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Araştırma Makalesi

Besi Ahırı Projelerinin Gübre İşletim Planlamasıyla Birlikte Ele Alınması: Çanakkale/Ayvacık Uygulama Örneği[&]

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Öz

Hayvancılık işletmelerinde hayvan barınakları hayvan refahı, verimlilik ve işgücünün etkin kullanımı dikkate alınmadan inşa edilmektedir. Tasarım ilkeleri izlenerek bu sorunlar ortadan kaldırılabilir. Ancak ülkemizdeki küçük aile işletmeleri dikkate alındığında büyükbaş hayvan barınaklarında oldukça büyük tasarım hatalarının olduğu görülmektedir. Hayvancılık işletmelerinde dikkate alınmayan bir diğer konu ise üretim sırasında ortaya çıkacak hayvansal atıkların toplanması, iletilmesi, depolanması ve bertarafı ile ilgili süreçlerdir. Bu durum ortaya çıkan atıkların yönetimini zorlaştırır, çevre sorunlarına neden olur ve çok değerli bir bitki besin kaynağı olan organik gübrenin israfına neden olur. Bu çalışmada, yukarıda belirtilen problem ve olası gübre yönetim seçenekleri dikkate alınarak küçük ölçekli (50 baş sığır) bir işletme tasarlanmıştır. Tasarımı yapılan işletme için yıllık 575 ton gübre üretimi hesaplanmıştır. Ancak toprak analizi sonuçlarına ve çeşitli tesislere göre bu işletmede yıllık 76 ile 902 ton gübre uygulanması gerekecektir. Bu uygulama miktarı, gübre yönetim planlarına dayalı olarak ayrıntılı bir bitki üretim planının yapılması gerektiğini göstermektedir. Alternatif plantasyonlar için gübre atılması gereken arazi ihtiyacı 13 – 91 da arasında değişmektedir. Gübre uygulamasına uygun arazi bu işletme için yaklaşık 20 dekardır. Bu nedenle, gübreyi yönetmek için başka araziler de gerekmektedir. Çalışmanın sonuçları, yıllık üretilen gübrenin ticari değerinin yaklaşık 874 $ olduğunu göstermiştir. Bu değer aynı zamanda toprak/gübre besin içeriğine ve plan ihtiyaçlarına dayalı gübre yönetiminin önemini de göstermektedir.

Anahtar kelimeler: Ahır projesi, sığır barınakları, çevresel kalite, gübre yönetimi, besin yönetimi

Consideration of Beef Cattle Barn Projects With Manure Management Planning: Çanakkale/Ayvacik Case Study

Abstract

Livestock barns are built without taking into account animal welfare, productivity and effective use of labor in cattle breeding enterprises. These problems can be eliminated by following the design principles. However, considering the small family businesses in our country, it is seen that there are quite large design errors in the cattle barns. Another issue that is not taken into account in livestock enterprises is the processes related to the collection, transmission, storage and disposal of animal wastes that will arise during production. This makes management difficult, causes some environmental problems, and wastes manure, which is a very valuable plant food source. In this study, a small scale (50 head beef) operation is designed considering the above mentioned design criteria and possible manure management options. Annual manure production capacity of 575 ton is calculated. However based on the soil analysis results and various plants this operation will need to apply 76 to 902 tons of manure annualy. This shows that a detailed plant production plan should be conducted based on the manure management plans. For alternative plantations land requirement to dispose of manure vary between 13 – 91 da. The land available for manure application is about 20 da for this operation. Therefore, additional land should be managed to manage manure. Results of the study showed that commercial value of manure produced annualy is about 874 $. This value aslo demonstrates the importance of manure management based on soil/manure nutrient contents and plan needs.

Key words: Barn project, beef housing, environmental quality, manure management, nutrient management

Introduction

Turkey, located between Europe and Asia, has an agricultural production potential. It's also one of the few countries that is self-sufficient as far as crop and livestock production (FAO, 2004). Livestock potential is quite high both in Çanakkale province and in its Ayvacık district. Despite this, the genetic value of animals and their environmental conditions, which are the two main factors that determine the yield in animal production, are not taken into account sufficiently in Ayvacık, as in other regions of Turkey. In order to achieve high productivity, animals must have a high genetic level of efficiency, as well as an environment that will allow the genetic potential of the animal to be transformed into yield. In summary, high-yielding animals must be housed in appropriate environmental conditions in order to increase productivity in animal husbandry (Han and Bakır, 2010; Kutlu et al., 2003).

The primary purpose of making livestock barns is to eliminate the effects of undesired environmental conditions on the animals, and to increase their productivity within economic limits. At the same time, it is to provide comfortable living conditions suitable for animal behavior. For this reason, when designing barns, they should be sized to provide sufficient space and interior detail for the movement, feeding and drinking behavior of animals, and should be kept within economic and optimal limits in care, management and hygienic conditions (Mutaf et al., 2001).

In Turkey, generally, especially in cattle barns, structural design and issues such as animal welfare and labor productivity are not given importance. However, many scientific studies are carried out in the design of livestock barns. For example, it has been observed that many animal welfare problems arise when concrete-floored group padocs are used to house cattle (Graf, 1984; Schulze Westerath et al., 2007). By contrast, litter-lined systems are a good alternative to concrete-lined systems and provide a soft resting area for beef cattle. In this context, when choosing the floor type, preferring litter-line systems instead of hard concrete covered floors for beef cattle will result in more positive results in terms of animal welfare (Koch and Irps, 1985; Lowe et al., 2001).

Combined barn systems have become increasingly popular in Austria, taking into account the advantages of both systems in order to reduce the cost of litter according to regional conditions, and to increase the welfare of cattle. Farmers keep animals in litter systems until they reach a weight of about 400-450 kg, and then they place them in concrete or grid-floored systems (Absmanner et al., 2009).

In countries where the number of housed animals is low, closed system animal shelters are generally preferred. In Scandinavia, for example, the numbers of animals in cattle herds are quite small, and so far, insulated buildings have been used to protect animals against low winter temperatures and wind (Mossberg et al., 1992; Redbo et al., 1996). One reason for this is to improve the working conditions of the farmer (Manninen, 2007). It is possible to see a similar approach in the conditions of our country.

However, it has been found that barn systems with an open front, closed with walls on 3 sides, or very simple building systems that protect animals from the wind, also give good results (Redbo et al., 1996). Before designing a suitable housing system, it is necessary to thoroughly study regional climatic conditions, legal regulations and other issues (Christopherson, 1985). Increasing public interest in animal welfare as well as livestock and economic aspects should be considered in the design of all animal shelter projects.

Producers often try to ensure the continuity of plant production by purchasing nitrogen (N), phosphorus (P_2O_5), potassium (K_2O) and some other nutrients that plants need. On the other hand, livestock operations may have difficulty in finding land where they can dispose of the resulting organic fertilizer without harming the environment (Mallory et al., 2010). In fact, although animal manure is often perceived as a waste problem, it is a valuable food source for plants (Kessel et al., 1999). When used appropriately, animal manure not only provides nutrients to plants, but also improves soil texture, aeration properties and water holding capacity (Hillel, 1980). However, fertilizer applications without any planning not only affect plant growth, but also cause soil and water resources to be polluted and plant nutrients to be wasted (Kızıl and Lindley, 2001).

Animal waste management is still not given enough importance in Turkey. On the other hand it has gained more importance as a result of specialization in production tools with industrialization in developed countries. This makes producers specialize in either livestock or plant production that negatively affects the balance in the use of organic and inorganic fertilizers (Russelle et al., 2007; Mallory ve ark., 2010). Therefore, it is necessary to ensure the integration of plant and animal production. In the absence of this integration, the balance of nutrients, especially N, cannot be achieved in nature (Schröder, 2005).

The primary purpose of livestock waste management is to utilize the manure in a way that will serve as s renewable resource within the livestock/plant production cycle. Hence, it is necessary to determine the amounts of plant nutrients to be obtained from manure. Since plants' need for micronutrients is relatively low, macronutrients such as N, P_2O_5 and K_2O are taken into account in nutrient budget calculations. The ion forms of phosphorus and potassium can remain stable in the soil by bonding with clay minerals and can be taken up by plant roots by forming reactive bonds over time. On the other hand, all molecular phases of nitrogen are mobile and their amounts in the environment vary. As a result, only nitrogen from the amount of macro nutrient obtained by fertilizer analysis can change over time and the lost part must be calculated and found. However, some losses occur during the mineralization of the organic part of nitrogen that is not useful for plants (MWPS, 1993).

In this context, while developing barn projects, it is necessary to act in line with a fertilizer operation plan, taking into account the plant production opportunity and potential of the enterprise. Therefore, the aim and objectives of this study are to prepare a cattle barn project suitable for the small scale family business approach that can be applied as a model, design and discuss the manure collection, transmission and storage options within the project, determine the application time, method and amount of the stored manure to the land within the framework of a manure management plan, and calculate the economic gain to be achieved as a result of using manure as a nutrient in plant production.

Material and Method

Project area

The livestock operation designed within the scope of the project is located in Bilaller village of Ayvacık district in Çanakkale. Ayvacık is surrounded by Edremit district in the east, Aegean Sea in the west, Ezine and Bayramiç districts in the north, and Edremit Bay in the south (Figure 1). There are 64 villages and 2 towns in Ayvacık. Total population is 32,136 according to TUIK data for 2017. Ayvacık has a surface area of 874 km² and has a coastline of 78 km. Ayvacık district, whose land structure is mountainous and hilly, is 270 m high above sea level located on a volcanic plateau (Anonymous, 2018). The land where the operation will be established is approximately 23,000 m^2.

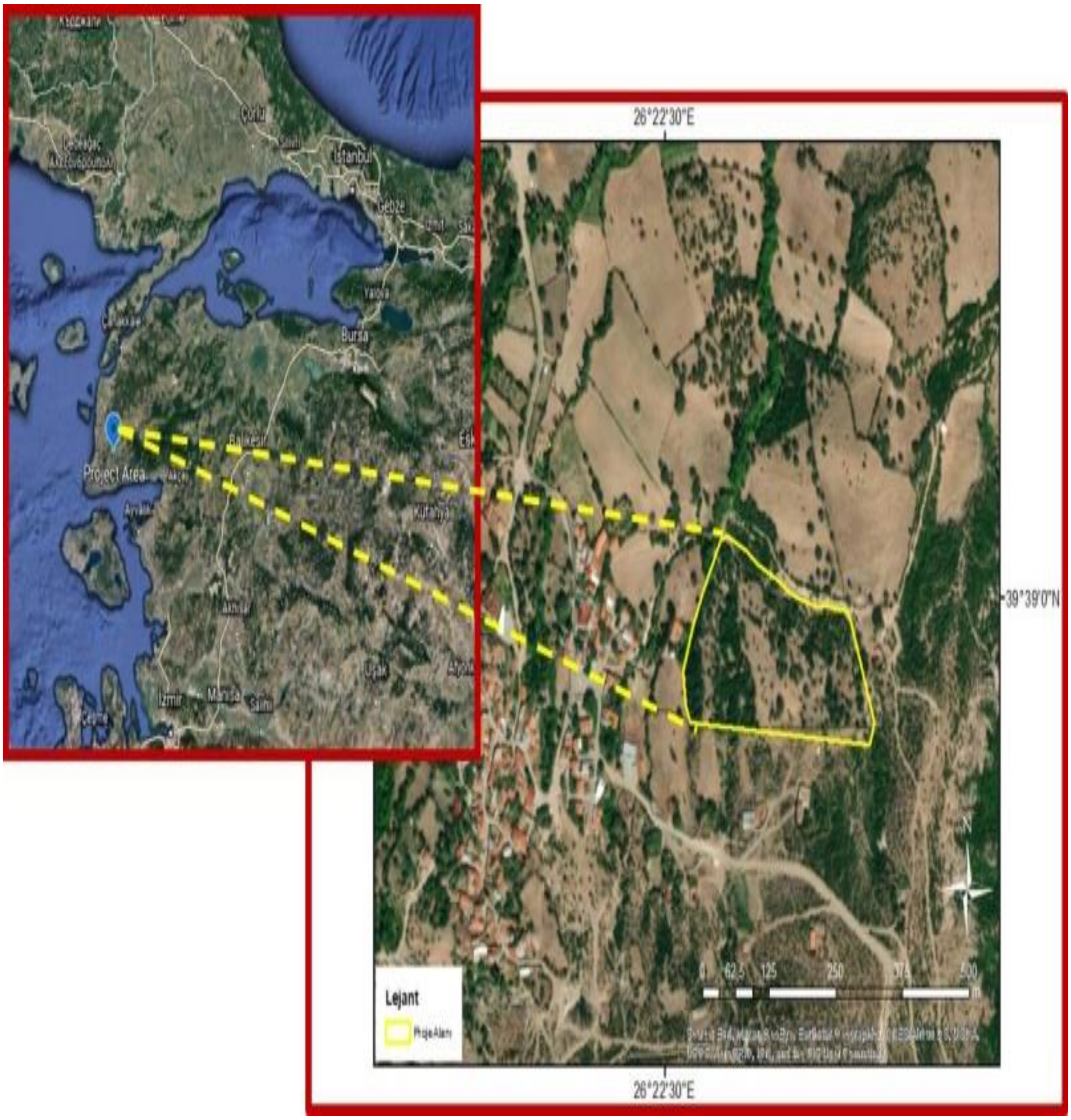


Figure 1. Ayvacık district and project area

Nutrient management planning

Data on manure nutrient contents is highly critical in nutrient budget calculations. Literature values or laboratory analysis of manure can be used to obtain data on nutrient contents. However, the literature values are approximate and variations are expected (Kessel et al., 1999). Therefore, best way to determine manure nutrient contents is to have sample analyzed by a laboratory (Schmitt, 1999). The disadvantage of this method is that it generally it takes 2 to 3 weeks to obtain results. During this time manure nutrients may change because of precipitation or other climatic conditions (Dagnew et al., 2000).

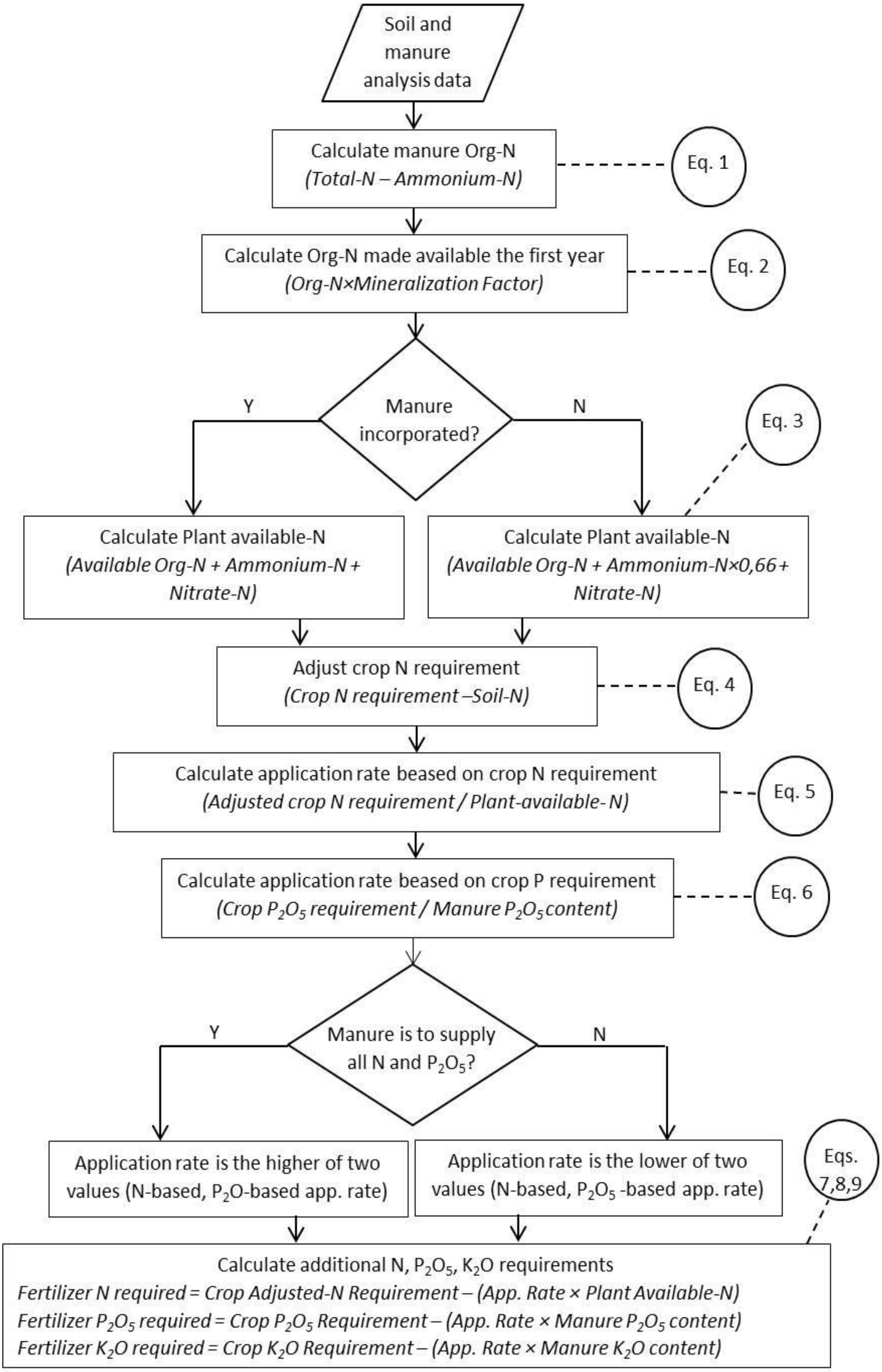


Figure 2. Nutrient management plan flow-chart

The method and equations given in MPWS (1993) were followed in nutrient management planning. Based on the method, the necessary information for nutrient management planning is fertilizer and soil analysis, mineralization factor, the purpose of manure application, nutrient requirements of the plant to be planted, manure application method and unit commercial fertilizer prices.

Mineralization factor is the percentage of Organic-N released during the application year. The purpose of the manure application might be either supplying all required N and P_2O_5 by manure application per decare or maximizing the using nutrients in manure. In order to conduct nutrient budget plant's nutrient requirements data is also needed. Manure application method is also an important decision that should be made for a proper nutrient budget plan. If the manure is surface applied it is assumed that one third of ammonia is lost be volatilization. If it is incorporated, or injected, the volatilization is ignored. The flowchart of the nutrient management plan is represented in Figure 2.

Land required to dispose of manure and commercial value of manure produced are calculated followed by the above nutrient management plan. Annual manure production by the animal housed in the operation should be calculated based on the number and average number of animals. Manure production rate per animal unit (AU) (500 kg live-weight) of 11.5 ton y^{-1} is used to estimate annual manure production. Based on annual manure production capacity and manure nutrient contents, annual manure nutrient produced is calculated as given below;

$$AMN_{Pr} = MPR \times (Plant\ Available - N) \times AU$$ (Eq. 10)

$$AMP_{Pr} = MPR \times (Manure\ P_2O_5\ content) \times AU$$ (Eq. 11)

$$AMK_{Pr} = MPR \times (Manure\ K_2O\ content) \times AU$$ (Eq. 12)

Where; AMN_{Pr}, AMP_{Pr}, and AMK_{Pr} are annual N, P_2O_5, and K_2O productions, respectively; and MPR is annual manure production rate per AU (11.5 ton y^{-1}). Once the nutrient production potential of the operation is calculated land required to dispose of manure produced is calculated as follows;

$$LR_N = AMN_{Pr}/(Adjusted\ Crop\ N\ requirement)$$ (Eq. 13)

$$LR_P = AMP_{Pr}/(Crop\ P_2O_5\ requirement)$$ (Eq. 14)

Where; LR_N and LR_P are land required to dispose of manure for N and P_2O_5 respectively (decare).

The final step of the nutrient management plan is the estimation of commercial value of the manure annualy produced. Based on the annual N, P_2O_5, and K_2O productions that are calculated above (Eqs. 10-12), fertilizer values are calculated as follows;

$$CV_M = (AMN_{Pr} \times UP_N) + (AMP_{Pr} \times UP_P) + (AMK_{Pr} \times UP_K)$$ (Eq. 15)

Where; CVM is the commercial value of manure produced ($); UP_N, UP_P, and UP_K are unit price of commercial N, P, and K, respectively.
In order to conduct these calculation easly a spreadsheet program is developed in MS Excel to evaluate different options such as plants, application methods, and manure application purpose.

Results and Discussion

Design specifications

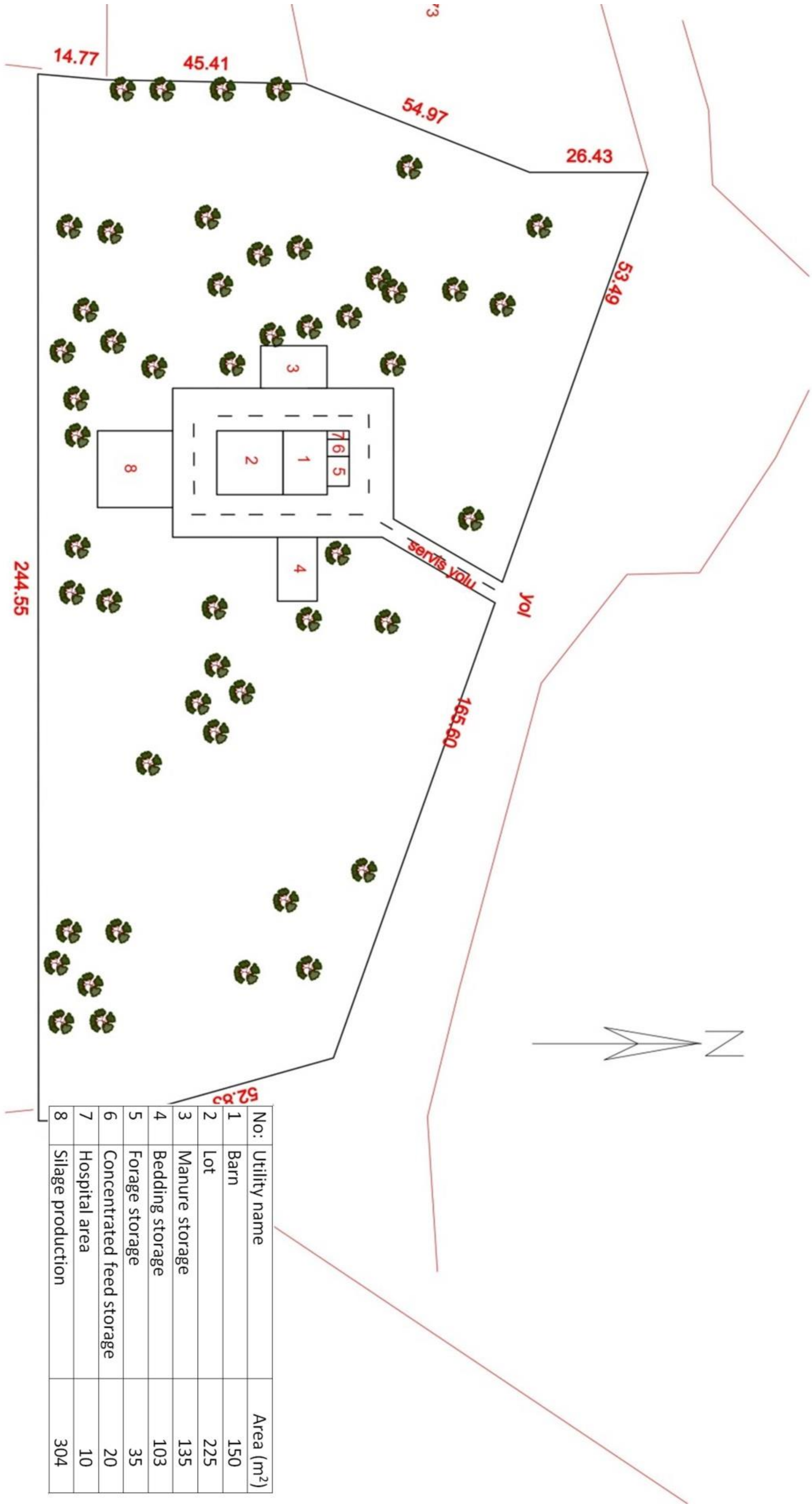
Based on the producer's demand the number of animals to be housed will be a maximum of 50 beef cattle. Tie-stall type of barn is generally used in cattle breeding in the region. However, it is known that tied stall barns are not preferred due to many disadvantages (Olgun, 2016). Therefore, the barn project is designed as a loose beef cattle barn with a walking yard, closed on 3 sides and open on the front facing south. Loose barns provide a low-cost housing system with advantages of easy expansion in the future and possible alternative usages. In the design space requirements of beef and capacity requirements of other facilities are first determined. Space and capacity requirements for this design are determined as follows (Table 1).

This operation needs about 1da area for building and associated facilities. Based on space requirements all facilities are located on the settlement plan as follows considering the prevailed wind direction, slope, and labor/time efficiencies among the buildings (Figure 3).

Table 1. Space and capacity requirements of the design

Barn space requirement		
Number of animals	50	head
Unit space requirement (barn)*	3	m^2 $head^{-1}$
Unit space requirement (open lot)*	4.5	m^2 $head^{-1}$
Total barn area	150	m^2
Total open lot area	225	m^2
Hospital pens		
Number of hospital pen*	2	
Area of one hospital pen*	5	m^2
Total hospital area	10	m^2
Concentrated feed storage		
Concentrated feed unit weight**	700	kg m^{-3}
Daily concentrate feed consumption**	3	kg day^{-1}
Storage period	180	days
Side wall height	4	m
Total concentrated feed consumption	27000	kg
Storage volume required	38.6	m^3
Floor area required	10	m^2
Forage storage unit		
Forage unit weight**	130	kg m^{-3}
Daily forage consumption**	2	kg day^{-1}
Storage period	180	days
Side wall height	4	m
Total forage consumption	18000	kg
Storage volume required	138	m^3
Floor area required	35	m^2
Silage unit		
Silage unit weight**	800	kg m^{-3}
Daily silage consumption**	20	kg day^{-1}
Storage period	365	days
Pile height	1,5	m
Floor area of a unit	6x12=72	m^2
Total silage consumption	365000	kg
Storage volume	456	m^3
Total silage unit floor area	304	m^2
Number of units	4	
Manure storage		
Daily manure production*	0,03	m^3 day^{-1}
Storage period	180	days
Total volume requirement:	270	m^3
Storage height	2	m
Floor area required	135	m^2
Bedding storage		
Bedding unit weight*	130	kg m^{-3}
Daily bedding requirement***	6	kg day^{-1}
Storage period	180	day
Side wall height	4	m
Total bedding requirement	54000	kg
Bedding volume required	415	m^3
Floor area required	103	m^2

*MWPS (1987),
**Anonymous (2007),
***Olgun(2016)



No:	Utility name	Area (m^2)
1	Barn	150
2	Lot	225
3	Manure storage	135
4	Bedding storage	103
5	Forage storage	35
6	Concentrated feed storage	20
7	Hospital area	10
8	Silage production	304

Figure 3. Facility settlement plan

Results of nutrient management plan

In this study, there is no manure samples obtained from the animals, as there is no established beef cattle farm. Therefore, nutrient budget calculations are made using the literature values. Sezen (1984) reported the nutrient contents of cattle manure as in Table 2. For the missing Ammonium-N value in the table, approximately 40% of the total nitrogen was considered (MWPS, 1993).

Table 2. Nutrient contents of beef cattle manure used in the nutrient management plan

Nutrient content	**%**
Total-N	0.29
Ammonium-N	0,12
Nitrate-N	0
P_2O_5	0.17
K_2O	0.10

At least 3 soil samples are collected from the land considering the changes in topography and different soil classes known by the producer. Then, a 1-kg of mixture of three samples are sent to Çanakkale Onsekiz Mart University, Science and Technology Application and Research Center (ÇOBİLTUM) laboratory for analysis. Soil analysis results are given in Table 3.

Table 3. Soil analysis results

Lab No	**Sample location**	**Depth (cm)**	**Saturation (%)**	**EC (mS/cm)**	**pH**	**Lime (%)**	**Org.Matter (%)**	**P (mg kg^{-1})**	**K (mg kg^{-1})**
168	Ayvacık Billaler		39.6	0.837	7.74	3.50	1.60	9.12	0.00

Explanations
9.12 N mg/kg = 5.20 kg da^{-1} P_2O_5
0.00 P mg/kg = 0.00 kg da^{-1} K_2O

A mineralization factor of 0.25 is considered since the animals will be raised on bedded floor (MWPS, 1993). Even though incorporation (or injection) is the best method to minimize odor problems and nutrient losses through volatilization and/or erosion surface application is considered to be the manure application method since obtaining an injector will be costly for such a small operation.

Another factor that should be considered is the purpose of manure application. As explained above manure should be applied either to supply all N and P_2O_5 need of plant or to maximize use of nutrients in it. If the second option is selected, land required to dispose of manure will be siginificantly big. On the other hand, the operator wants to utilize manure within his 23 da area. Therefore, the first option is selected.

Based on manure and soil analysis results and above mentioned assumptions manure application rates for various crops, additional fertilizer requirements, and land required to dispose of manure are calculated (Table 4).

Table 4. Nutrient management options for various plants

	Manure Application Rates (t/da)			Additional Fertilizer Required ($kgda^{-1}$)			
Plant	**N-based**	**P_2O_5-based**	**Selected**	**N**	**P_2O_5**	**K_2O**	**Land Required (da)**
Corn	22.6	8.40	22.6	0.00	0.00	0.00	25
Wheat	17.2	5.20	17.2	0.00	0.00	9.40	34
Barley	10.8	3.20	10.8	0.00	0.00	12.1	53
Sugar beet	24.4	6.50	24.4	0.00	0.00	19.8	24
Potatoes	45.1	12.9	45.1	0.00	0.00	18.9	13
Sunflower	13.5	5.80	13.5	0.00	0.00	12.7	42
Carrot	10.8	4.50	10.8	0.00	0.00	15.1	53
Celery	19.0	6.50	19.0	0.00	0.00	12.7	30
Cucumber	7.20	3.20	7.20	0.00	0.00	5.40	80
Lettuce	8.10	3.20	8.10	0.00	0.00	8.60	71
Melon	10.8	5.20	10.8	0.00	0.00	20.1	53
Watermelon	23.5	6.50	23.5	0.00	0.00	23.6	24
Pepper	12.6	3.20	12.6	0.00	0.00	6.50	45
Tomato	22.6	10.3	22.6	0.00	0.00	27.5	25
Spinach	10.8	3.20	10.8	0.00	0.00	10.1	53
Cabbage	10.8	2.60	10.8	0.00	0.00	10.1	53
Egg plant	16.3	2.60	16.3	0.00	0.00	15.2	35
Apple	9.90	2.60	9.90	0.00	0.00	8.00	58
Pear	6.30	1.30	6.30	0.00	0.00	2.20	91
Peach	11.7	5.80	11.7	0.00	0.00	9.30	49
Strawberry	9.00	2.60	9.00	0.00	0.00	3.80	64
Grape	9.00	2.60	9.00	0.00	0.00	6.80	64

In its current situation the land is partly covered by local trees and grasses. Other alternative of application of manure may be utilizing it for trees and grasses instead of production of specific plants as explained above. An average application rate of 3 ton da^{-1}may be used for this purpose (Brady, 1991). In this case total of 60 t/year manure will be required. On the other hand, 575 t of manure will be produced annualy. Therefore, alternative lands will be required to dispose of excess amount of manure.

Again, since the purpose of manure application is to supplay all N and P_2O_5 requirements of target plant, no additional commercial N and P_2O_5 required (Table 4). Additional commercial K_2O requirements for various plants are calculated and given in the same table. Based on the calculations, if this operation is to produce corn, there will be no additional K_2O requirement.

Another purpose of nutrient management planning is the estimation of commercial value of annualy produced manure. Equation 15 is used to estimate commercial value of the manure. Unit costs of equivalent N, P_2O_5, and K_2O must be known to calculate this value. These costs are obtained from the commercial fertilizer companies. Considering the annual manure nutrient production capacity and unit costs commercial value of manure is calculated as 874 \$ y^{-1} (7,689 TL y^{-1}). It is clear that utilizing manure as plant nutrient will significantly reduce the fertilizer expenses.

Conclusions

In today's world where environmental awareness is increasing, it is necessary to give importance to manure management in order to minimize the environmental problems arising from livestockoperations. Thus, both the environmental effects of manure will decrease and a significant part of the plant nutrient need will be met from livestock manure. Therefore, only structural calculations and techniques should not be considered while preparing farm projects. The land owned by theoperation, crop production potential, soil fertility and potential manure application lands must be determined. The traditional method of randomly applying manure to the land, which is produced without relying on a calculation, should be abandoned. Otherwise, either more than necessary manure application will be made or the plant will be given deficient nutrients. The results of this study, which was conducted to raise awareness on these issues, revealed different crop production scenarios. Although manure nutrient contents are based on the literature, the amount of manure application required for different crop patterns can be taken into account by considering environmental sensitivity. It is seen that the 23 da of land owned by the enterprise has sufficient area to establish buildings and auxiliary facilities. However, considering the amount of manure produced by this enterprise every year, there must be other lands to dispose of the manure. Alternatives such as composting or biogas production, which are other disposal methods, are not very economical solutions for these small family businesses. Considering that the livestock enterprises in our country are generally in the form of family enterprises with 50 or less animals, it turns out that the most appropriate manure disposal method is using it as plant nutrients. As a result, structural projects should be prepared together with manure management plans, producers should be made aware of this issue and relevant govrenment institutions should conduct necessary actions on this issue. Otherwise, many environmental problems such as pollution of our water and soil resources and odor will adversely affect production activities.

[&]This study was produced from Masters thesis.

Conflict of Interest: The authors declare no conflict of interest.

Contribution Rate Statement Summary: The authors declare that they have contributed equally to the article.

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