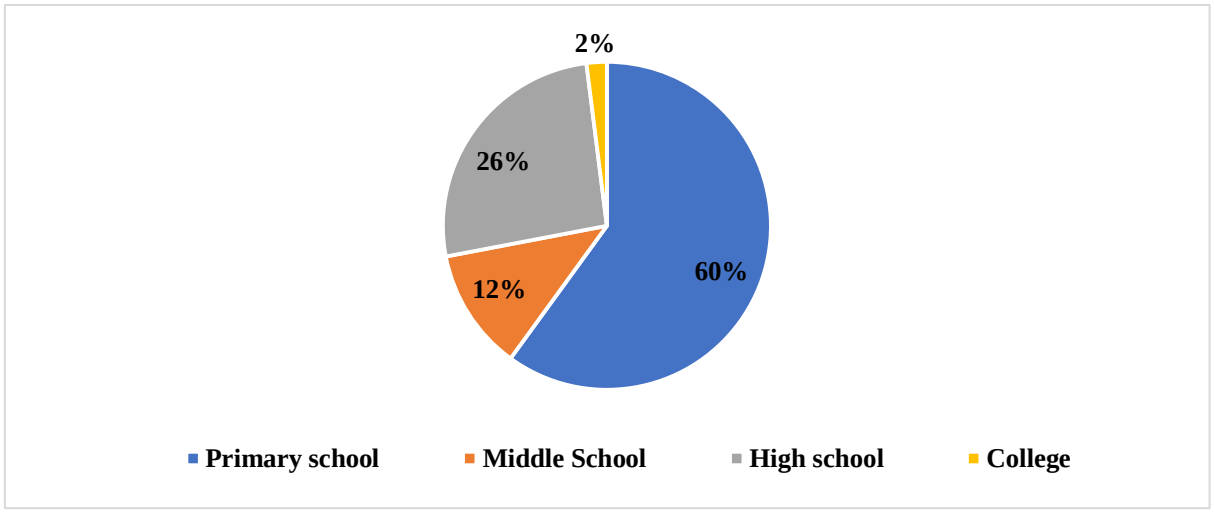

Figure 3. Distribution of producers by education level

The choices of people from different beliefs and segments that make up the country can naturally differ. The most important factors that can shape people's choices are; economic conditions, population, regional locations and education (Güngör, 2007). On the other hand, the relatively high level of education is important for manufacturers to accept some innovations (Mishra and Goodwin, 2003). For this reason, the educational status of the enterprises examined in the study areas was examined. In the study, it was determined that 60% of the target population was primary school, 26% high school, 12% secondary school and 2% college graduate (Figure 3). Therefore, approximately 72% of the target audience had primary education at most, while only 28% of the population had a high school or higher education. When the education levels of the farmers in Tokat Kazova region are examined, it is observed that 64.29% of them are primary school graduates, 14.29% are secondary school graduates, 20% are high school graduates, and 1.43% are undergraduate graduates (Gözener, Sayılı, & Yurdabakan, 2016).

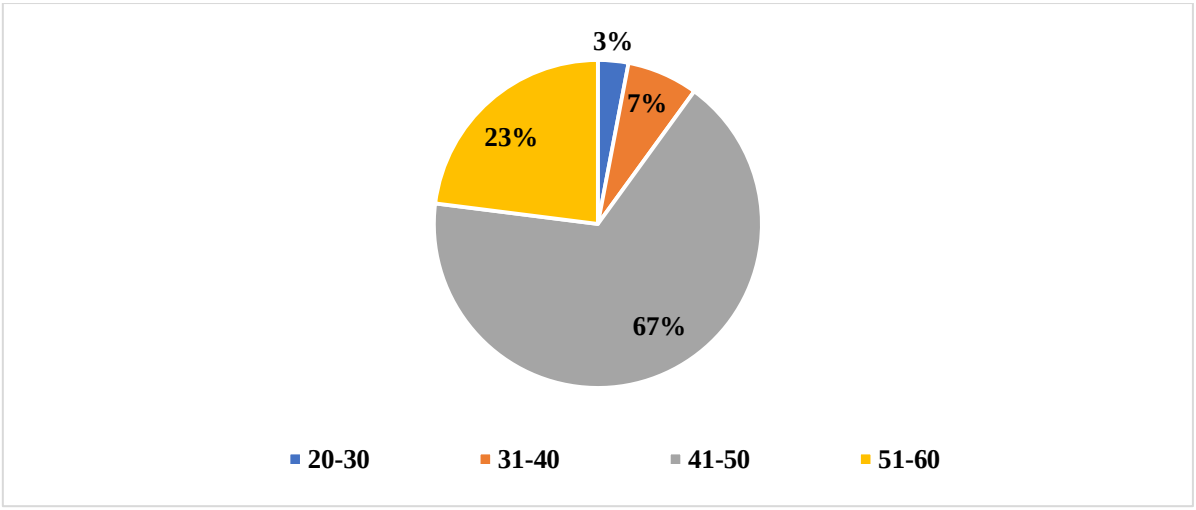

Figure 4. Distribution of producers by age groups

Considering the age groups of the producers, about 67% of the examined enterprises are between the ages of 41 and 50. The group between the ages of 20 and 30 follows with a rate of 3%. While a large part of the region, which is about 90%, can constitute the age group of 40 and above, only 10% of it can constitute the age group of 40 and below (Figure 4). The majority of the manufacturing segment is in the active working age range. In a study on the

use of chemical fertilizers in the province of Tokat, it was observed that the average age was 52 (Yüzbaşıoğlu, 2020). In another study on the use of chemical fertilizers in Tokat province, it was observed that a high percentage of producers were between the ages of 39-58 (Kızılaslan and Kızılaslan, 2005). Considering the age range of the farmer population in Turkey, it can be said that it is in the higher age range compared to other countries.

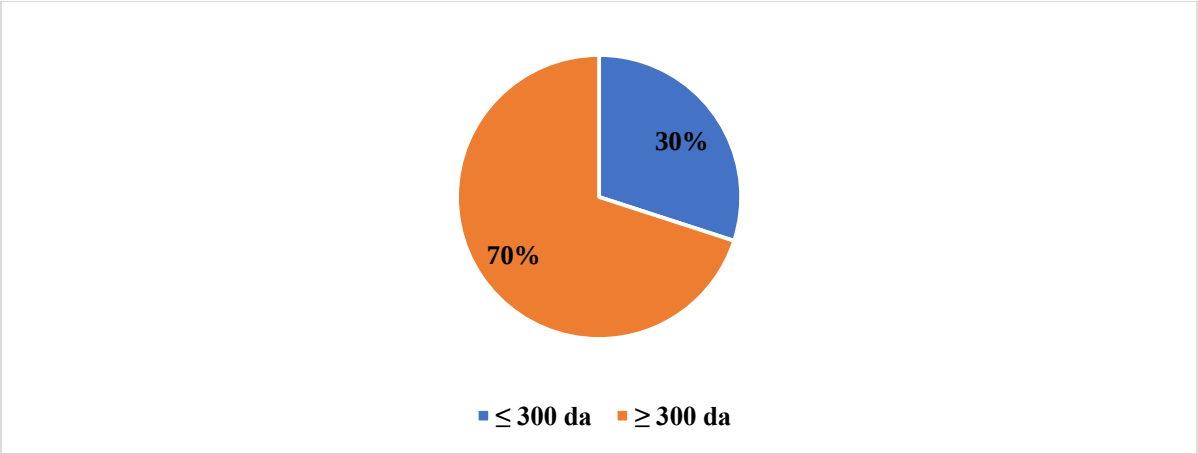

Figure 5. Distribution of total dry land assets owned by individuals

With the thought that the farmers' positive approach to innovations and land evaluations may be related to the way of saving land, the land ownership status was examined. According to the results of the survey study, 70% of the producers participating in the research produce on 300 decares or more of dry land with their own dry land assets. The remaining 30% of the producers produce by leasing in an area of 300 decares or less (Figure 5). In the survey study conducted by Yüzbaşıoğlu (2020), it was concluded that 84.14% of the agricultural land used by the farmers belonged to them. The values obtained in the observation of these results are adopted by the land owners.

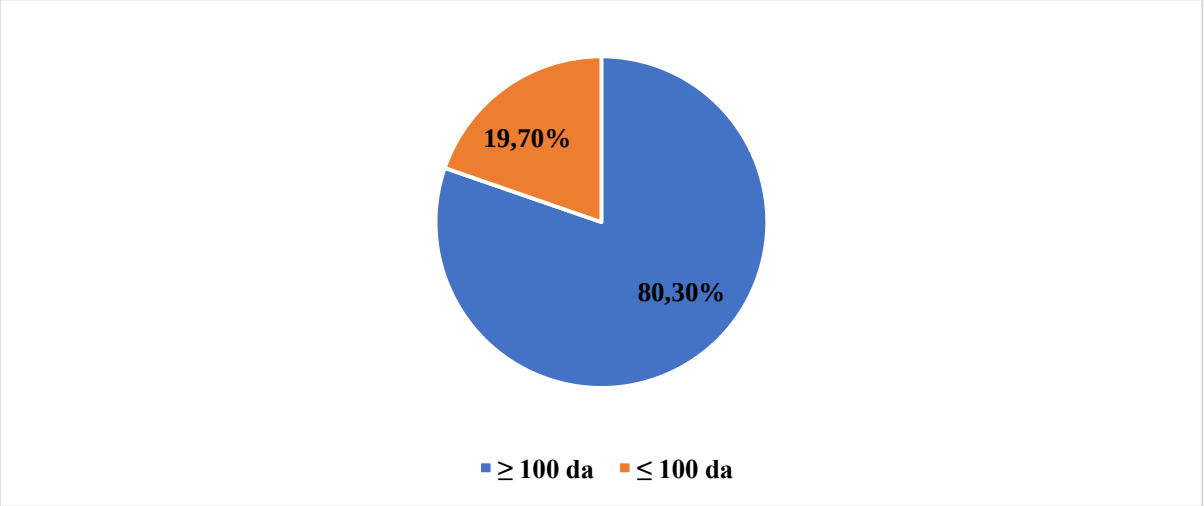

Figure 6. Distribution of total dry land assets rented by individuals

According to the results of the survey study, 80.3% of the producers participating in the research produce on 100 decares or more of dry land with their own dry land assets. The remaining 19.7% of the producers produce by leasing on an area of 100 decares or less (Figure 6).

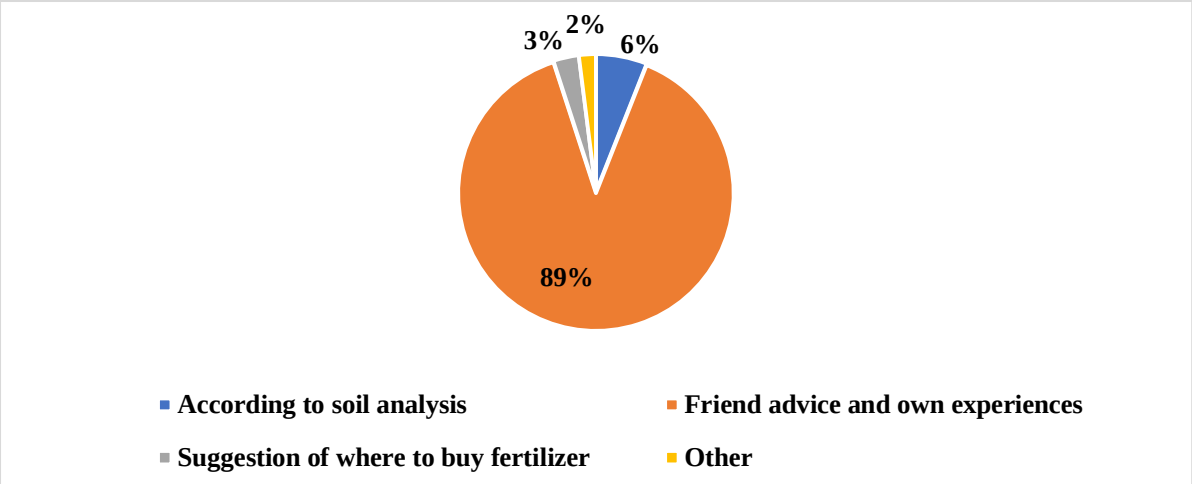

Figure 7. Manufacturers' methods of specifying the amount of fertilizer

Crop production can be increased by maintaining and improving soil fertility. Fertilization is one of the factors that increase the efficiency and quality of production in plants. In fertilizer use, attention should be paid to the content, amount, application method and regional climate, irrigation and soil characteristics of the fertilizer used (Eyüpoğlu, 2002).

While determining the fertilizer amount of the examined enterprises, 89% of them based on the advice of friends and their own experience, only 6% of the remaining part determines the fertilizer amount according to the soil analysis, 3% of them determines the fertilizer amount according to the recommendation of the place where they buy fertilizer, and 2% of the other part of the fertilizer is determined. It was determined that he fertilized in this way by ticking the option (Figure 7).

In the study of Gözener, Sayılı and Yurdabakan (2016), 82.86% of them evaluate their own experience while determining the fertilizer to be used by Tokat Kozova farmers. It was observed that what they evaluated afterwards was based on the recommendations of fertilizer dealers. In this case, it has been observed that the first place that our farmers apply when determining the type and amount of fertilizer is their own experiences and friend recommendations.

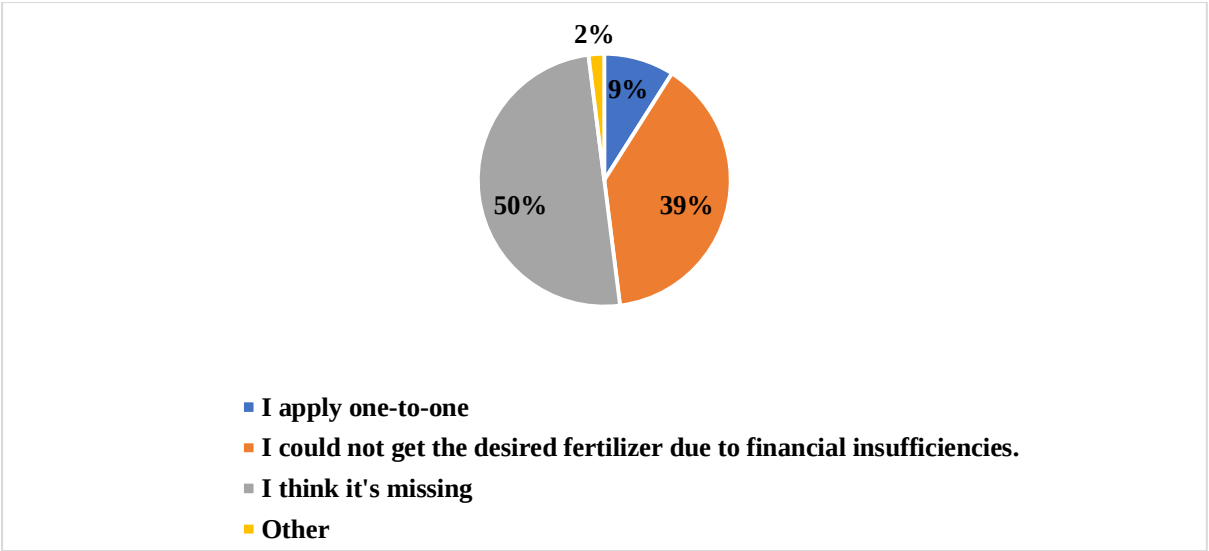

Figure 8. Reasons for non-compliance with fertilizer analysis data

It is the fertilization evaluated according to the results of the analysis made before conscious and balanced fertilization. A feeding should be made according to the amount of nutrients in the soil. In the studies, the farmers make random fertilization without relying on any fertilization analysis in the high majority (Kacar, 1994). Those who had fertilizer analysis did not comply with their data, 50% of them thought it was insufficient, 39% of them could not get the desired fertilizer due to financial inadequacies, 9% applied one-to-one, and 2% contributed to the results by marking the other option (Figure 8).

All these previous studies support the results of the research and show that ignoring soil analyzes constitutes a national problem. When asked about the reasons for not having a soil analysis done to the producers; It is seen that the producers mostly attribute this to their habits from the past.

Table 2. Effect of fertilization on yield increase after soil analysis

Product	**Old yield (kg/da)**	**Post-analysis yield (kg/da)**
Wheat	543	667
Sunflower	206	281

The producers who had soil analysis in the examined enterprises stated the yield increases observed in the most grown wheat and sunflower in the region, while the pre-analysis yield was 543 kg/da in wheat, an increase of 667 kg/da was observed in the post-analysis. There was an increase in 281 kg/da. It has been determined that the producers mostly prefer Trakya Birlik organizations (Table 2). Awareness trainings on soil analyzes and encouraging farmers to have analyzes are among the most important moves to be made on fertilizer consumption in Turkey. The producer should be aware of the fact that his profit from production will increase when he fertilizes according to his needs.

Table 3. Missing or over-used fertilizers after soil analysis

Fertilizers	**Missing (kg/da)**	**More (kg/da)**
Micro Fertilizer		66
Nitrogen	24	
Phosphorus	20	
Potassium		20
Zinc		25
Microbial		50

The fertilizers used less by the producers who had the soil analysis done after the analysis were 24 kg/da nitrogen and 20 kg/da phosphorus, while the first and more used fertilizers after the analysis were 66 kg/da micro fertilizer, 50 kg/da microbial fertilizer, 25 kg/da. Zinc is followed by potassium at 20 kg/da (Table 3).

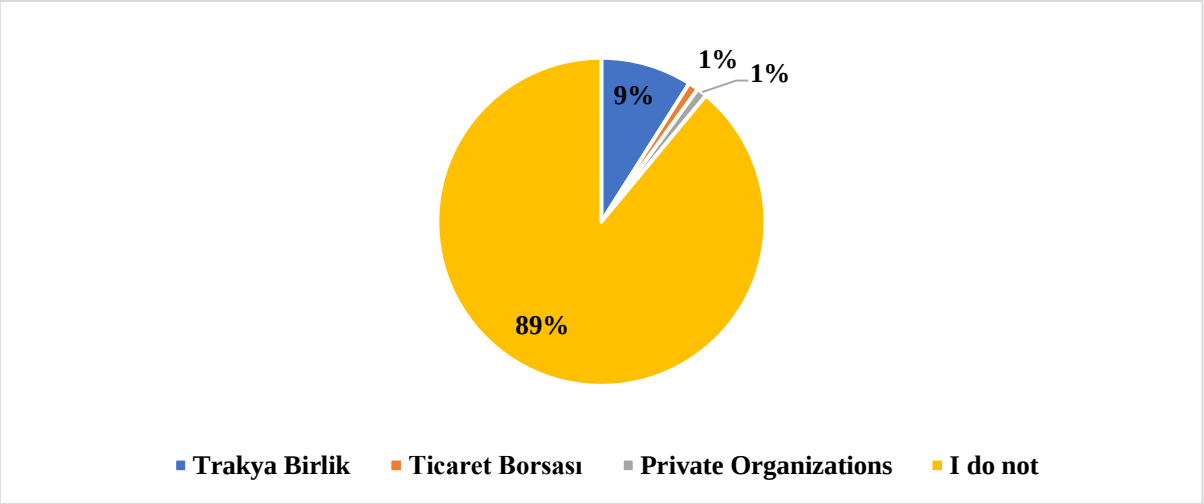

Figure 9. Soil analysis places

It was determined that only 11% of the producers had soil analysis, even if it was irregular. It was determined that 9% of those who had soil analysis had this work done together with Thrace, and the remaining 1% of the producers had their soil analyzes done by private institutions in the region, and 1% of them had it done in the commodity exchange. In some previous studies in the region, it was determined that the most important part when choosing the place where soil analyzes were made was the closeness of the laboratory where the analysis was made, with a rate of 92%, and the reasons such as easy communication, fast results and accurate results in 8% (Figure 9).

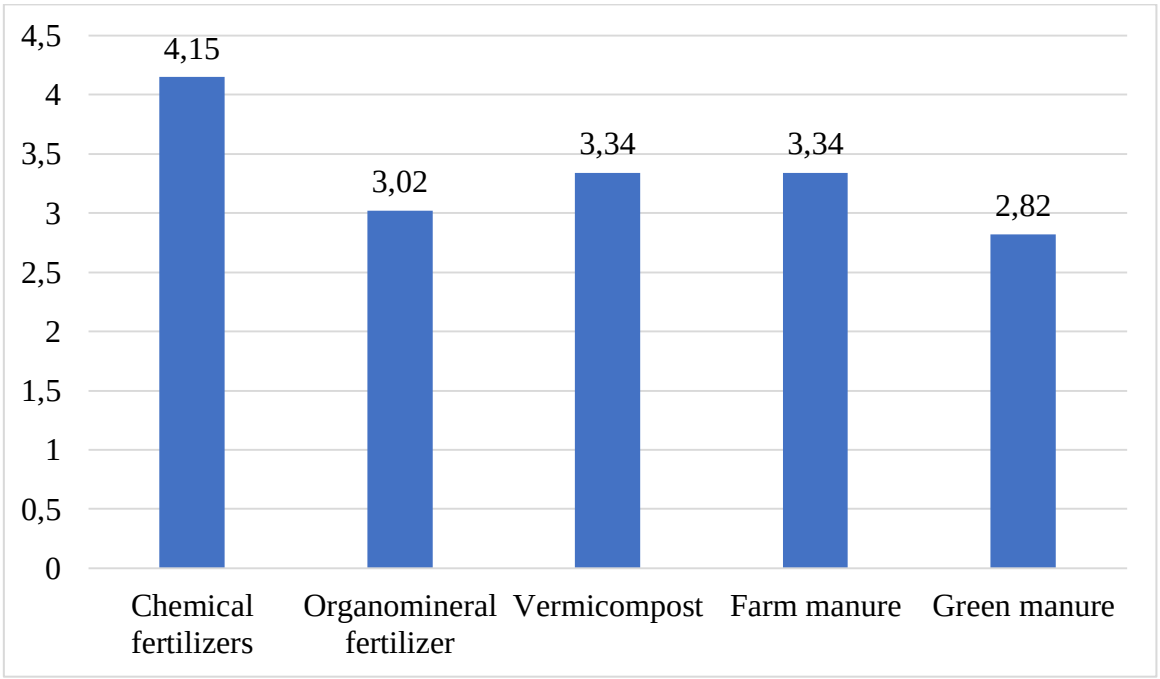

Figure 10. Evaluation perception of producers in terms of access to fertilizer

Considering our farmers' perception of access to fertilizer (Figure 10), it is seen that access to chemical fertilizers is easier than other fertilizers; access to organomineral manure, vermicompost and farm manure creates similar perceptions; It has been observed that green manure is not evaluated much by our farmers.

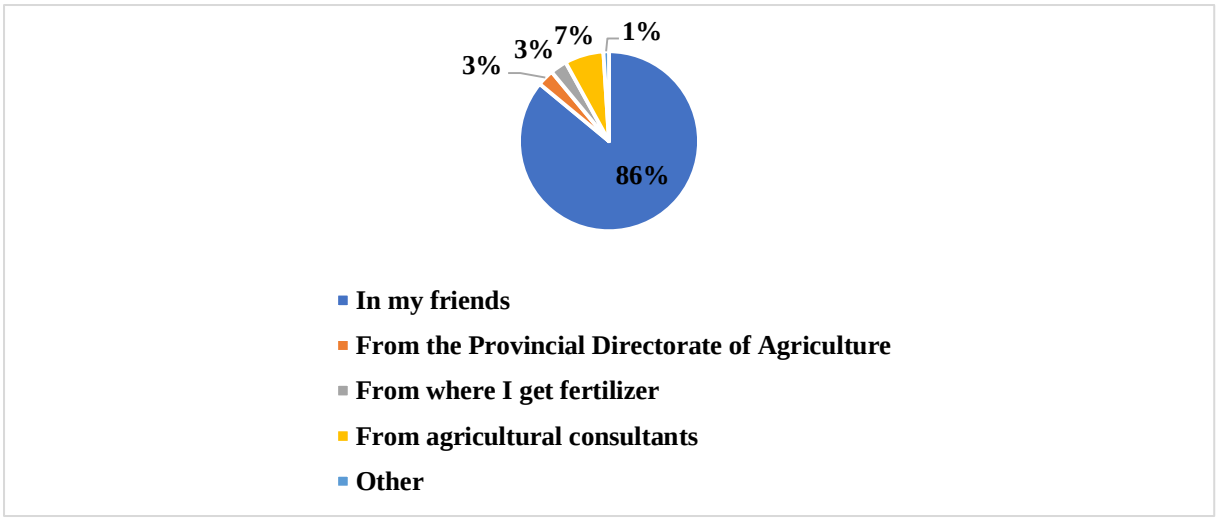

Figure 11. Where did you first hear about organic fertilizers?

The fact that about 86% of the examined businesses hear about the producers from their friends, is a data that supports the widespread coffee culture and communication among the producers when the other survey results are taken into consideration. 7% of them heard from agricultural consultants that the relationship between the producers in the region gradually increased, and the remaining 7% contributed to the survey by marking 3% from where they get fertilizer, 3% from where they get fertilizer, and 1% from where they get fertilizer. found (Figure 11).

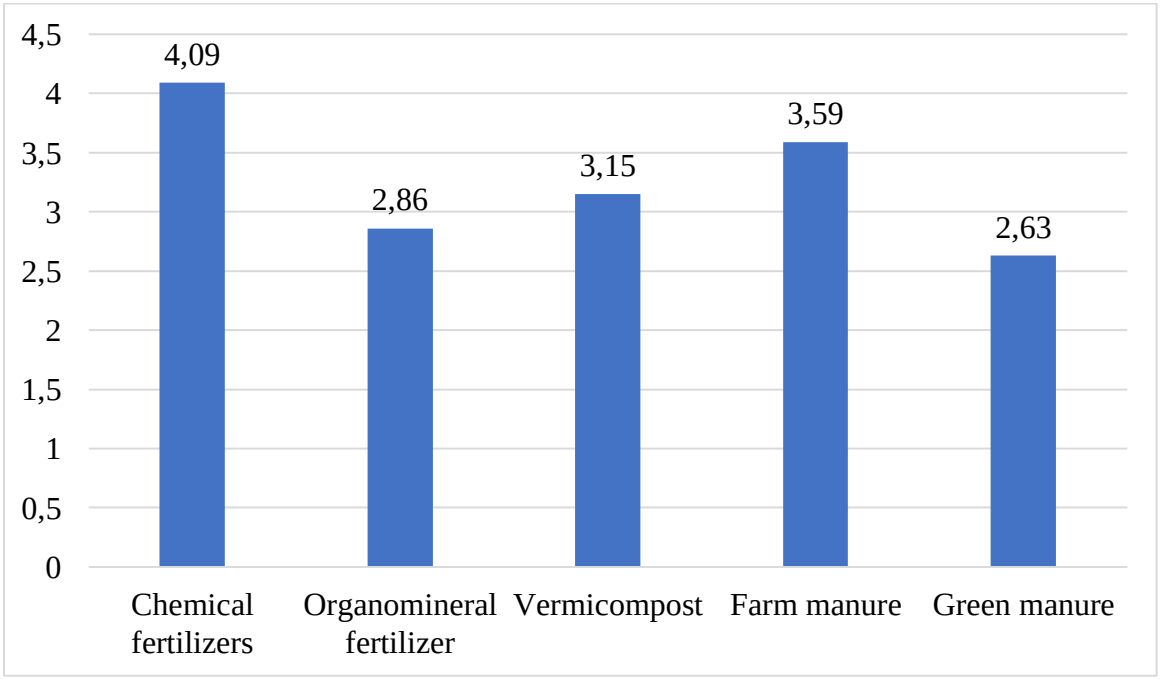

Figure 12. Evaluation perception of manufacturers in terms of advertising

While our farmers are evaluating fertilizers for advertisements and recommendations, it has been perceived that there are more referrals to chemical fertilizers, and that guidance and information about green fertilizers is lacking (Figure 12).

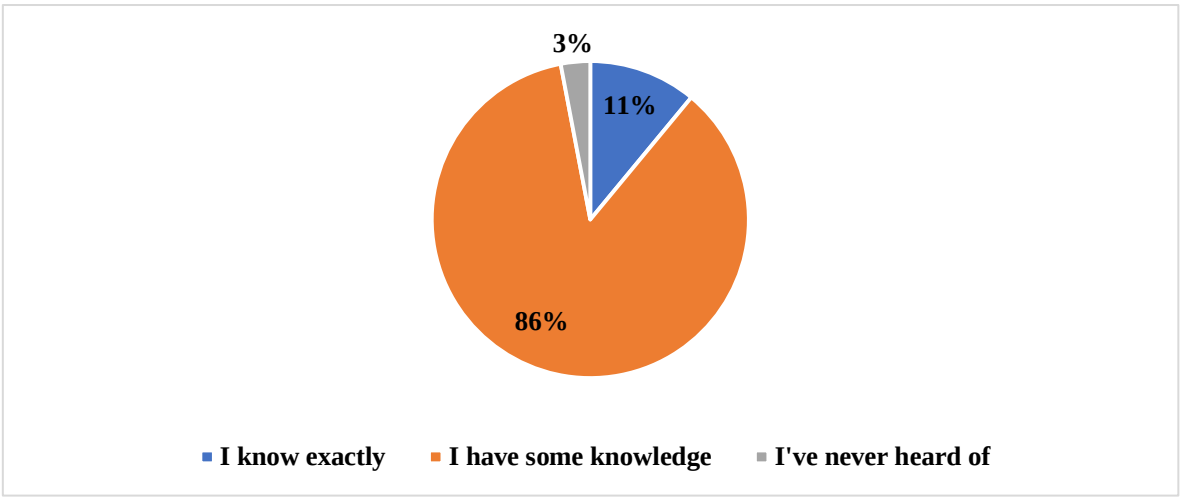

Figure 13. Organic fertilizer information of producers

When we look at the organic fertilizer knowledge level of the producers in the examined enterprises, approximately 86% of them have some knowledge, 11% of them know fully and 3% of them have never heard of data (Figure 13).

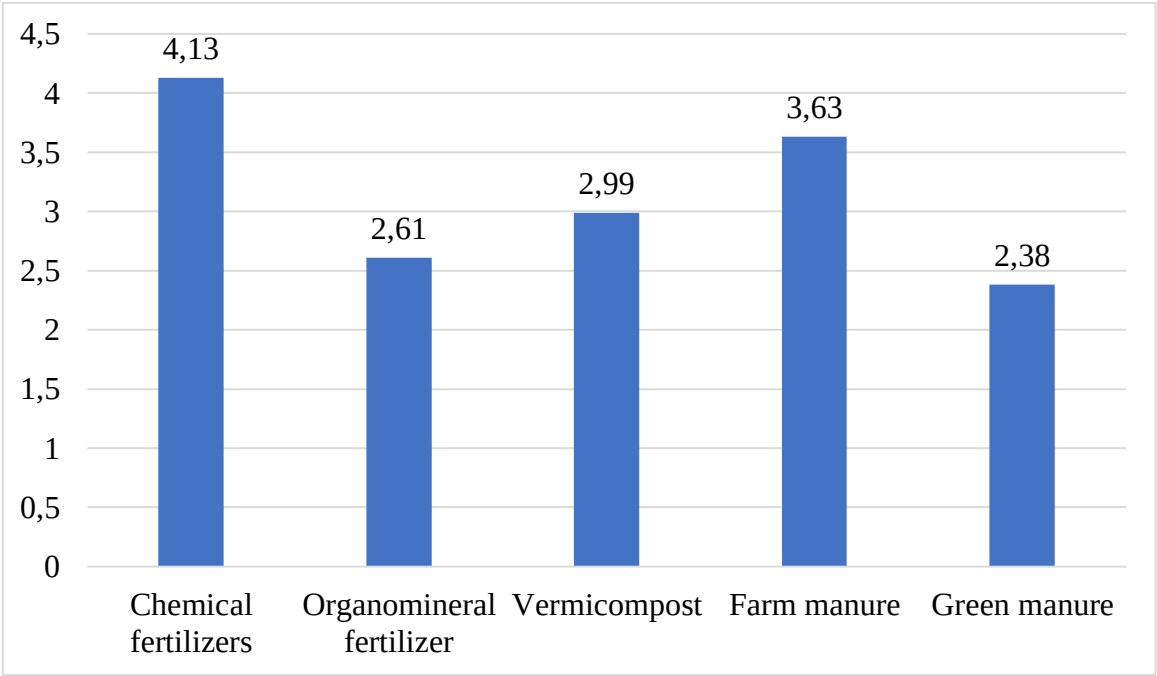

Figure 14. Evaluation perception of producers in terms of habit

Our producers are to be conscious of the use of fertilizers and environmental pollution rather than habits. When the fertilizer usage habits of our producers are evaluated, it has been observed that their orientation to chemical fertilizers is much higher than their orientation to other fertilizers. The usage habits of organomineral, vermicompost and farm manure were observed to be similar to each other, and the habit of using green manure is very low (Figure 14). The fact that the producers cannot make any distinction on organic fertilizers is due to the information they cannot obtain about them. This causes unconscious fertilization and chemical orientation in the next process. In the survey study conducted by Yüzbaşıoğlu (2020), it was observed that while 55.17% of the producers preferred chemical fertilizers, 44.83% of them preferred organic fertilizers to farm manure. It has been understood that 63.45% of the producers evaluate farm fertilizers together with chemical fertilizers, even in

small quantities. It can be thought that this fertilization issue, which varies according to the observed results, is in the form of regional characteristics, state of consciousness, and differences in the products grown.

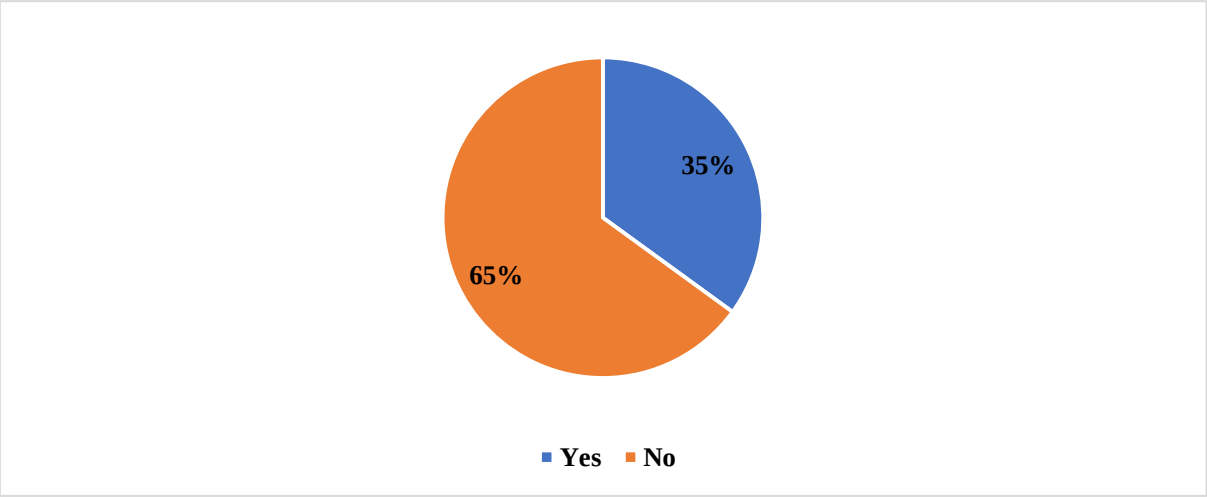

Figure 15. Information on organic fertilizer supplements of manufacturers

Turkey's income from agriculture and the country's economy have been supported continuously, and a growth parallel to economic development has been aimed (Yavuz, 2001). According to the data obtained as a result of the survey, it was concluded that approximately 65% of the producers knew about the producer supports and the remaining 35% did not know about the organic fertilizer supports (Figure 15).

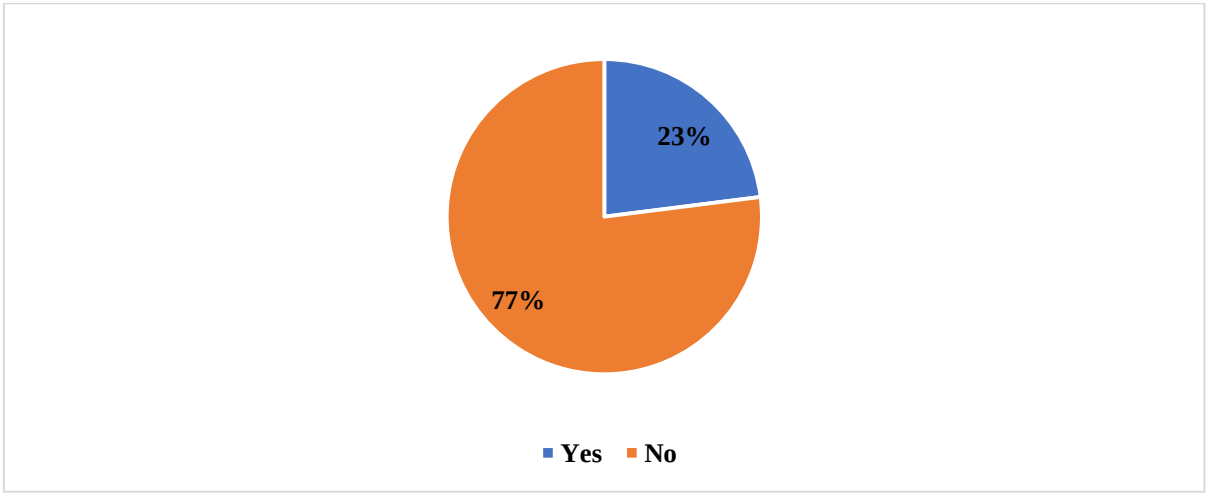

Figure 16. Information on the amount of organic matter in the soils of the producers

The organic matter of our soil is a parameter that affects the fertility of the soil. Enriching the amount of organic matter in the soil means increasing the mineral and nutrient resources in the soil. The higher the organic matter content in the soil, the higher the intake of micronutrients (Aktaş and Ateş, 1998). In addition, the organic matter in the soil regulates the aggregate structure of the soil and positively affects the uptake of all nutrients. On the other hand, with the continuous decomposition of the organic matter in the soil, high amounts of nitrogen pass into the soil and some nitrogen need can be met in this way, and the amount of nitrogen to be added is evaluated considering this situation (Schachtschabel, Blume, Brummer Hartge and Schwertmann, 1998). The amount of organic matter is very low in the majority of Turkey's soils and organic fertilization is not preferred much (Eyüpoğlu, 1999).

Approximately 23% of the producers in the enterprises we examined stated that they knew the amount of organic matter in their soil, while 77% said that they did not know (Figure 16). The vast majority of our producers do not know how much organic matter is in their soil. It is necessary to increase the amount of organic matter in the soils evaluated for agricultural purposes. Not knowing how much organic matter is and its consequences will make our soils unproductive over time. Therefore, it is important to know the amount of organic matter in soils.

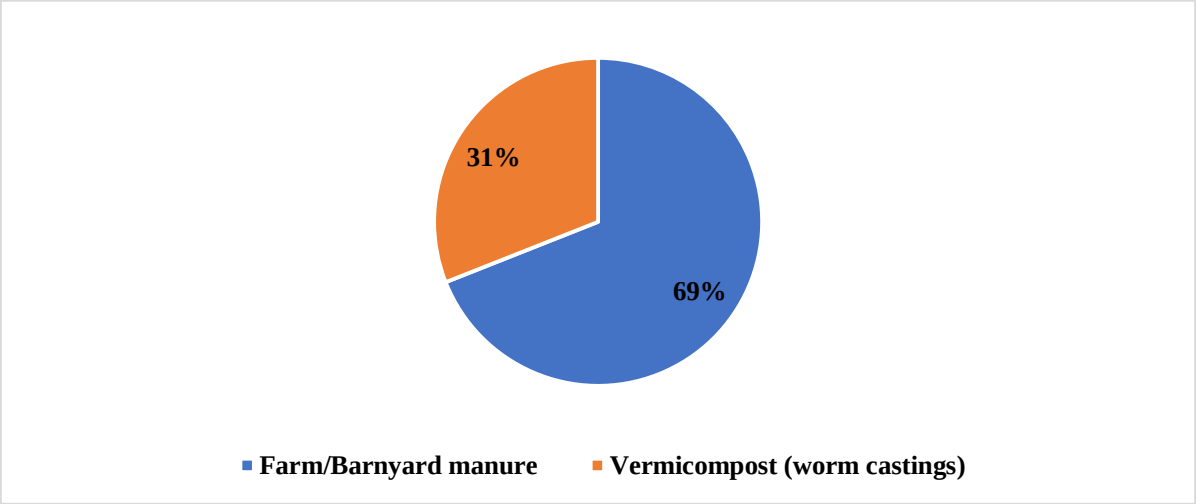

Figure 17. Organic fertilizers used by manufacturers

Fertilization is a necessary application to get high efficiency from the unit area (Borlaug, 2003). The amount of chemical fertilizer used in Turkey is high (Güneri, 2008). Organic fertilizers are generally preferred by those who do organic farming (Erol et al., 2010). 31% of the producers using organic fertilizers in the examined enterprises use vermicompost and 69% of them use farm manure (Figure 17). In other studies, 63.45% of farmers prefer to use chemical and farm fertilizers together (Yüzbaşıoğlu, 2020). In another study on the use of fertilizers in Antalya, it was observed that the majority of the organic fertilizers were used together with chemical fertilizers (Atılgan et al., 2007).

One of the important rules of successful production is to enrich and protect the organic matter content in the soil. It should be ensured that organic wastes of animal and vegetable origin are converted into organic fertilizers and used in agricultural production (Kacar and Katkat, 2007).

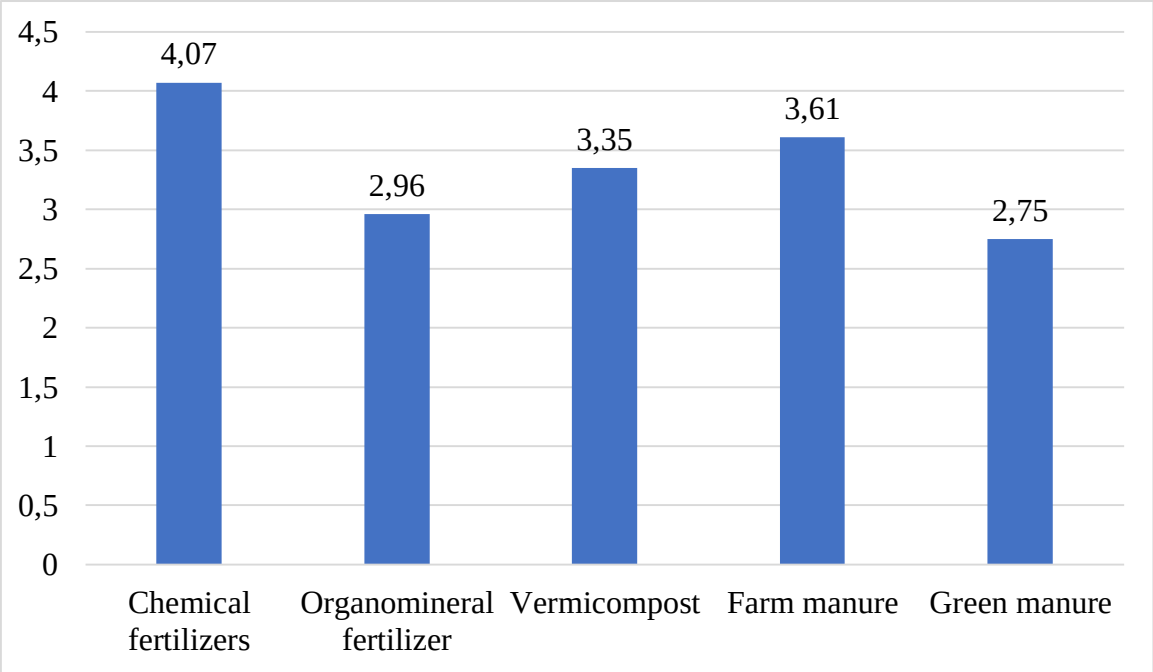

Figure 18. Evaluation perception of producers in terms of yield

When our farmers evaluated the yield they obtained after the use of fertilizers, it was observed that while they benefited from chemical fertilizers at maximum, they thought that they benefited less from organic fertilizers than chemicals (Figure 18). It has been observed that organomineral, vermicompost and farm manure create similar perceptions on yield in farmers. It has been observed that green manure is perceived to have lower yields compared to other fertilizations. In the survey study conducted by Yüzbaşıoğlu (2020), it was observed that 86.21% of the producers use chemical fertilizers with the thought that they increase the yield.

In the study conducted in Buea, Cameroon, 91% of the farmers use chemical fertilizers in the same way, considering that the yield increase rate is higher. It has been observed that 53.79% of the farmers using chemical fertilizers make purchases for the benefit they provide, 34.48% based on previous experiences, 26.90% considering their application areas, and 22.07% considering price performance (Tayoh et al., 2016).

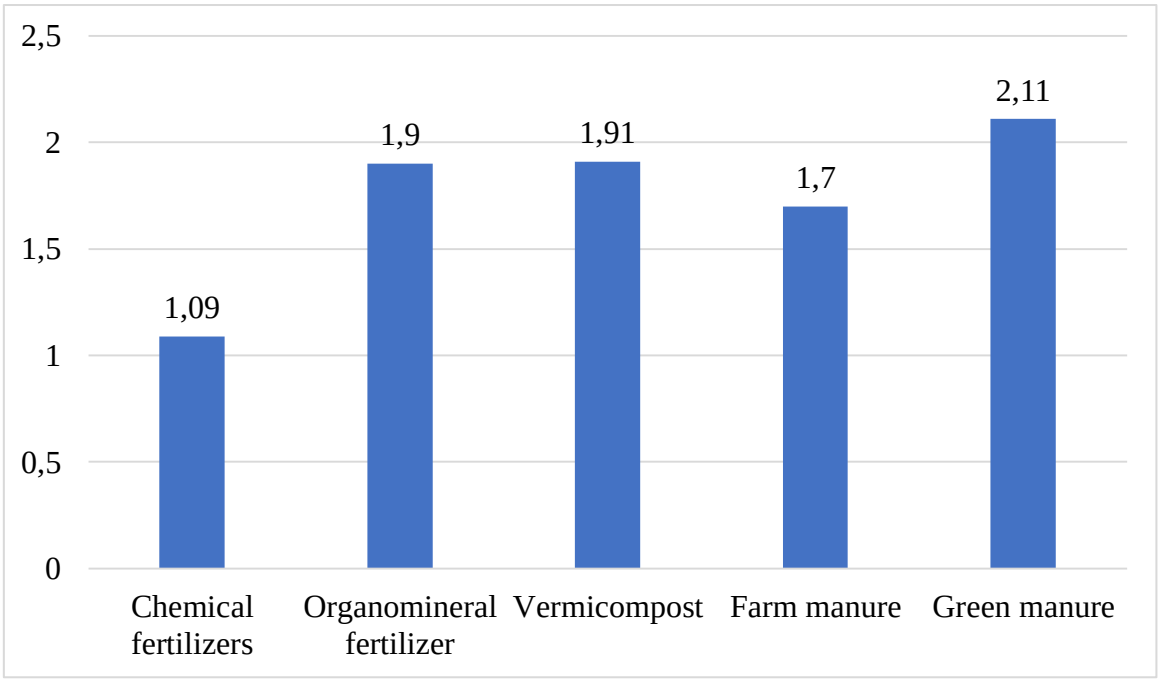

Figure 19. Evaluation perception of producers in terms of price

When our farmers' approach to fertilizers is observed in terms of price performance, green manure costs are higher; The fact that the prices of organomineral, vermicompost and farmyard manure are similar and that chemical fertilizers have lower prices compared to organic fertilization has increased the tendency of farmers to chemicals (Figure 19). It has been observed that the perception formed by the farmers is that chemical fertilizers are cheaper and green manure is more expensive.

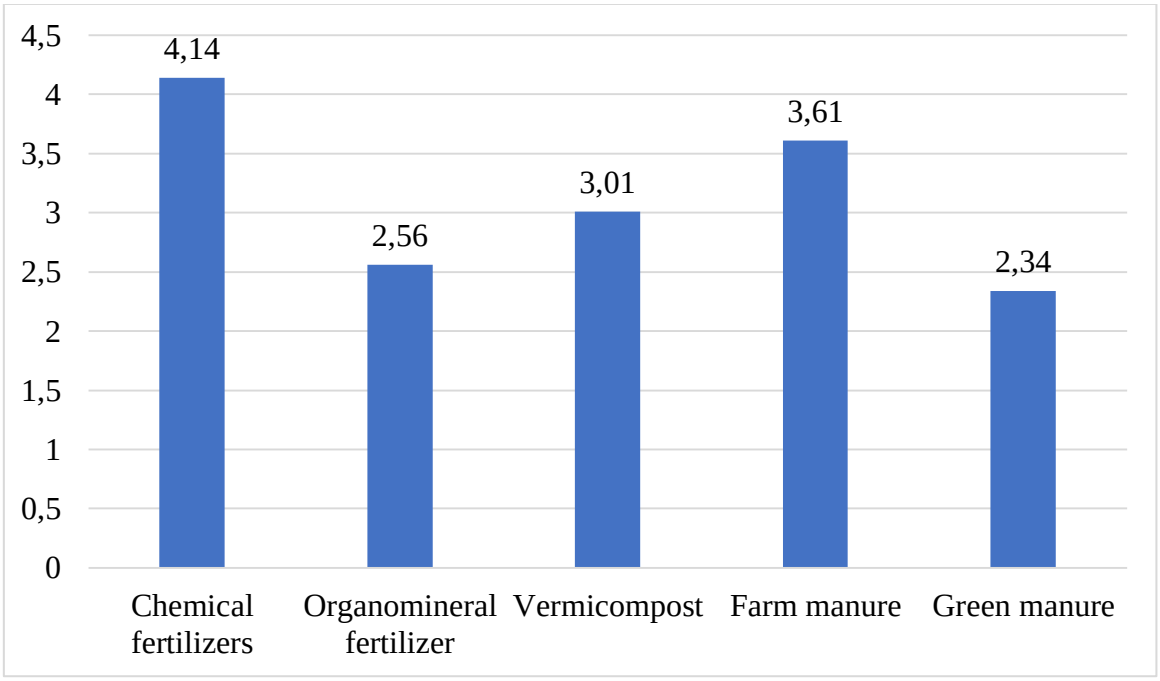

Figure 20. Evaluation perception of producers in terms of trust

When the perception of trust of our producers is taken into consideration, it has been observed that the tendency and trust towards chemicals is higher. It was found that organomineral, vermicompost and farm manure create similar perceptions, while green manure does not

create trust in production by the couple (Figure 20). In line with these results, it has been observed that the tendency of our farmers to chemical fertilizers is still very high. It is thought that the reason why our producers are less inclined towards organic fertilizers and green manure is not preferred so much is due to insufficient information and misdirection.

Agriculture and agricultural production, apart from other sectors, include lifestyle, education, consumption habits, production systems, etc. it is affected by the whole social, economic and political structure. For this reason, it is of great importance to reveal the demographic, economic and social characteristics of the surveyed segments while revealing the qualifications of the workforce engaged in agricultural activities in a region (Sivaslıgil, 1990; Tümsavaş, 2003). In this framework, some of the questions in the questionnaire included some social and demographic descriptive information about the producers who applied the questionnaire. At this stage, the farmers were asked to evaluate these concepts by comparing them with each other. A 7-point Likert scale (1: Not at all similar, 7: Very similar) was used in this evaluation. As a result of comparing six different concepts with each other, 15 comparison pairs were created according to the n(n-1)/2 formula (Table 4).

Table 4. Comparison pairs used in data collection (example)

Not similar at all					Very similar			
Chemical fertilizers	1	2	3	4	5	6	7	Organomineral Fertilizer
Chemical fertilizers	1	2	3	4	5	6	7	Vermicompost
Chemical fertilizers	1	2	3	4	5	6	7	Farm Manure (Barn)

'Multidimensional Scaling Analysis' was used to evaluate the primary data obtained from face-to-face surveys with producers dealing with agricultural production.

CONCLUSIONS

Soil; it is a natural environment on which plants, animals and people dwell and where living things continue. A quarter of the earth is covered with land, these areas are mountainous, barren, etc. due to natural constraints there is limited availability for agricultural production. In addition, the land poses an environmental problem with unconscious production and consumption together with urbanization. Producers lie on the basis of consciously using the land sustainably. Fertilizers, which we are dependent on outside as raw materials, have an extremely important function in order to achieve sustainable efficiency in plant production. However, the increase in the prices of fertilizers and the raw materials used in their production and the energy prices for these raw materials cause an increase in the prices of fertilizers, which causes the farmers to buy fertilizer irregularly, fertilize irregularly and even sometimes not to get fertilizer. Fertilizers that are not used in a timely manner and that are used in minimum doses cause great yield losses, while the use of more than necessary fertilizers can cause important economic and environmental problems and is a luxury consumption. The more we increase the organic matter ratio of the soil and keep the use of

chemical fertilizers at an optimum level, the more the productivity, quality and sustainability of the soil will increase. Conscious production is important in agriculture as in every field.

Soil pollution is an issue that many sectors need to find a solution together by providing the necessary sensitivity to the issue in terms of plant production. Otherwise, deterioration in human health caused by environmental pollution will continue, and the risks of today's plague and cancer will increase (Polat et al., 2019).

The findings obtained from this study have shown us that the agricultural part of Turkey does not have sufficient knowledge and does not have knowledge about unconscious fertilization practices and organic fertilizers. These results suggest that policy approaches to educating farmers on the benefits of organic matter in organic fertilizers should encourage the use of more organic fertilizers and less use of chemical fertilizers. Second, the findings show that the organic matter in the organic fertilizer has moderate substitutability (substitution elasticities of around one) with nitrogen, phosphorus, and potassium in the chemical fertilizer. Thus, the supply of organic fertilizer containing sufficient amount of organic matter and bacteria can reduce the use of chemical fertilizers together with the production cost. It will also offer broader scope to encourage farmers to test their soils for nutrient deficiencies, better educate farmers on the effectiveness of organic fertilizer, and adopt relevant land management measures such as drip irrigation, animal manure and crop rotation.

CONFLICTS of INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTION

Conceptualization, K.B., H.H. and Y.M.K.; methodology, K.B. and Y.M.K.; formal analysis, K.B. and H.H.; investigation, H.H. K.B. and Y.M.K.; resources, K.B., H.H. and Y.M.K.; data curation, K.B.; writing-original draft preparation, K.B., H.H. and Y.M.K.; writing-review and editing, K.B. and H.H.; visualization, K.B. and H.H.; supervision, K.B. and H.H.; Project administration, K.B. and H.H.

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