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Economic analysis of fertilization based on nutritional value of rangeland: A new opinion

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ABSTRACT

Concepts behind the best management practices of rangeland improvement include production, economics, as well as social and environmental aspects. Although revenue in rangelands can be increased by fertilization, total production cost can increase and as a result, net benefit may reduce due to increase in fertilizer application cost. This study examined differences between three economic analysis models (EAM): total revenue based on i) hay yield (HY), ii) conversion rate of consumable crude protein to meat on the hoof in cow-calf (CPM) and iii) yield and relative feed value (RFV) index as a new opinion to highlight the economic aspects related to the N (0, 60 and 120 kg ha^{-1}), P (0, 60 and 120 kg ha^{-1}) and K (0 and 80 kg ha^{-1}) fertilization (NPK) in degraded rangelands. For this purpose, a series of data, gathered from an experiment conducted to increase the productivity of degraded rangelands by fertilization were analyzed. The results were most dissimilar for 'the revenue' variable and this difference lies in the fact that the EAMs estimated income in different ways. Due to the different revenue measurements, net benefit of CPM was the highest, while that of HY was the lowest. The HAY and RFV models indicate that NPK fertilizers did not increase forage production enough to be profitable for animal production. This study does not strive to suggest one EAM over another; however, it examines the respective models concerning various data and describes underlying characteristics of EAMs to obtain a given increase in net benefit.

Keywords:
Crude protein yield
Economic fertilization
Feed value
Improving rangeland
Net benefit

Meranın besin değerine dayalı gübrelemenin ekonomik analizi: Yeni bir görüş

ÖZET

Mera iyileştirme uygulamaları ile ilgili kavramlar, sosyal ve çevresel etkilerin yanında üretim ve ekonomikliği de kapsamaktadır. Mineral gübrelemesi, meraların verimliliğini arttırabilse de, gübre uygulama maliyetindeki artış nedeniyle üretim maliyeti artabilir ve sonuç olarak, net fayda azalabilir. Çalışmada, bozulmuş merada N (0, 60 ve 120 kg ha^{-1}), P (0, 60 ve 120 kg ha^{-1}) ve K (0 ve 80 kg ha^{-1}) gübre (NPK) uygulamasının ekonomik hususlarını vurgulamak için i) kuru ot verimi (KOV), ii) tüketilen ham proteinin et ırkı sığırlarda can ağırlığa dönüşüm oranı (HPD) ve iii) yeni bir analiz modeli olarak verim ve nispi yem değeri (NYD) endeksi esasına dayalı toplam gelirleri esas alan üç ekonomik analiz modeli (EAM) arasındaki farklılıklar incelenmiştir. Bu amaçla, bozulmuş bir meranın gübreleme ile verimliliğini artırmak için yürütülen bir araştırmaya ait bir dizi veriler analiz edilmiştir. Bulgular, en çok 'gelir' değişkeni bakımından farklılık göstermiş ve bu farklılığın, üç EAM'ın da gelirleri farklı şekillerde tahmin ettiği gerçeğinden kaynaklandığı belirlenmiştir. Farklı gelir ölçümleri nedeniyle, HPD, en yüksek net kara sahip olurken, KOV en düşük değere sahip olmuştur. KOV ve yeni bir görüş olarak NYD esaslı EAM, NPK gübreleri ile hayvansal üretim için kârlı olacak kadar kaba yem üretilemediğini göstermiştir. Bu çalışma, bir EAM' nin bir diğerine üstünlüğünü göstermek yerine, farklı verilerle ilgili modelleri incelemekte ve net faydada belirli bir artış elde etmek için EAM' lerin temel özelliklerini açıklamaktadır.

Anahtar Kelimeler:
Ekonomik gübreleme
Ham protein verimi
Mera ıslahı
Net karlılık
Yem değeri

1. Introduction

Rangelands, which compose ~69% of the world's dryland area (du Toit et al., 2017) are the cheapest feed resource available for domestic ruminants (Louhaichi et al., 2009). The nutrition of sheep, goats and cattle is mainly based on the exploitation of rangeland resources in many parts of the World. Therefore, degradation of rangelands subjected to heavy grazing for a long time is a fundamental problem in the countries like Turkey (Kohestani and Yeganeh, 2016; Uzun et al., 2016). Indeed, it has been reported that the proportion of species desirable for grazing plant species and the plant density or species richness decreased because of the elimination of the less grazing-tolerant species (Anderson and Hoffman, 2007; Uzun et al., 2016). Because the performance of domestic ruminants mainly depends on the quality of forage available (Amiri and Shariff, 2012), in practice, performance of animals reflects forage quality, which is a broader term that not only includes nutritive value, but also forage intake (Koc et al., 2014).

Disturbances in promoting and maintaining diversity in rangelands are important in terms of forage quantity and quality determining grazing animal performance. Rangeland rehabilitation and optimal exploitation are the most important scientific and technical efforts in range management (Kroeger et al., 2009; Kohestani and Yeganeh, 2016; Şahinoğlu and Uzun, 2016). In countries like Turkey, rangeland restoration is a goal of Governments with the enactment of the Rangeland Law. Although adequate fertilization with mineral compounds is the most practical and effective method to increase the herbage quantity and quality in rangelands is (Aydin and Uzun, 2005; Frame and Laidlaw, 2011; du Toit, 2014), fertilizers supplied by government are inconsiderately used by villagers on the rangelands (Aydin and Uzun, 2005). It has increased the use of fertilizer inputs (i.e. nitrogen, phosphorous and potassium shorthanded as 'NPK') to achieve that level of real production. Concepts behind the best management practices of crop nutrition include production, economics, as well as social and environmental aspects. Range management practices, including fertilization improve livestock productivity and protect the environmental status. Although total revenue in degraded rangelands can be increased by mineral fertilization, production costs can increase and as a result, net benefit may reduce due to an increase in fertilizer application cost. (Guevara et al., 2000; Aydin and Uzun, 2005; Islam and Adjesiwor, 2005).

The economic analysis of fertilizers in terms of the productivity requires that one estimate both the costs and the benefits from this application through time. Costs include both the initial investment and the annual maintenance and repairs, whereas benefits include all the annual returns. Therefore, the decision to improve rangelands depends on several factors such as financial returns from the improvement and alternative practices, risk of failure and government subsidies as well as current and projected livestock prices and ranch costs (Manyeki et al., 2015). Unfortunately, there is inadequate information on the expected economic returns of rangeland fertilization resulted to relatively low priorities assigned to range improvement by farmers and the government. Although benefits from livestock forage produced are relatively straightforward, to estimate the benefits from rangeland improvement practices can be more difficult. Indeed, farmers are interested in seeing the criteria required to obtain a given increase in net benefits.

The benefit from herbaceous production can be valued by either considering the cost of alternative feeds such as straw and/or alfalfa hay or total revenue based on hay yield and nutritive value (Islam and Adjesiwor, 2005). These processes should estimate how much additional forage will be produced by the practices such as fertilization (Kroeger et al., 2009). Several economic analysis models based on hay yield (HY) or conversion rate of consumable crude protein (CP) to meat on the hoof in cow-calf (CPM) has been used to determinate the economic impacts of sustainable rangeland management, including fertilization (Guevara et al., 2000; Aydin and Uzun, 2005; Islam and Adjesiwor, 2005). However, there is not enough information on whether the relative feed value (RFV) index, a tool for evaluating and marketing, can be used as an economic analysis model. Therefore, the RFV model taken into consideration together with the yield and nutritive value in the total revenue may be asserted as a new opinion. Accordingly, the objectives of this study was twofold: firstly, to estimate the hay prices based on RFV as a tool for evaluating and marketing for the RFV economic analysis model as new opinion, but the main aim was to examine differences between three economic analysis models: the total revenue based on i) HY, ii) CPM and iii) RFV to highlight income response to applications of N, P and K on rangelands degraded by overgrazing.

2. Material and Methods

The data related to hay and protein yields, CP content and RFV of this research were obtained from a study carried out in a heavily grazed rangeland in Ondokuz Mayis town of Samsun province, in Turkey (41° 29' 0" N, 36° 4' 0" E, elevation of 10 m) between 2013 and 2015 (Aydın et al., 2016). The botanical composition of the experimental area consisted of 20% legume, 35% grass and 45% other family plants. The studied rangeland had a ratio of desirable perennial plant species of 10%. In this study, two overseeding (unseeded and seeded) methods and different fertilization rates composed of three N (0, 60 and 120 kg N ha^{-1}) and P (0, 60 and 120 kg P ha^{-1}) and two K (0 and 80 kg K ha^{-1}) on yield and quality of overgrazed rangeland have been studied. Aydın et al. (2016) reported that the rainfall probability was taken account of the region for determining fertilizer combinations, because rainfall is one of the most limiting environmental factors influencing production plant (Snyman, 2005). Total precipitation and mean temperature were 578.3 mm and 16.0 °C in the first year and 776.2 mm and 15.5 °C in the second year of the experiment (Aydın et al., 2016). Some soil characteristics such as soil texture, organic matter content, saturation extract pH, extractable P, and exchangeable K of experimental site was determined as loamy, 2.1%, 7.1, 2.6 mg, and 43.0 mg kg^{-1}, respectively.

This study is an analysis of some of the economic aspects related to the NPK fertilization in rangeland degraded by overgrazing. Therefore, the study examined differences between three economic analysis models: total revenue based on i) hay yield (HY), ii) conversion rate of consumable crude protein to meat on the hoof in cow-calf (CPM) and iii) yield and relative feed value (RFV) index as a new opinion The assumptions of economic analysis models used in this study were as follows, i) to use of NPK fertilizers in order to improve rangelands degraded by overgrazing and as a result, to achieve greater production of excellent quality forage, ii) to utilize the herbages from these rangelands as hay, iii) to evaluate the conversion to meat of CP consumed by the grazing animals, iv) to evaluate the sale of hay obtained from the rangelands improved by fertilizer and v) to determine the role RFV in determining the commercial value of forages. Therefore, to evaluate the profitability (profit or loss) of different fertilizer combinations, the HY and hay price, the RFV or conversion of consumable CP to meat on the hoof in cow-calf were used in the economic analysis models.

The benefit cost ratio is used to compare the present value of all benefits to that of all costs (Gentner and Tanaka, 2002). To determine fertilization profitability therefore is required the comparison of costs and returns from economic analysis models, in all economic analysis models were used the total production cost and total revenue (Islam and Adjesiwor, 2005). Parameters prices (January 2017) used in cost and revenue estimation are shown in Table 1.

Table 1. Parameters and prices used in cost and revenue estimation

Item	Unit	Price ($)
Fertilizers		
Ammonium nitrate	kg	0.21
Triple superphosphate	kg	0.57
Potassium sulphate	kg	1.16
Other expenditures	20% of fertilizer prices	
Meat on the hoof	kg	4.45
Hay	kg	0.17

Profit (or loss) and net benefits were calculated using the following equations (Islam and Adjesiwor, 2005):

Profit/loss ($ ha^{-1}) = total revenue – total production cost

Net benefit ($ ha^{-1}) = profit for each fertilizer combination - profit of control

Price data for fertilizers and hay were obtained from local sources in central Samsun. The conversion rate of consumable CP to meat on the hoof in cow-calf was assumed to be 1.8 kg (NRC, 2000; Aydin and Uzun, 2005). The RFV, based on ADF and NDF contents is an index representing forage quality and is one of the systems used by forage testing laboratories last decades. Thus, the higher RFV is the higher the quality this means a higher price for that hay. Buyers and sellers have used this index for estimating hay quality and price of hay (Newman et al., 2014). This equation was based on the prices of hays with the lowest RFV (e.g. wheat straw) and the highest RFV (e.g. alfalfa hay) in Turkey during the last three years (Table 2). All Turkish lira amounts are converted into today's or “present” the United States dollar ($) terms since most financial inputs (e.g. prices and costs) and production inputs (e.g. yields, product quality) can be readily varied on a yearly basis.

Table 2. The relative feed value (RFV) and unite price of feedstuffs used in calculation of RFV price

Feedstuff	RVF	Unit price ($ kg^{-1})
Wheat straw	50	0.08
Alfalfa hay	150	0.22

Equation and bivariate correlation displaying the relationship between the yield, prices and RFV of hay were determined by means of simple linear regression analysis. To test our hypothesis, hay and protein yields, CP content and RFV of rangeland were analyzed by one-way ANOVA with fertilization as the only factor. When differences appeared, Duncan’s test was used at the P = 0.05. All statistical analysis was performed by means of SPSS 11.0 for Windows software (SPSS Inc., NY, USA).

3. Results and Discussion

The hay prices based on RFV can be expressed by the following linear equation: The RFV prices ($ kg^{-1}) = 0.0133 + 0.0014x (r=0.999), where x is RFV of produced hay. This regression equations and correlation coefficient indicate that RFV can be used in determining the commercial value of forages. Thus, in the present study, the total revenue based on yield and RFV was calculated by using this linear equation. The economic benefit and expected revenue are the most important parameters to be considered when planning an investment (Torell et al., 2014). Therefore, to highlight the economic aspects related to the NPK fertilization in degraded rangelands, these variables were evaluated in the present study. The results were most dissimilar for ‘revenue’ variable and this difference lies in the fact that the three models estimated income in different ways. Due to different income measurements, net benefit of CPM was the highest, while that of HY was the lowest.

The cost of improving an acre of rangeland by fertilization has had to compete with the amount of marketable hay or meat produced in this area, as recommended by Kroeger et al. (2009) and Newman et al. (2014). In our study, this competition was found to be important or useful tool in terms of the economic analysis model based the CPM. Therefore, rangeland improvement practices implemented for managing domestic ruminants such as cattle, sheep and goat cause different benefits and incur different costs (Workman and Tanaka (1991) and Unterschultz et al. (2004).

The HY, CPY, the CP content and RFV varied among treatments (Table 3). There were a significant increase (10 to 60%) in the HY and CPY of plots fertilized by different NPK combinations compared to control plot. However, the CP content and RFV of forage decreased (ranged: 0.2 to 18%) in the plots fertilized by N alone and high dose N with P and K fertilizers or increased (ranged: 0.2 to 14%) in the plots fertilized by other fertilizer combinations. This may be the result of the beneficial effect of NPK fertilization on the HY and CP (Brum et al., 2009; Balabanli et al., 2010) and of a negative association between yield and nutritive value. In addition, this result may be explained by the fact that the yield and quality of rangelands is primarily designated by botanical composition (Samuel and Hart, 1998; Algan et al., 2017). The yields of grass and legume biomass were affected, as grasses increased and legume biomass decreased with increasing N fertilization rate, whereas P and K fertilizers promote the growth of legumes (Aydin et al., 2016).

The primary benefit from NPK in the grazing season supported increase in the HY and forage quality when based on changes in the HY and CPY (Figure 1) and CP content and RFV (Figure 2) of fertilized plots as the percentage of control plot. Although our results revealed that for high-dose N fertilization to be effective on HY of the rangelands (Table 3), the NPK fertilizer should be composed of 60 kg N, 120 kg P, 80 kg K ha^{-1}, due to an adverse effect on botanical composition and long-term sustainable production (Aydın et al., 2016). This result supports that P and/or K alone has little effect for increasing forage production (Rubio et al., 1996), since all other treatments had forage yields that were significantly greater than the control (Table 3). Both P and K fertilization (except for 80 kg K without N and P) without N increased the CP content of the rangelands. High CP and HY content of the rangelands fertilised by fertilizer with high-dose P and K without N had the greatest CPY. Rangelands respond differently to fertilizer applications due to botanical composition, climate, soil and management applications (Nohong and Ako, 2016; Adjesiwor et al., 2017). The results with respect to HY support idea that N fertilizer application was profitable, but might not be sustainable in the long term (Samuel and Hart, 1998; Kowaljow et al., 2010; Interrante et al., 2012). Therefore, based on the results of previous studies and the present study, NPK fertilization did not increase average forage production enough to be profitable for grazing livestock.

Table 3. The hay and crude protein (CP) yields, CP content and relative feed value (RFV) of the degraded rangeland fertilized with different NPK combinations

Fertilizer	Yield (kg ha^{-1}) Hay	CP	CP content (g kg^{-1})	RFV
$N_0P_0K_0$	1837 i	286.9 i	156.2 de	115.3 abc
$N_0P_0K_{80}$	2025 hi	333.7 hi	164.8 bcd	122.3 ab
$N_0P_{60}K_0$	2171 ghı	373.4 h	172.0 ab	124.9 ab
$N_0P_{60}K_{80}$	2679 fg	452.8 fg	169.0 abc	124.6 ab
$N_0P_{120}K_0$	2736 fg	462.1 efg	168.9 abc	120.4 ab
$N_0P_{120}K_{80}$	3107 df	556.5 bcd	179.1 a	128.1 a
$N_{60}P_0K_0$	2457 gh	384.5 gh	156.5 de	111.1 b-f
$N_{60}P_0K_{80}$	2601 fgh	407.1 gh	156.5 de	114.7 a-d
$N_{60}P_{60}K_0$	3205 def	505.4 def	157.7 de	124.1 ab
$N_{60}P_{60}K_{80}$	3376 cde	536.4 b-e	158.9 de	123.4 a-e
$N_{60}P_{120}K_0$	3656 b-e	562.3 bcd	153.8 def	122.7 ab
$N_{60}P_{120}K_{80}$	3727 bcd	610.1 ab	163.7 bcd	123.4 ab
$N_{120}P_0K_0$	3479 cde	525.0 c-f	150.9 ef	100.6 d-g
$N_{120}P_0K_{80}$	3603 b-e	553.8 bcd	153.7 def	101.0 g
$N_{120}P_{60}K_0$	3677 b-e	555.6 bcd	151.1 ef	100.0 b-f
$N_{120}P_{60}K_{80}$	3872 bc	590.5 abc	152.5 ef	103.4 c-g
$N_{120}P_{120}K_0$	4153 ab	596.8 abc	143.7 f	98.8 fg
$N_{120}P_{120}K_{80}$	4484 a	644.8 a	143.8 f	100.2 efg
SEM	177.7	24.27	2.24	2.54

a,b,c… Means with different letters in the same raw are different (P<0.05).

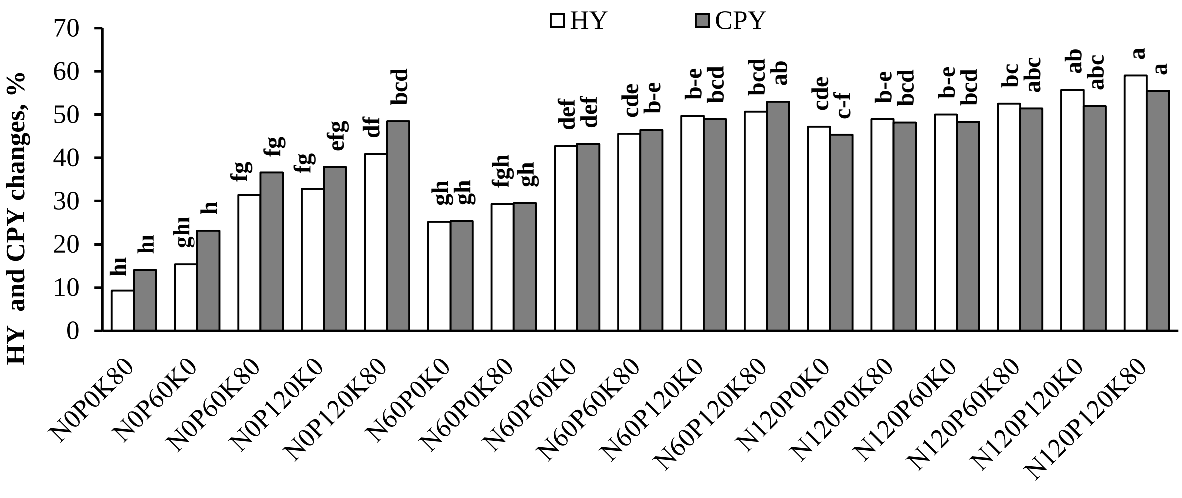

Figure 1. Changes in the hay (HY, SEM = 3.5) and crude protein (CPY, SEM = 2.9) yields of fertilized plots as the percentage of control ($N_0P_0K_0$) plot. a,b,c... Bars denoted by the different letter are different (P<0.05).

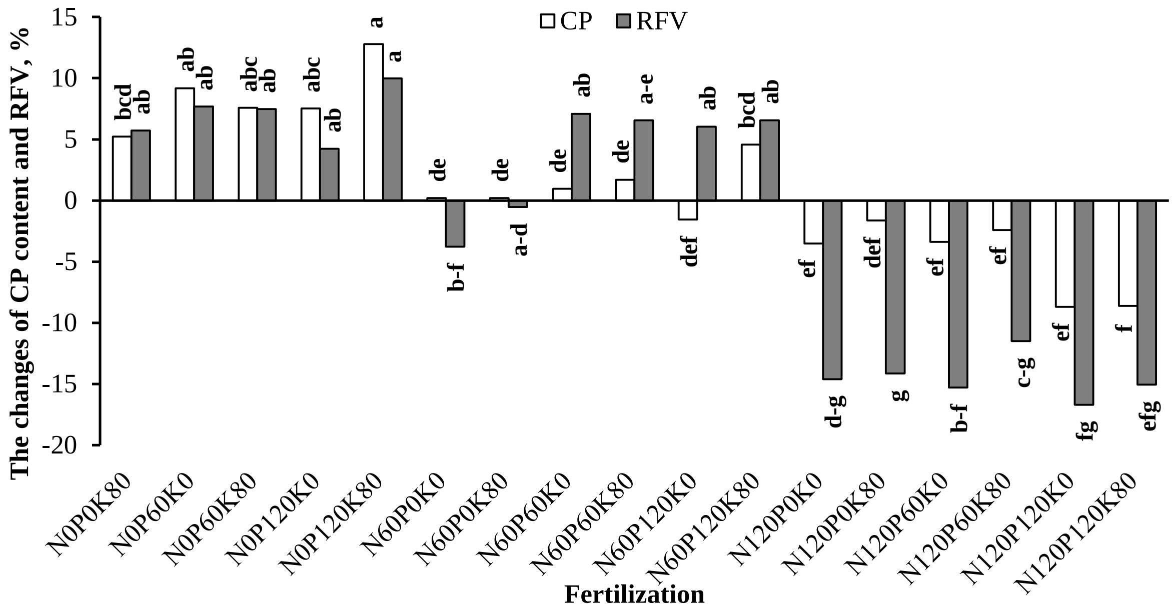

Figure 2. Changes in the crude protein (CP) content (SEM = 1.4) and relative feed value (RFV, SEM = 2.5) of fertilized plots of fertilized plots as the percentage of control ($N_0P_0K_0$) plot. a,b,c... Bars denoted by the different letter are different (P<0.05).

Fertilization can provide high amount and quality forage during the growing season in the degraded rangelands (Islam and Adjesiwor, 2005; Aydın et al., 2016). In the present study, the relative economic value was determined by calculating the difference between the expected values for revenues and the costs for each fertilizer combinations (Islam and Adjesiwor, 2005; Interrante et al., 2012). Therefore, key indicators as the benefit to cost ratio and net value must be positive for the analysed practices taking account of the increases in forage yield and quality in terms of a common botanical composition and long-term sustainable production for various combinations of NPK fertilization. The economic analysis models of the costs and benefits from various combinations of fertilization practices indicate that profit and loss conservation can be comparable. In the present study, the best net returns for HY, CPM and RFV models were obtained from rangelands fertilized with the $N_{120}P_0K_0$, $N_{120}P_{120}K_0$ and $N_{60}P_{120}K_0$ fertilizers, respectively (Table 4). This result may be related to the fact that vegetation recovery was higher following NP fertilization (Kowaljow et al., 2010) and the best sources of fertilizer to apply in such rangeland are ammonium nitrate or ammonium sulphate (Rubio et al., 1996).

The net benefits for all fertilization combinations were lower for the analysis models based on HY and RFV than for CPM model. When based on the conversion rate to meat of forage CP consumed by the grazing animals, all fertilization combination used, except for $N_0P_0K_{80}$ were profitable for operations that dominate rangeland. Therefore, our belief was that improved knowledge will not only lead to better decisions of farms, but also to develop and support the use of economic analysis models that inform government and corporate decisions. For a profit maximizing or cost minimizing, the profitability of fertilization can be provided some insights into the decisions to be made. While the profit for most ranchers is not the weightiest decision criterion in the economic sense, they can generally be assumed to prefer more income to less (Gentner and Tanaka, 2002).

Nitrogen fertilization without P and K of the overgrazed rangelands is not profitable at present fertilizer, hay and meat prices, as reported by Samuel and Hart (1998). Contrary to the results reported herein, Polat et al. (2007) showed that fertilization with N and P is profitable based on economical analysis of two years results. The net profit obtained from the treatments can depend on fertilizer doses and net return obtained from the CPM model (Guevara et al., 2000; Aydin and Uzun, 2005). After taking account of the botanical composition (Aydın et al., 2016) and long-term sustainable production, the profit of CMP analysis model was more profitable than the other two models by around twice. As in the present study, when rangelands were fertilized, the herbage yield and quality increase, but this enhance has a serious detrimental effect on RFV (Aydin and Uzun, 2005; Frame and Laidlaw, 2011).

The total revenue, profit and net benefit of fertilizer combinations in the economical analysis based on CPM was greater than those based on HY and RFV models (Figure 3). In the model based on HY, the plots fertilized N at 120 kg ha^{-1} with or without P and K had a greater the corresponding values compared to that on RFV model. However, the CPM (1052.1,839.2 and 231.3 \$ ha^{-1}), RFV (465.2, 252.3 and -23.1 \$ ha^{-1}) and HY (460.1, 247.2 and -20.4 \$ ha^{-1}) models had the highest, middle and the lowest total revenue, profit and net benefit as averages of fertilizer combinations among all economic analysis models. Guevara et al. (2000) reported that fertilizer application did not increase forage production enough to be profitable for cattle production at present fertilizer and meat prices, as reported herein for rangeland degraded by overgrazing. Rangeland management practices should be provided many benefits (Kroeger et al., 2009). The N application decreases the benefit of forage while N and P application together increase the net return (Polat et al., 2007). The NPK combinations used in the present study for improving of the degraded rangeland showed the least and a similar profitable in analyses based on HY or RFV model. This may be related to selling of hay obtained from each fertilization application.

Table 4. The hay (HY) and crude protein (CPY) yields, CP content and relative feed value (RFV) of the degraded rangeland fertilized with different NPK combinations

	Total revenue of EAM (\$ ha^{-1})			Total cost	Net benefit of EAM (\$ ha^{-1})		
Fertilization	CPM	HY	RFV	(\$ ha^{-1})	CPM	HY	RFV
$N_0P_0K_0$	709	312	321	0			
$N_0P_0K_{80}$	825	344	374	223	-107	-191	-170
$N_0P_{60}K_0$	923	369	409	91	123	-34	-4
$N_0P_{60}K_{80}$	1120	455	504	314	97	-171	-132
$N_0P_{120}K_0$	1142	465	498	182	251	-30	-6
$N_0P_{120}K_{80}$	1376	528	599	405	261	-189	-127
$N_{60}P_0K_0$	951	418	416	46	195	60	48
$N_{60}P_0K_{80}$	1006	442	453	269	29	-139	-137
$N_{60}P_{60}K_0$	1249	545	600	137	**403**	96	**142**
$N_{60}P_{60}K_{80}$	1326	574	629	360	257	-98	-52
$N_{60}P_{120}K_0$	1390	622	678	228	**453**	81	**128**
$N_{60}P_{120}K_{80}$	1508	634	694	451	348	-130	-78
$N_{120}P_0K_0$	1298	591	537	92	**497**	**188**	**124**
$N_{120}P_0K_{80}$	1369	613	559	314	345	-14	-77
$N_{120}P_{60}K_0$	1374	625	565	183	**481**	**130**	61
$N_{120}P_{60}K_{80}$	1460	658	613	406	345	-60	-114
$N_{120}P_{120}K_0$	1475	706	631	274	**492**	**120**	36
$N_{120}P_{120}K_{80}$	1594	762	690	497	388	-47	-128

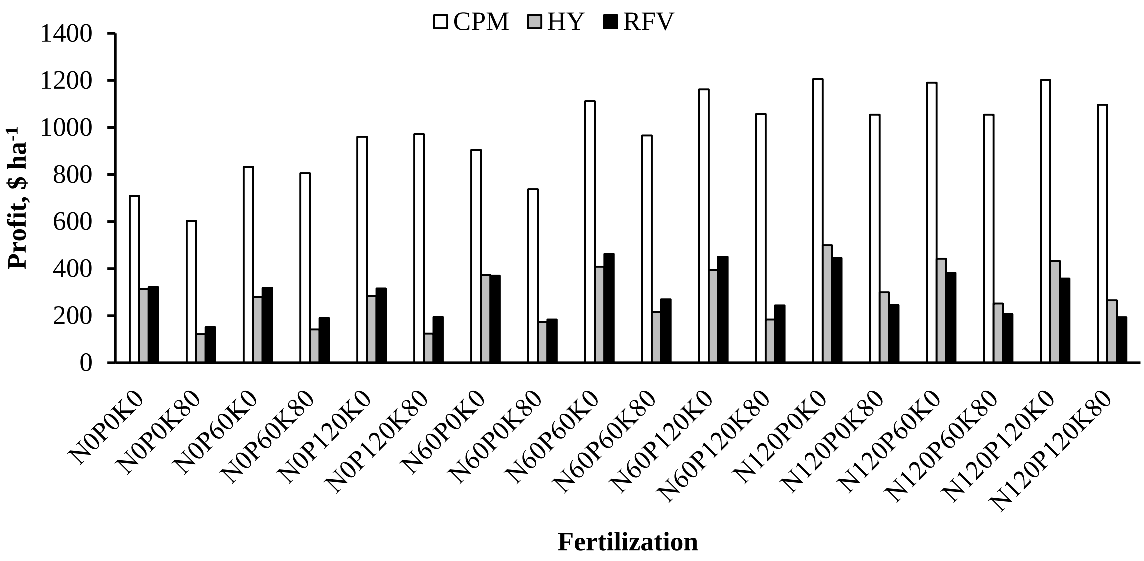

Figure 3. The profits from the degraded rangeland fertilized with different NPK combinations when based on economic analysis models such as conversion rate of consumable crude protein to meat on the hoof in cow-calf (CPM), hay yield (HY) and relative feed value (RFV) index as a new opinion.

4. Conclusions

The economic analysis models based on HY and RFV had a lower the net benefit compared to CPM model. Except for $N_0P_0K_{80}$, all NPK combinations had higher net benefit in the analysis based on CPM model. Moreover, the analysis models based on HY and RFV Phad a lower profit or higher loss in the N fertilization up to 60 kg ha^{-1}. Our results suggest that the reductions in net benefit as result of the selling of hay from the rangelands fertilized by different NPK may be protected by live weight gains of grazing animals. Indeed, the economic analysis based on RFV as a new option and HY models was not to equate the value of the marginal product to the marginal factor costs. The benefit of the economic analysis model based on RFV as a new option indicate to be small to make them worth adopting given the forages available, especially in the rangelands fertilized with high-dose N. Therefore, it can be said that the grazing of animals in such rangelands may produce enough income to cover the cost of producing it and the practices like fertilization are costly to ranchers and are not viable in purely private financial terms.

Prior to selecting one economic analysis model over another, decision makers should consider the following primary factors: i) total production cost, ii) assumptions outlined previously of the economic analysis, iii) time period (multi-year or static) of the analysis and iv) indirect and induced effects. The CPM model is more suitable for specific rangeland management practices and fertilization-related analyses. The present study does not strive to suggest one economic analysis model over another; however, it examines the behaviour of respective models concerning various data and describes underlying characteristics of the economic analysis models to obtain a given increase in net benefit. These results indicate that this comparison was important to farmers because they are interested in seeing the criteria required to obtain a given increase in net benefits. The precautions should be proposed to repair natural rangelands and achieve greater production of excellent quality of forage by using different agricultural practices. Therefore, all of these should be considered in the development process of fertilizer recommendations.

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