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Exploratory factor analysis of manure utilization for sustainable dairy farming: Evidence from crop-dairy farming systems in Turkey

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A B S T R A C T

The present study aimed to carry out an exploratory factor analysis to understand how manure utilization can contribute to sustainable dairy farming in integrated farming with crop-dairy farming systems. Factor analysis was used to put forth the sustainable manure utilization of farmers. The principal component method and varimax rotation were used in factor analysis. A total of 4 factors explaining the sustainable manure utilization of farmers were obtained as a result of the factor analysis. These 4 factors explain 51.29 % of the total variance. Factor 1 "Chemical fertilizer and manure utilization level and efficiency perception, Factor 2 "Soil analysis and crop nutrient utilization", Factor 3 "Correlation between manure sufficiency and expenses (cost)", Factor 4 "Limitations in chemical fertilizer and manure utilization". Of these factors, Factor 1: "Chemical fertilizer and manure utilization level and efficiency perception" was identified as the most important explanatory factor. Factor 1 explains 19.06 % of the total variance. Chemical fertilizer applications integrated with manure can be made ecologically and economically more effective by increasing the awareness levels on sustainable manure utilization and nutrient management of farmers at the integrated farming in the study region.

Introduction

The agriculture sector is a socially and economically important sector in Turkey. The share of agriculture in total GNP is 4.9 %. The agricultural sector contributes of about 15.9 % to total employment (TURKSTAT, 2021). The share of agricultural products in total export is 10.4 % whereas their share in total imports is 6.2 %. There are a total of 3,1 million agricultural farms in Turkey with dairy farming activities conducted in 1,1 million. Dairy farming in Turkey is carried out at small scale-farms (Yılmaz and Ata, 2016) with 75,3 % having 1–6 dairy cattle. The average agricultural farm size in Turkey is 6,1 ha. Animal production is conducted at 5,3 % of the total number of the agricultural farm in Turkey whereas crop production is carried out in only 23,5 % with 71,2 % conducting both livestock and crop production (TURKSTAT, 2018).

Strategies that give importance to environmental protection are developed when determining agricultural policies because of the environmental problems caused by the agricultural systems that are widely used in agricultural production as well as the chemical raw materials used (Innes, 2000). Recent studies on the agriculture sector have primarily focused on the development of highly efficient species for more sustainable agricultural production and the less frequent use of more effective chemical raw materials. In this scope, environmentally friendly, sustainable and economic agricultural production applications are encouraged (Adhikari et al., 2005).

The use of manure in crop production increases in importance because it is a rich source of nutrients. Manure is one of the important components of sustainable agricultural production as an organic soil regulator. Manure especially makes environmental and economic contributions to the crop nutritional cycle, especially at farms where both livestock and crop production are carried out simultaneously (Araji et al., 2001). Thus, the importance of meeting the deficits of nutrient uptake from the soil through the use of manure is increasing in developing countries (Yılmaz et al., 2010). The use of manure in crop production for increasing soil productivity also reduces dependence on external sources (Ghosh, 2004; Subedı, 1998). The use of manure acquired from integrated crop and animal production systems especially in the production of feed crop contributes to sustainable agriculture by reducing the dependence on external sources (Yılmaz et al., 2019).

It is estimated that approximately 186.5 million tons of fresh manure, 105 million tons of which can be collectable, is produced in Turkey every year, and 65 % of this manure is obtained from cattle (Yılmaz et al., 2019). In previous studies, it was reported that 58 % and

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75 % of the manure obtained in Turkey was used as an energy source for heating purposes in rural areas, while only 10 % and 25 % was used in crop production for agricultural purposes (Goncagul, 2003; Life, 2006; Olgun and Polat, 2005).

There is an important manure potential in Turkey that is not adequately utilized. In Turkey, manure is either used uncontrollably or burned in open areas and left to rot. In both cases, it has a significant negative environmental impact while also causing a loss of usable plant nutrients. However, the technology, environmental impacts, economics and input–output analyses regarding the effective application of manure to the soil as plant nutrients are unknown. (Yılmaz et al., 2010; Yılmaz et al., 2009).The problem is that the storage, collection, preservation, maturation, application, and effective utilization processes related to the production, consumption, and recycling of manure, which is a rich renewable resource, are not known, and environmental and economic research on the use of manure has not been conducted. Furthermore, there are unbalanced in the use of animal manure per unit area according to products, farms and regions. Additionally, since there is no use of animal manure based on soil analysis, there is a problem of unnecessary and unbalanced use of manure (Yılmaz et al., 2010; Yılmaz et al., 2009; Yılmaz et al., 2019). Manure, which is an important renewable resource in sustainable agricultural production and preservation of soil fertility, cannot be used effectively and cannot be brought into the country's economy.

The cattle population in Burdur province is 216.974. There are 15.154 dairy farms in the province. A total of about 400.000 tons of milk is produced in the province. Of the total agricultural GNP in the province, 34,8 % is acquired from livestock production (TURKSTAT, 2020). Dairy farming in the province is carried out both in traditional and modern small family farms. These farms also conduct crop farming in addition to milk production (Ata and Yılmaz, 2015). The farms utilize manure obtained during milk production as fertilizer in crop farming as well. The development of manure processing, storage and utilization along with manure management systems is of significant importance for sustainable agricultural production in the study region. The sustainable use of manure will make important contributions to solving dairy farming based environmental issues, management and planning of environmental problems in rural areas, technological changes in agriculture, dairy farming, agricultural waste management, organic agriculture and rural employment. When the previous studies on the subject are examined; manure management (Malomo et al., 2018; Millner, 2009; Ndambi et al., 2019; Oenema et al., 2007; Van Horn et al., 1994; Yılmaz et al., 2019; Burton and Turner, 2003) and manure applications (Gami et al., 2009; Kumar et al., 2013; Maillard and Angers, 2014; O'Brien and Hatfield, 2019; Parham et al., 2002; Rotz et al., 2011; Saha et al., 2010; Sheng et al., 2019; Yang et al., 2007; Yılmaz et al., 2009) have been found in various studies. The present study aimed to carry out a factor analysis to understand how manure utilization can contribute to sustainable dairy farming in integrated farming with crop-dairy farming systems in the Burdur province which holds an important position in Turkey for milk production. The theoretical and conceptual framework of the study is associated with the following assumptions.

1. The use of animal manure in crop production has environmentally friendly and environmentally friendly effects.
2. With sustainable agricultural practices, it is economical to use fertilizer and manure together without reducing productivity and quality in crop-dairy farming systems.
3. It is possible to establish an environmentally friendly and profitable agricultural production system by using chemical fertilizer integrated with manure.
4. The process of utilizing manure as fertilizer, processing and storing it contributes to sustainable crop-dairy farming systems.

Material and method

Data collection

The main material of the study was comprised of primary data acquired via survey method from livestock farms in the Burdur province that carry out dairy and crop farming activities with at least 5 dairy cattle. Lists for the number of dairy farming and their animal assets (number) were prepared for the Burdur province, districts and villages within the scope of the field study. A total of 633 dairy farms with a cattle asset of 5 heads and above comprised the main population of the present study. Simple Random Sampling Method expressed by the formula given in Eq. (1) was used for determining the number of farms to be included in the survey implementation (Çiçek and Erkan, 1996). The number of sample farms was calculated using Eq. (1).

$$n = \frac{N^*S^2{}^*t^2}{(N-1)^*d^2 + S^2{}^*t^2} \tag{1}$$

Here;

n: sample volume,
N: number of farms within the framework of sampling.
S: standard deviation
d: a predetermined deviation (10 %) from the average,

whereas t denotes the t-table value (1.65) corresponding to the 90 % confidence limit.

It was determined as a result of the calculation based on the formula given above that a total of 102 farms should be included in the survey study with a 90 % confidence interval and 10 % error margin. The farmers to be surveyed were randomly selected.

$$n = \frac{633^*158,89^*2,72}{(633-1)^*3,55 + 158,89^*2,72} = 102,08 \tag{2}$$

Propositions were presented to the farmers included in the survey conducted for the examination via factor analysis of the sustainable manure utilization by the farmers and their levels of accepting each proposition were measured using a 3-point Likert scale. The propositions regarding the utilization of sustainable manure were prepared in the form of a 3-point Likert scale with the responses of: 1: I do not agree, 2: I am indecisive, 3: I agree'. The suggested statement to farmers in the survey were formulated by the authors from the literature studies on the article, in accordance with the purpose of the subject. The propositions were formulated by scanning and examining the literature on sustainable agriculture, sustainable dairy farming, sustainable manure and fertilizer use, and sustainable crop-dairy farming systems. In the reviewed literature (Burton and Turner, 2003; Gami et al., 2009; Kumar et al., 2013; Maillard and Angers, 2014; Malomo et al., 2018; Millner, 2009; O'Brien and Hatfield, 2019; Oenema et al., 2007; Parham et al., 2002; Rotz et al., 2011; Saha et al., 2010; Sheng et al., 2019; Van Horn et al., 1994; Yang et al., 2007; Yılmaz and Ata, 2016; Yılmaz et al., 2009; Yılmaz et al., 2019), the most important propositions related to sustainability were selected and it was decided that 20 propositions would be sufficient.

Statistical analysis

The data collected in the present study for the evaluation of the manure and chemical fertilizer practices of farmers in sustainable agriculture were analyzed via factor analysis. Factor analysis is a frequently used multivariate statistical analysis method that transforms a large number of related variables into a smaller number of independent factors (Yong and Pearce, 2013). Factor analysis explains the reason for the mutual dependence among the variables in the dataset by reducing them to a smaller number of variables.

Three methods are used to test whether the dataset to be subject to the analysis is suited for factor analysis or not. These make up the formations of the correlation matrix, Barlett test and Kaiser-Meyer-Olkin (KMO) test. The first stage in testing whether the survey data are suitable for factor analysis is examining the correlation coefficients between the variables after which the Bartlett's Test of Sphericity is evaluated. Accordingly, the greater the correlation values are among the variables the higher the probability that the variables will form common factors (Yong and Pearce, 2013). Kaiser-Meyer-Olkin (KMO) test is an index comparing the magnitude of the observed correlation coefficients. The Kaiser-Meyer-Olkin (KMO) ratio should be greater than 0.5. Higher Kaiser-Meyer-Olkin (KMO) ratios indicate higher suitability of the dataset for factor analysis. Thus, a Kaiser-Meyer-Olkin (KMO) ratio of 0.90 is evaluated as perfect, Kaiser-Meyer Olkin (KMO) ratios of around 0.80 are considered as very good, 0.70 s as good, 0.60 s as moderate, 0.50 s as weak and below 0.50 as unacceptable (Anderson et al., 1992). The eigenvalue scree test and variance criteria are important criteria taken into consideration when deciding on the number of factors. The eigenvalue indicates the total variance explained by each factor. Only factors with the eigenvalues of above were 1 selected during the implementation.

Varimax method

While some load values in each column approach the value of 1 in this method that gives priority to the columns of the factor loads matrix for simplifying the data, the other load values approach 0. For this purpose, varimax rotation was applied to maximize the factor variances after which principal components method was used for factor analysis for a better interpretation of the results (Kaiser, 1958).

Result and discussion

Table 1 presents the general attributes of the farms included in the study. Accordingly, the mean age of the farmers at the farms examined was determined as 48.81. It was identified that the farmers have an education of 7.53 years on average. The mean farming experience of the farmers was determined as 28.20 years, while the mean dairy farming experience was set forth as 20.36 years. The mean dairy farming experience duration has been indicated as 17,8 years in a previous study (Şahin, 2001). In another study, it was determined that 47 % of dairy farmers had 14–36 years of experience (Kılıç and Eryılmaz, 2020). Uzmay (Uzmay, 2017) determined that the dairy farm experience period of the producers was 21 years.

The mean cattle asset of the farms included in the study was calculated as 33.63 head. Whereas the mean crop production area which is an important indicator for the profitability and sustainability of animal production was identified as 8.29 ha. The mean farm size of the farms included in the study was 9.61 ha with a forage crop production of 86,29 %. This ratio was identified in another study as 73,5 % (Bakır and Kibar, 2018). The farmers meet 45.12 % of the total amount required for their dairy farming activities from the production at their farm. In another study, it was determined that 27.1 % of the farm meet the concentrate feed supply from the feed dealers and their production (Kılıç and Eryılmaz, 2020). In the study of Mat and Cevger (Mat and Cevger, 2020), it was stated that 68 % of the roughage used by dairy cattle farms was produced by them. It was observed that the farms use on average about 11.10 tons/ hectares of manure and 516 kg/ hectares of chemical fertilizer during crop production. It should be emphasized here that since no animal manure is applied based on soil analysis, it is difficult to say whether the amount of animal manure used is more or less. However, a study conducted in Turkey stated that an average of 7.67 tons/ hectare of animal manure was applied (Yılmaz et al., 2009). While the amount of manure that the farms obtained through their dairy farming activities was calculated as 213,23 tons/year.

Table 1
General characteristics of the farms included in the study.

Characteristics	Mean	Standard deviation	Max	Min
Age of the farmer (years)	48.81	11.85	78	22
Education status (years)	7.53	3.77	15	0
Farming experience (years)	28.20	11.72	62	5
Dairy farming experience (years)	20.36	10.51	45	2
Cattle (head)	33.63	27.41	147	6
Average farm size (hectares)	9.61	9.15	6.90	2.0
Forage crop production area (hectares)	8.29	8.94	6.90	1.25
Forage crop ratio in the cultivated area (%)	86.29	–	–	–
Manure produced at the farm (tons/year)	213.23	223.25	1.450	30
Utilized amount of manure (tons/ hectares)	11.10	14.10	70.00	2.20
Utilized amount of chemical fertilizer (kg/hectares)	516.00	162.20	850.00	150.00

Analysis of the sustainable manure and chemical fertilizer practices of farmers via factor analysis

Table 2 presents the 20 propositions and coding developed for identifying the factors that are effective in measuring the perspectives of the farmers regarding the correlation between sustainable farming and the manure and chemical fertilizer practices of the farmers at the farms included in the study. A 3-point Likert scale was used to measure the levels of perceptions of the farmers regarding these propositions. The participants responded to these propositions by selecting one of the responses; "1:I do not agree, 2: I am indecisive, 3: I agree".

Descriptive statistics for the 20 propositions used in factor analysis are presented in Table 3. The mean values calculated for measuring the perspectives of farmers regarding the correlation between sustainable agriculture and the utilization of manure and chemical fertilizer practices have been presented in descending order. The average levels of

Table 2
Propositions and codes regarding the sustainable manure and chemical fertilizer practices of farmers.

Codes	Propositions
A1	I do not use manure for plant production.
A2	I randomly apply manure to the field.
A3	I think that the amount of manure I obtain from my farm is insufficient.
A4	Weed pesticide cost increases because the amount of weed increases at the farm on which I utilize manure.
A5	I am knowledgeable about the methods of manure utilization.
A6	I need knowledge of the storage of manure and its application on farms.
A7	I keep a record of the time and amount of the manure and chemical fertilizer I utilize.
A8	Yield will increase if I increase the amount of chemical fertilizer and manure I utilize.
A9	Manure utilization increases the amount of organic substance in the soil.
A10	Manure utilization helps to sustain soil yield.
A11	I utilize a sufficient amount of chemical fertilizer in plant production according to the needs of the plant.
A12	I determine the type of chemical fertilizer and the amount to use myself.
A13	I conduct soil analysis annually.
A14	I use fertilizers by the results of the soil analysis.
A15	My fertilizer cost is reduced when I use manure.
A16	I know how much manure and chemical fertilizer I have to use for which product.
A17	The collection, transportation and utilization of manure are more costly compared with chemical fertilizer
A18	I refrain from excessive use of fertilizer since it can harm the soil and the environment.
A19	I cannot utilize manure excessively due to the weeds it contains.
A20	The resistance of the plant against diseases and pests is reduced due to the excessive use of chemical fertilizer.

Table 3
Descriptive statistics for the variables.

Variables	N	Minimum	Maximum	Mean*	Standard error	Standard deviation	Ordered Variables	Mean
A1	102	1	3	1.108	0.044	0.443	A9	2.814
A2	102	1	3	2.402	0.087	0.882	A10	2.775
A3	102	1	3	2.000	0.092	0.933	A16	2.618
A4	102	1	3	2.588	0.072	0.722	A4	2.588
A5	102	1	3	2.353	0.080	0.804	A11	2.588
A6	102	1	3	1.824	0.084	0.849	A15	2.559
A7	102	1	3	1.765	0.092	0.925	A12	2.510
A8	102	1	3	2.392	0.087	0.881	A2	2.402
A9	102	1	3	2.814	0.057	0.576	A8	2.392
A10	102	1	3	2.775	0.059	0.595	A18	2.392
A11	102	1	3	2.588	0.066	0.665	A5	2.353
A12	102	1	3	2.510	0.075	0.754	A17	2.265
A13	102	1	3	1.471	0.078	0.792	A20	2.059
A14	102	1	3	1.627	0.085	0.855	A3	2.000
A15	102	1	3	2.559	0.073	0.739	A6	1.824
A16	102	1	3	2.618	0.065	0.661	A7	1.765
A17	102	1	3	2.265	0.087	0.878	A19	1.637
A18	102	1	3	2.392	0.080	0.810	A14	1.627
A19	102	1	3	1.637	0.082	0.830	A13	1.471
A20	102	1	3	2.059	0.087	0.877	A1	1.108

* Likert interval: 1:I do not agree, 2: I am indecisive, 3: I agree.

participation of the farmers in the propositions vary between (A9 = 2.814; A1 = 1.108). The variable of "Manure utilization increases the amount of organic substance in the soil (A9)" has the highest mean value among the propositions. Whereas the variable of "I do not use manure for plant production (A1)" was observed to have the lowest mean value. As can be seen from the table, it has been identified that 7 (A9, A4, A16, A15, A12, A11, A10) out of 20 propositions regarding the measurement of the perceptions of the farmers related to the correlation between sustainable agriculture and the utilization of manure and chemical fertilizer practices have been perceived as positive by the farmers (Average = 2.814; 2.510). It has been identified that the remaining 13 propositions (A8, A7, A6, A5, A3, A20, A2, A19, A18, A17, A14, A13, A1) have been perceived negatively (Average = 2.402; 1.108).

Factors with eigenvalues of greater than 1 were selected when determining the number of factors. "Varimax rotation analysis method" was utilized for identifying the factor loads. Variables with factor load value of greater than 0.32 were taken into consideration when interpreting the analysis results.

As can be seen in Table 4, Kaiser-Meyer-Olkin test (KMO) value statistics were calculated as 0.607. This is an indication that the variables identified can be used for factor analysis. In addition, 4 variables were excluded to increase the reliability of the analysis. For each excluded variable, transformation to the first judgement was applied for factor analysis until all judgments are in accordance.

Fig. 1 presents the graph for the four factors effective in the measurement of the perspectives of farmers after factor analysis regarding the correlation between sustainable agriculture and the manure and chemical fertilizer practices. The scree plot is the plot of the eigenvalue against all factors. The X axis denotes the factors, while the Y axis shows the eigenvalues. The number of factors to be included was decided based on this graph. The factors up to the point where the curve starts to get horizontal were included in the analyses, whereas the factors after the point where the curve becomes horizontal were excluded. The curve starts to get horizontal after the 5th factor in the following figure. The first 4 factors were included in the analysis and the factors after the 5th were excluded from the analysis. The eigenvalues of the first 4 factors were greater than 1. While the eigenvalues of the excluded factors were below 1.

Table 4
Kaiser-Meyer-Olkin (KMO) and Bartlett's Test.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.607
Bartlett's Test of Sphericity	Approx. Chi-Square	397.867
	df	120
	Sig.	0.000

Table 5 presents the statistical results for the factor analysis solution. Accordingly, it has been decided that 4 factors will be sufficient for explaining the variables taking into consideration the eigenvalues, variance and additive variance criteria. These 4 primary factors explain 51.29 % of the total variance. While the first factor explains 19.06 % of the total variance, the second factor explains 13.44 %, the third factor explains 9.75 % and the fourth factor explains 9.05 % of the total variance.

Factor analysis rotation results based on the varimax method are shown in Table 6. Variables with factor loads of 0.35 and above were taken into consideration when naming the factors based on the Varimax rotation solution results.

Factor load is a coefficient that explains the correlation between the items and the factors. The factor loads for the variables that explain the factors are expected to be high. To state that an item is good at measuring a factor, the factor load value should be 0.30 or above. Negative factor loads should also be taken into consideration when naming a factor in addition to the positive factor loads above 0.30 (Kline, 1994). The minimum magnitude of the factor loads should be 0.30 (Barnes et al., 2001).

High factor load values in factor analysis indicate that the factor is explained well. However, the boundary value can be reduced to 0.30 in cases when the number of items is low in application. Moreover, cases in which the propositions enter more than one factor should also be considered. In such cases, it is suggested that the minimum difference between the factor load values is 0.10 (Yong and Pearce, 2013). A total of 4 factors were identified based on the factor analysis results by considering the variance and additive variance criteria. Considering that the number of items subject to analysis is low and the requirement for a more accurate explanation of the data set, variables with factor loads of 0.35 and above were taken into consideration. The identified factors were named and interpreted.

The 4 primary factors determined as a result of factor analysis were named as; Factor 1"Chemical fertilizer and manure utilization level and efficiency perception, Factor 2 "Soil analysis and plant nutrient utilization", Factor 3 "Correlation between manure sufficiency level and expenses (cost)", Factor 4 "Limitations in the utilization of chemical fertilizer and manure".

Factor 1: *"Chemical fertilizer and manure utilization level and efficiency perception"*. This factor explains 19.06 % of the total variance. It is related to the farmers determining the amount of chemical fertilizer and

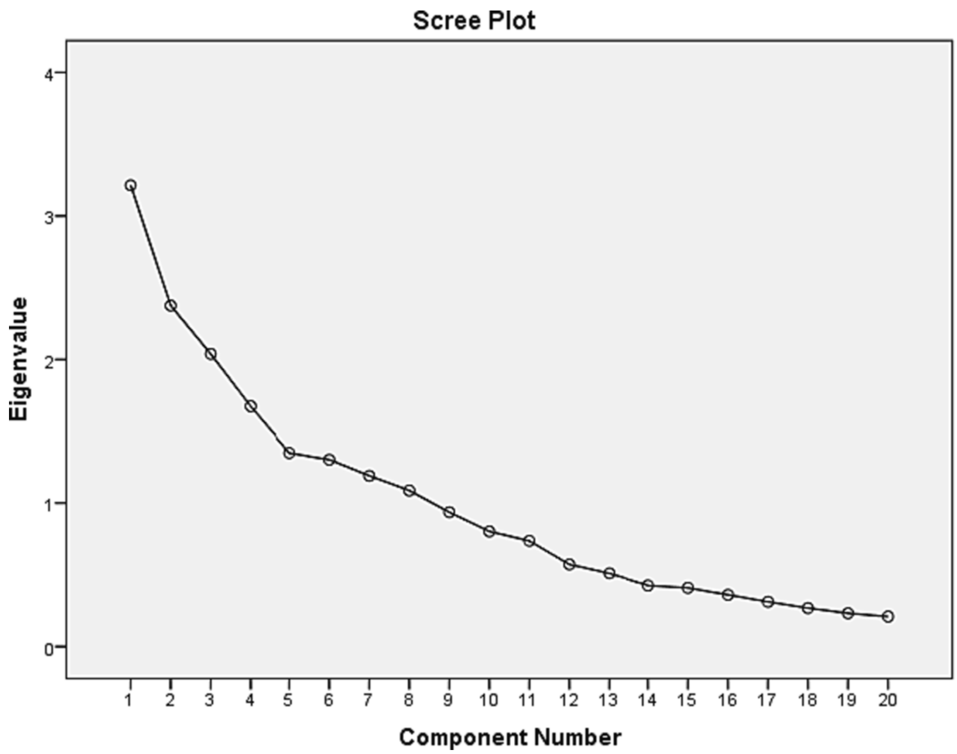

Fig. 1. Factors effective in the utilization of sustainable manure by the farmers (Scree plot).

Table 5
Factor analysis initial solution statistical results.

Explained Total Variance									
Factors	First eigenvalues			Extraction loads of the square loads			Rotation sums of the square loads		
	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %
1	3.049	19.058	19.058	3.049	19.058	19.058	2.99	18.688	18.688
2	2.15	13.438	32.496	2.15	13.438	32.496	2.004	12.522	31.21
3	1.56	9.749	42.245	1.56	9.749	42.245	1.653	10.329	41.538
4	1.448	9.05	51.295	1.448	9.05	51.295	1.561	9.756	51.295

Table 6
Varimax rotation results.

Rotated Component Matrix[a]				
Variables	Factor			
	1	2	3	4
A9	0.777	0.159	-0.275	0.059
A10	0.720	0.233	-0.299	0.021
A8	0.699	-0.038	0.218	-0.279
A2	0.625	-0.314	-0.054	-0.081
A7	-0.570	0.264	0.078	-0.121
A5	0.546	0.140	0.129	0.381
A6	-0.409	-0.005	-0.294	-0.051
A13	-0.122	0.834	0.015	0.031
A14	-0.023	0.787	-0.017	0.078
A17	-0.161	-0.466	0.331	0.127
A3	0.003	0.061	-0.760	-0.141
A12	-0.100	-0.074	0.540	0.005
A15	0.217	0.187	0.397	-0.200
A16	-0.048	0.075	0.214	0.695
A20	0.198	0.115	-0.345	0.682
A4	-0.069	-0.374	0.115	0.527

manure to be used based on their experiences, application in the field and the impacts of manure on yield. It can be concluded based on the level of knowledge of the farmers on the utilization of manure that the amount of manure and its application in the field is directly related to yield. In other words, it is considered that the utilization of manure is directly effective on the sustainability of the yield of the fields. *Factor 1* was observed to be related with the variables of A9, A10, A8, A2, A7, A5, A6. Nicholson et al (Nicholson et al., 2004) conducted a study in which it was emphasized that manure is important not as a waste but as a plant nutrient with the economic value used for improving yield in crop production. Xiang et al. (Xiang et al., 2008) emphasized that the use of rational fertilizers is the most effective and important application in increasing plant production. Sahin (Şahin, 2016) stated in his study that the use of fertilizers is one of the main activities used to increase the quality of the soil and to obtain high yields. Ghosh (Ghosh, 2004) carried out a similar study in India illustrating the environmental and economic benefits of utilizing manure for the sustainment of product yield and farmer income. Yılmaz et al. (Yılmaz et al., 2009) identified in a previous study that the utilization of manure for meeting the plant nutrient requirement needed for plant production increases with the increasing scale of establishment in private beef farms. It has been concluded that the utilization of animal fertilizer in plant production will reduce the dependence of farmers on chemical fertilizer while also leading to an economic outcome. Moreover, it has also been determined that the effective use and management of manure and chemical fertilizer will lead to less environmental pollution while also contributing to sustainable agriculture.

Factor 2: "Soil analysis and plant nutrient utilization" explains 13.44 % of the total variance. Based on the soil analysis result of the farmers, this factor is related to the use of crop nutrients to meet the requirement of the soil and the crop. *Factor 2* was observed to be related to the variables of A13, A14, A17. Adhikari et al. (Adhikari et al., 2005) conducted a study a result of which it was indicated that the manure obtained from dairy farming can be used economically instead of chemical fertilizer in plant production due to its nitrogen, phosphorous and potassium content. Farmers in the study region are aware of the importance of manure for increasing soil yield. However, it has been identified that they carry out the manure utilization practices (collection, loading, transportation and utilization on the farm) in a wrong and incomplete manner. Only 16.67 % of the farmers in the study region get a soil analysis done. It can be stated that the ratio of farmers who get a soil analysis done is quite low. Only 23.53 % of the farmers have participated in a training program on fertilization. A lack of training and awareness has been identified in the study region about both manure and chemical fertilizer utilization. In addition to observing that the ratio of farmers who get soil analysis done is low, it was also identified based on the analysis results that they do not use fertilizer as well. It was illustrated that the farmers decide on the amount and type of fertilizer they use in plant production based on their own experiences.

Factor 3: *"Correlation between manure sufficiency level and expenses (cost)"* This factor explains 9.75 % of the total variance. Factor 3 was observed to be related to the variables of A3, A12, A15. It was calculated that the farmers save 800,60 TL/ hectare (1 USD dollar = 6,12 Turkish Lira (TL)) when they utilize manure integrated chemical fertilizer. These results indicate that manure utilization can be economical for farmers. Yılmaz et al. (Yılmaz et al., 2009) carried out a study as a result of which it was reported that the integrated utilization of manure obtained from private beef farms with chemical fertilizer in plant production is an economic alternative and that it is also an ecologically suitable biological resource about integrated nutrient management. Rausch and Sohngen (Rausch and Sohngen, 2010) conducted a study in which the labor, equipment and annual utilization costs were calculated for the utilization of manure. These costs were compared with the nutrient values of the manure integrated with chemical fertilizer. It was shown that the annual utilization cost of manure is higher than the chemical fertilizer nutrient value. It has been set forth as a result of the study conducted by Mutiro and Murwira (Mutiro and Murwira, 2003) that the utilization of chemical fertilizer together with manure by small farming in corn production is profitable. It has been emphasized in various recent studies that the integrated utilization of manure with chemical fertilizer is promising not only for the sustainment of high yield but also for greater consistency in plant production (Selim, 2020; Zingore et al., 2008). In a study conducted on dairy farms, it was determined that all of the manure obtained in the farms was used in crop production, and it was determined that 87.4 % of them used the manure on their land and the rest was sold (Soyer, 2014).

Factor 4: *"Limitations in the utilization of chemical fertilizer and manure"* This factor explains 9.05 % of the total variance. Factor 4 was observed to be related to the variables of A16, A20, A4. Battel and Krueger (Battel and Krueger, 2005) carried out a study in which it has been indicated that manure management and utilization practices should be subject to technical and environmental analyses and that it is necessary to understand the reasons and limitations underlying the inability to make sustainable and economical use of manure. Various limitations have been observed in the study region regarding the utilization of manure with chemical fertilizer and integrated plant crop management. These are a lack of knowledge regarding the manure utilization practices, the greater reliance of manure on external labor for transportation and utilization compared with chemical fertilizer, and the difficulties involved in its utilization, insufficient agricultural extension services and low income of farmers. One of the most important limitations for the farmers is the increase of weeds on the farm due to the use of manure leading to increased costs resulting from the use of pesticides. In addition, the insufficiency of publications on integrated nutrient management on the part of the farmers, the establishment of the soil nutrient balance with consideration given to soil characteristics and plant requirements, environmental impacts of the utilization of manure and chemical fertilizer and means to increase profitability along with the lack of farmer organizations and cooperatives impact have been identified as significant limitations. Excess applications of manure can result in the runoff and leaching of nutrients, thus leading to surface and groundwater pollution (Carr et al., 2020). Important technical and environmental limitations have been identified in studies conducted on the utilization of manure such as the emergence of weed problems due to the utilization of manure leading to the germination of weed seeds, the undesired odor due to the utilization of manure disrupting the healthy environmental conditions and the accumulation of nitrate in underground waters due to excessive use (Karaman, 2006; Yılmaz et al., 2019).

Conclusion

Manure is an economical input that can also be utilized as a nutrient in plant production. The integrated use of manure with chemical fertilizer improves the properties of soil, increases product yield and reduces erosion. In addition to its environmental and yield benefits, manure also contributes to sustainable agriculture by reducing operational costs.

The present study aimed to carry out a factor analysis on the utilization of sustainable manure by the farmers in integrated farming where dairy farming and crop production are conducted. It was concluded as a result of factor analysis that 4 factors are effective in the explanation of the sustainability of the utilization of manure integrated with chemical fertilizer which are; (a) Chemical fertilizer and manure utilization level and efficiency perception, (b) Soil analysis and crop nutrient utilization, (c) Correlation between manure sufficiency and expenses (cost) and (d) Limitations in chemical fertilizer and manure utilization.

The utilization of manure as fertilizer has certain economic and ecological advantages and disadvantages in the study region. The proper utilization of manure may lead to the sustainability of soil yield while increasing product yield. However, different manure management policies are required in the study region for the storage of manure, its transportation to the field, its utilization and its integrated use with chemical fertilizer. Moreover, encouraging agricultural support policies should be implemented for the preservation of the nutrients in manure during storage, transportation and utilization practices in addition to increasing its use. In addition, it has been identified that the farmers in the study region do not have sufficient knowledge of integrated manure and fertilizer utilization and management. In order to prevent the loss of nutritional value of the obtained manure, manure storage should be made mandatory on farms and farmers' storage construction costs should be subsidized by the government. In addition, the maximum amount of manure to be applied per unit area should be determined in order to reduce soil and groundwater pollution. An important problem that needs to be solved before the use of manure is to inform farmers about the importance of soil analysis. Farmers' manure and fertilizer applications based on soil analysis should be encouraged and farmer training and extension programs should be developed to solve this problem. Agricultural extension activities are provided to the farmers by both the state and private companies. However, information is not provided on the utilization of manure and integrated utilization of fertilizer during the farmer education and extension services. For this reason, more education practices are required to ensure that the farmers take on improved manure and chemical fertilizer management practices in addition to increased awareness for the utilization of establishment resources. For further studies, research is recommended to determine the technical, economic, social and environmental effects of the collection, storage, preservation, maturation, field application and effective use of animal manure in sustainable crop-dairy farming systems through econometric analysis.

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Contributions

HDÖ analyzed the samples and wrote the first version of the manuscript. MMD contributed to the introduction and discussion part of the article. HY designed the study and contributed to the writing of the final version of the manuscript. HDÖ collected the data via survey. HY participated in writing through reviewing and editing. All authors have read and approved the final version of the paper.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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