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Original Article

Economic Analysis of Chemical Fertilizer Use In TRA1 Region

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ABSTRACT

This study aims to examine the agricultural enterprises' use of fertilizers in the TRA1 region enterprise levels, analyzing farmers' knowledge, attitudes, and behaviors regarding fertilizer use. The study, conducted in the TRA1 region (Erzurum, Erzincan, Bayburt), involved interviews with 570 agricultural enterprise owners. Data were collected regarding fertilizer preferences, farmers' awareness levels in fertilization applications, and the factors influencing their choices. It was determined that enterprises primarily use nitrogenous fertilizers, followed by phosphate fertilizers, compound fertilizers, and potassium fertilizers. A significant proportion of enterprises (80.9%) determine the amount of fertilizer based on their experience, while only 4.7% decide after conducting soil analysis. Most enterprise owners purchase fertilizers from fertilizer dealers (40.2%) and obtain information about fertilizers from the same source (27.7%). Given that only 17.7% of enterprises receive information from agricultural institutions, it is evident that comprehensive farmer training programs should be implemented with the support of public institutions to enhance farmers' technical knowledge and skills.

Key words: *TRA1 region,agriculture, agriculture enterprise, fertilizer use.*

TRA1 Bölgesi Kimyasal Gübre Kullanımının Ekonomik Analizi

ÖZ

Bu çalışma TRA1 bölgesindeki tarımsal işletmelerin tarımsal gübre kullanımlarını işletme bazında detaylı olarak incelemek, çiftçilerin gübre kullanımı konusundaki bilgi tutum ve davranışlarını analiz etmek amacıyla yapılmıştır. TRA1 (Erzurum, Erzincan, Bayburt) Bölgesinde kimyasal gübre kullanımını inceleyen bu çalışmada 570 tarımsal işletme sahibi ile görüşme yapılmıştır. Tarımsal işletmelerin gübre tercihleri, gübreleme uygulamalarında çiftçilerin bilinç düzeyleri ve tercihlerinde rol oynayan hususlar ile ilgili bilgiler derlenmiştir. İşletmelerin kimyasal gübre olarak sırasıyla en fazla azotlu gübreleri, fosfatlı gübreleri, kompoze gübreleri ve potasyumlu gübreleri kullandıkları tespit edilmiştir. İşletmelerin büyük bölümü (%80.9) gübre miktarını kendi deneyimlerine göre belirlerken sadece %4.7'si toprak analizi yaptırdıktan sonra gübre miktarına karar vermektedir. İşletme sahipleri gübre alımını en fazla gübre bayilerinden (%40.2) yaparken, gübrelerle ilgili bilgileri yine en fazla gübre bayilerinden (%27.7) edinmektedirler. Gübre seçiminde işletmelerin sadece %17.7'sinin tarım teşkilatlarının elemanlarından bilgi aldığı düşüldüğünde üreticilerin Teknik bilgi ve becerilerinin arttırılması konusunda kamu kurumlarının da katkısıyla detaylı çiftçi eğitim programları yapılması gerekmektedir.

Anahtar kelimeler: *TRA1 bölgesi, tarım, tarımsal işletme, gübre kullanımı*.

INTRODUCTION

Fertilizers are substances that can return the plant nutrients lost by the soil as a result of the cultivation of agricultural products and increase the productivity of the soil. The use of fertilizers is one of the most effective methods of increasing the productivity as well as the quality of the agricultural products grown. When compared

to other agricultural inputs used to increase productivity, fertilizers significantly increase agricultural production by providing a yield increase of over 40%. Therefore, fertilizers make important contributions to people's access to the basic foods they need, ensuring global food supply and increasing people's living standards (Eraslan et al., 2009). While the world population is rapidly increasing, the need for food is increasing faster than the increasing population. In the last 50 years, the world population has doubled while the increase in food production has been threefold (Ekşi and İşçi, 2012). The increase in the need for food due to changing eating habits and the decrease in agricultural land per person with the increasing world population necessitates an increase in productivity in plant production (Karaçal and Tüfenkçi, 2010). Therefore, fertilizers, which have an important place in increasing productivity, are one of the most important inputs of sustainable agriculture (Eraslan et al., 2009).

Historically, people have used various additives to improve soil fertility. After the 19th century, research on plants and soil has shown that plants take mostly nitrogen, phosphorus, potassium, and calcium from the soil, while using less of the other substances. For this reason, it has become necessary to add these substances that are depleted from the soil to the soil (Ilgar, 2020). Today, there has been a significant increase in the use of chemical fertilizers.

Total chemical fertilizer use in the world was 187,925 thousand tons in 2022. While the most fertilizer is used in Asia, the continent of America, Europe and Africa follow Asia. The continents of Oceania have the least fertilizer use (Table 1). When we look at total fertilizer use on a country basis, the country that uses the most fertilizer is China, followed by India, the United States, Brazil and Indonesia. Turkey ranks 13th in total fertilizer use with 2,230 thousand tons.

Table 1. Fertilizer Utilization Statistics, 2022

Regions	Consumption (1,000 Tons)	Percentage (%)	Countries	Consumption (1,000 Tons)	Percentage (%)
World	187,925	100.0	Chinese	44,498	23.8
Asia	106,307	56.6	India	29,844	15.9
America	49,043	26.1	USA	20,464	10.9
Europe	22,033	11.7	Brazil	18,663	9.9
Africa	7,153	3.8	Indonesia	6,377	3.4
Oceania	3,389	1.8	Türkiye	2,230	1.2

Source: Anonymous, 2021.

The amount of chemical fertilizer used in Turkey has fluctuated over the years. While it was 2,203 thousand tons in 2015, it increased to 2,644 thousand tons in 2017 and decreased to 2,575 thousand tons in 2019. It increased again to 2,575 thousand tons in 2021 and 2,830 thousand tons in 2023. The most used fertilizer group among chemical fertilizers is nitrogenous fertilizers with approximately 69%. Phosphorus fertilizers are in second place with approximately 26%. The least used chemical fertilizer group is potash fertilizer with 5% (Table 2).

Table 2. Fertilizer Utilization Statistics (1,000 Tons)

Fertilizer	2015	2017	2019	2021	2023
Total	2 203	2 644	2 466	2 575	2 830
Nitrogenous (N)	1 487	1 765	1 683	1 787	1 948
Phosphorous (P_2O_5)	585	755	667	634	736
Potash (K_2O)	132	125	116	154	146

Source: Anonymous, 2023.

When the studies on fertilizer use are examined today, where the use of chemical fertilizers in plant production is intense, the studies are mostly focused on determining the awareness level of enterprises in fertilizer use (Kızılaslan and Kızılaslan , 2005; Yılmaz et al., 2009; Unakıtan et al., 2017; Katip, 2020; Yüzbaşıoğlu (2020) . It has been determined that the use of chemical fertilizers increases yield and income (Matsumoto and Yamano, 2011; Mengel et al., 2006). Kaplan and Gözükara (2021) emphasized that there should be a change in chemical fertilizer consumption.

In today's world where the need for food products is increasing day by day, it is very important to determine the levels of fertilizer use, which makes a significant contribution to the increase in productivity of

producers. This study was conducted to examine the agricultural fertilizer use of agricultural enterprises in the TRA1 region enterprise basis and to analyze the knowledge, attitudes and behaviors of farmers on fertilizer use.

MATERIALS AND METHODS

Research Area and Sample Method

In the study, 2021 production data obtained from face-to-face surveys conducted with 570 business owners operating in Erzurum, Erzincan and Bayburt provinces constituted the main data source. Other data were obtained from national and international publications, websites, FAO statistics, Turkstat and other institution websites. The framework created from the Farmer Registration System obtained from the Provincial Directorates of Agriculture in the TRA1 Region was used as the main mass. There are a total of 40,508 agricultural businesses registered in the Farmer Registration System in the TRA1 region, including 31,034 farmers in Erzurum, 6,791 in Erzincan and 2,683 in Bayburt.

The Method Applied to Determine the Number of Samples

The number of surveys to be applied was determined using the Neyman Method using data from the Farmer Registration System received from the Provincial Directorates of Agriculture in the TRA1 Region (Erkuş, 1977). The Neyman method, developed by Jerzy Neyman, is one of the cornerstones of statistical inference and is one of the most widely used methods for determining sample size (Neyman, 1937). The total population is 40,508 agricultural holdings.

$n = \sum(N Sh)^2 / (N^2 * D^2 + \sum Nh (Sh^2)$

The following formula ensures that businesses are distributed to the specified layers.

$n = Nh Shx n / \sum Nh Sh$

N: Total number of enterprises in the population

Nh: Number of enterprises in the h-th stratum

n: Sample size

ni: Sample size for the i-th stratum

Sh^2: Variance in the h-th stratum

Sh: Standard deviation in the h-th stratum

D^2: Correction factor

Z^2: Z-table value for the given confidence level

d: Allowed margin of error from the population mean

Considering the attitudes of the people working in the agricultural sector and their willingness to answer the survey questions, the error limit was kept low and the confidence interval was taken wide. Accordingly; The sample size was found to be 570 with an 85% confidence interval and a 3% error limit. 272 survey samples were taken from the first layer, 202 from the second layer and 96 from the third layer (Table 3).

Table 3. Distribution of Agricultural Enterprises

Agricultural Business Groups	Land Size (Decare)	Number of Businesses	Survey Rate (%)
Group 1	0 - 49	272	47.7
Group 2	50 - 149	202	35.4
Group 3	150+	96	16.9
Total		570	100.0

Data Analysis Method

In the study, the factors affecting the problems encountered by the farmers of TRA1 region in deciding on fertilizer needs and receiving agricultural support (education, agricultural experience, land size and tractor presence) were addressed and the Multinomial probit model was used to measure the effects of these factors. In this context, the model tried to determine the factors that distinguished the farmers from other options by having soil analysis, asking family elders or neighboring businesses, asking the members of the agricultural organization, relying on their experiences and asking agricultural engineer consultants in deciding on fertilizer needs.

The multinomial probit model is used when a dependent variable can take on two values and estimates the probability of these values. The estimates obtained from the two-valued probit model ensure that the parameter estimates of the multinomial probit model are consistent. (Menard , 2002) . Both models use a

probability distribution function to estimate probabilities of choices between multiple categories. This means that the two models are interconnected, and the estimates from the two-valued probit model provide a basic reference point for the multiple nominal probit model (Begg and Gray , 1984; Miran, 2021).

RESULTS AND DISCUSSION

The business owners who participated in the survey were asked how they determined the amount of fertilizer to be used. 80.9% of them, i.e. 461 business owners, answered “I decide based on my experiences”, while 9.3% answered “By consulting family elders or neighboring enterprises”. The rate of those who answered “By conducting soil analysis” was 4.7%, while those who decided “By consulting my agricultural engineer advisor” was 3.3% and those who decided “by asking the technical staff at the Agricultural Organization” was 1.8% (Table 4). Several studies have indicated that farmers often rely on their experience or traditional knowledge in determining fertilizer use. According to Yılmaz et al. (2009), the majority of farmers in Turkey make fertilization decisions based on experience rather than scientific soil analysis, leading to inefficient use. Similarly, Unakıtan et al. (2017) found that lack of access to professional agricultural consultancy and low awareness of soil testing methods contribute to this trend.

Table 4. Distribution of Factors Influencing the Determination of Fertilizer Quantities

Determining the Amount of Fertilizer to Use	Number of Businesses	Percentage
By conducting soil analysis	27	4.7
By consulting family elders or neighboring enterprises	53	9.3
By consulting technical staff in the Agricultural Organization	10	1.8
I decide based on my experience	461	80.9
By consulting my agricultural engineer advisor	19	3.3
Total	570	100

When the places where fertilizer is supplied in the enterprises surveyed are examined, it is seen that 40.2% of the fertilizer is supplied mostly from fertilizer dealers, 29.5% from cooperatives, and 30.3% from other supply places (Table 5). This pattern aligns with findings by Katip (2020), who reported that fertilizer dealers are the primary source of supply due to their accessibility and immediate availability. However, reliance on dealers may result in biased product recommendations, as highlighted by Eraslan et al. (2010), who emphasized the importance of agricultural extension services in providing unbiased fertilization recommendations.

Table 5. Distribution of Fertilizer Procurement Sources

Fertilizer Supply Locations	Number of Businesses	Percentage
Dealer	229	40.2
Cooperative	168	29.5
Other	173	30.3
Total	570	100

When examining the organizations from which enterprise owners participating in the study obtained information on fertilizer selection, 40.6% (231 enterprise owners) stated "Other", while 27.7% (158 enterprise owners) mentioned "Fertilizer dealers". The proportion of those who responded "Agricultural organization staff" was 17.7%, whereas 11.9% of them indicated "Consulting agricultural engineers". Only 2.1% of the participants responded with "Fertilizer company representatives". The high percentage of the "Other" category may be due to enterprise owners who do not seek information from any organization when selecting fertilizers (Table 6). The limited reliance on agricultural professionals for fertilizer recommendations is consistent with previous studies. Kızılaslan and Kızılaslan (2005) reported that farmers often prioritize convenience over technical advice. Similarly, Yüzbaşıoğlu (2020) found that while agricultural organizations provide more scientifically grounded advice, their accessibility and engagement with farmers remain limited.

Table 6. Distribution of Factors Influencing the Selection of Fertilizer Types

Organizations that provide information on fertilizer selection	Number of Businesses	Percentage
Agricultural organization staff	101	17.7
Fertilizer company representatives	12	2.1
Fertilizer dealers	158	27.7
Consulting agricultural engineers	68	11.9
Other (relatives, friends, those who do not receive information)	231	40.6
Total	570	100

When the criteria that the business owners who participated in the research pay attention to when choosing fertilizer are examined; 42.4% , that is, 242 business owners, said "I buy the most effective fertilizer regardless of the price", while 23.3%, that is, 144 business owners, said "I buy the fertilizer that an acquaintance uses and recommends". The rate of those who answered "I buy the fertilizer recommended by the dealer" was 18.4% , while those who said "I buy the fertilizer recommended by agricultural engineers working in agricultural organizations" was 10.4%, and those who answered "I buy the one with the cheapest price" was 3.5%. The majority of business owners prefer fertilizers that they have used before and whose effectiveness (Table 7). These findings align with the study by Kaplan and Gözükara (2021), which emphasized the role of perceived effectiveness in farmers' purchasing decisions. Matsumoto and Yamano (2011) also highlighted that farmers' fertilizer choices are largely influenced by word-of-mouth recommendations rather than scientific evaluation.

Table 7. Distribution of Criteria for Fertilizer Selection in Surveyed Enterprises

Criteria for Fertilizer Selection	Number of Businesses	Percentage
I buy the cheapest one	20	3.5
I buy the fertilizer that a friend of mine recommends.	144	25.3
I buy the fertilizer recommended by the dealer	105	18.4
I buy the most effective fertilizer no matter what the price is	242	42.4
I buy the fertilizer recommended by agricultural engineers working in agricultural organizations.	59	10.4
Total	570	100

The majority of the business owners who participated in the survey stated that they did not have soil analysis done. While 92.5% of the business owners , or 527 of them, did not have soil analysis done, 7.5%, or 43 of them, said that they had soil analysis done (Table 8). This result is consistent with findings by Mengel et al. (2006), who reported that soil testing rates remain low in many agricultural regions due to a lack of knowledge, accessibility, and perceived necessity. Similarly, Ilgar (2020) emphasized that increasing farmer awareness about soil analysis through targeted extension programs is essential for improving fertilizer efficiency and reducing environmental impact.

Table 8. Soil Testing Status of Surveyed Enterprises

Soil Analysis Status	Number of Businesses	Percentage
It was done	43	7.5
Not made	527	92.5
Total	570	100

According to the research findings, the production area is mostly allocated to forage crops. Since animal husbandry is developed in the region, the production of forage crops is high. Forage crops are followed by wheat, barley, rye and sugar beet, respectively. It is also seen that 19.4% of the agricultural land is not cultivated. Production amounts are also parallel to the production area, the percentage distribution of production amounts is; forage crops 37.4% , wheat 10.6%, barley 4.7%, rye 0.6% and sugar beet 10.0% (Table 9). Studies by Eraslan et al. (2010) and Kızılaslan & Kızılaslan (2005) confirm that regions with developed animal husbandry tend to allocate a higher percentage of their cultivated land to forage crops, ensuring a sustainable feed supply. Additionally, the presence of significant uncultivated land suggests the potential for agricultural expansion or policy-driven land-use optimization.

Table 9. Distribution of Products Produced by Surveyed Enterprises

Product Produced	Area (Decare)	Area %	Production (Kg)	Production %
Fodder Plant	34 273	42.4	12 804 310	37.4
Wheat	16 462	20.4	3 630 481	10.6
Barley	6 801	8.4	1 615 302	4.7
Rye	1 246	1.5	194 986	0.6
Sugar beet	827	1.0	3 413 511	10.0
Other	5 527	6.8	15 097 466	36.8
Uncultivated Land	15 661	19.4	-	-
Total	80 877	100.0	34 249 470	100.0

When analyzing the chemical fertilizer usage of the enterprises, nitrogenous fertilizers were found to be the most used, accounting for 50.9% of the total amount. These were followed by phosphate fertilizers (27.1%), compound fertilizers (21.9%), and potassium fertilizers (0.1%). The distribution of land (in decares) where these fertilizers were applied showed a similar pattern. However, when examining the expenditures on chemical fertilizers, although the ranking remained the same, significant differences were observed in percentage distributions. The primary reason for this is the price variations among different fertilizers. For instance, since phosphate fertilizers are more expensive per unit compared to nitrogenous fertilizers, while they were used on 27.1% of the land, they accounted for 33.6% of the total fertilizer expenditures. (Table 10). According to Mengel et al. (2006), nitrogen-based fertilizers play a crucial role in increasing yield, yet excessive use can lead to environmental issues such as nitrate leaching.

Table 10. Chemical Fertilizer Usage Statistics of Surveyed Enterprises

Use of Chemical Fertilizers	Area (Decare)	Area %	Quantity (Kg)	Amount %	Value (TL)	Value %
Nitrogenous	28 258	50.0	511 724	50.9	6 333 600	45.9
Phosphate	16 178	28.6	271 882	27.1	4 628 510	33.6
Potassium	68	0.1	550	0.1	10 900	0.1
Composite	12 012	21.3	220 350	21.9	2 815 600	20.4
Total	56 515	100	1 004 506	100	13 788 610	100

In the Multinomial Probit Model, the dependent variable is how farmers determine their fertilizer needs. Here, the farmers choose one of seven alternative approaches, including: conducting soil analysis, consulting family elders or neighboring enterprises, asking the staff in the agricultural organization, based on my experience, consulting an agricultural engineer advisor, a combination of consulting family elders and relying on personal experience, a combination of relying on personal experience and consulting an agricultural engineer advisor.

In the Multinomial Probit Model, interpretations are based on the criterion of conducting soil analysis. Farmers with higher education levels tend to determine their fertilizer needs by consulting technical staff in agricultural organizations and agricultural engineer advisors (Table 11). More educated farmers are less likely to rely on their personal experience and instead base their decisions on soil analysis. As the experience of working in the sector increases, instead of soil analysis, they determine the need for fertilizer by asking the technical staff in the agricultural organization. Producers who own tractors determine their fertilizer needs by having their soil analyzed. It was also found to be statistically significant.

Table 11. Results of the Multinomial Probit Model Analysis of Factors Influencing Farmers ' Decisions on Fertilizer Needs

Variables	To family elders or to neighboring businesses by asking (2)	Asking family elders or neighboring businesses - I decide based on my experiences (2-4)	By asking the technical staff in the Agricultural Organization (3)	I decide based on my experience (4)	I decide based on my experience - By asking my Agricultural Engineer advisor (4-5)	By asking my Agricultural Engineer advisor (5)
Constant	1.14555	0.34389	-3.14044 '	4.57609 ***	1.10985	-3.74845 **
	1.00998	1.24441	1.50854 *	0.83203	2.70118	1.44988
Education	-0.05600	-0.00276	0.49399 '	-0.60247 **	-0.47675	0.63119 **
	0.20897	0.24901	0.28606	0.17499	0.58838	0.26762
Agricultural Experience	-0.01416	-0.01193	0.04635 '	-0.00812	-0.01816	0.03249
	0.01782	0.02263	0.02464	0.01459	0.05556	0.02327
Land size	0.00044	-0.00085	-0.00149	0.00109	0.00132	0.00132
	0.00131	0.00259	0.00357	0.00109	0.00127	0.00109
Tractor presence	-0.81883 **	-0.77082	-1.08682 '	-0.61975 *	-9.87272	-0.35889
	0.39417	0.50252	0.61746	0.33011	0.00001	0.50644
Log likelihood					-267.05232	
Wald chi2(4)					67.37	

, *,*** indicate statistical significance of 0.01, 0.05 and 0.10, respectively.

Table 12, where marginal effects are given, is examined, statistically significant results were found for education level and tractor presence. Those with a higher education level are 2.90% more likely to decide on fertilizer needs by having a soil analysis done compared to other criteria. Similarly, they are 4.10% more likely to decide by asking their elders or neighboring businesses and 1.69% more likely to decide by asking their agricultural engineer consultant . Those with a tractor are 4.56% more likely to determine fertilizer needs by having a soil analysis done compared to those without one.

Table 12. Marginal Effects of Factors Influencing Farmers ' Decisions on Fertilizer Needs in the Multinomial Probit Model

Variables	By having a soil analysis done	By asking family elders or neighboring businesses	In the Agricultural Organization technical by asking the staff	I decide based on my experience	By asking my Agricultural Engineer advisor
Variables	**Coefficient**	**Coefficient**	**Coefficient**	**Coefficient**	**Coefficient**
Education	0.02898 ***	0.04097 ***	0.00865	-0.10883 ***	0.01689 **
Agricultural Experience	0.00048	-0.00083	0.00053	-0.00063	0.00065
Land size	-0.00006	-0.00005	-0.00003	0.00017	0.00001
Tractor presence	0.04565 **	-0.02345	-0.00459	-0.01109	0.00413

, *,*** indicate statistical significance of 0.01, 0.05 and 0.10, respectively.

CONCLUSION

This study was conducted to examine in detail the agricultural fertilizer use and fertilization costs of agricultural enterprises operating in the TRA1 region, both on a product and enterprise basis, and to analyze the knowledge, attitudes and behaviors of farmers regarding fertilizer use. For this purpose, the findings obtained from the face-to-face survey conducted with agricultural enterprise owners operating in the TRA1 region are summarized.

In order to meet the increasing food demand parallel to the increase in the world population, it is very important to increase the efficiency in agricultural production. Fertilizer use has an important place in the sustainability of efficiency. Therefore, the right time and amount of fertilizer used by the producers as required by the soil affects the efficiency and therefore the continuity of the business.

The study results indicate that the vast majority of businesses determine the type and amount of fertilizer they use based on their own experience or by consulting older family members, while only a very small proportion conduct soil analysis and apply fertilizers according to the results. Only farmers with a high level of education have their soil analyzed and apply fertilizer by taking into account the existing plant nutrients in the soil and the needs of the plant to be planted.

The application of fertilizers without prior soil analysis poses a significant risk of either overuse or underuse relative to the actual needs of the crop. Excessive fertilizer application not only increases production costs but also leads to adverse environmental consequences. Conversely, insufficient fertilizer application may result in inadequate nutrient supply to the crop, thereby causing a decline in yield. The findings of the study suggest that farmers in the region do not place sufficient emphasis on soil analysis when selecting fertilizers and determining application rates. Addressing this deficiency will require comprehensive farmer training programs to enhance awareness and adoption of soil-based fertilization practices.

Declaration of interests

The authors of the article declare that they do not have any conflict of interest

Author Contributions

The authors declare that they have contributed equally to the article.

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