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6.

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6th

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Predgovor

Ekonomski fakultet u Osijeku u kontinuitetu već duži niz godina potiče sudionike Simpozija na radove koji će (na osnovu istraživanja i obrađenih podataka) sadržavati viziju razvoja ne samo istočne Hrvatske već cijele RH i zemlje Koridora Vc (poveznice prometnica od Baltika do Jadrana i Dunavom od zapada do istoka cestovnom, riječnom, zračnom i željezničkom infrastrukturom). Do sada su na osnovu znanstvenih istraživanja, stručnih i iskustvenih metoda predloženi brojni projekti koji se mogu uklopiti u strategiju razvoja RH. Na taj način želimo pripomoći Vladi RH u donošenju stimulativnih programa za gospodarski prosperitet.

Pozivamo uspješne i u Svijetu dokazane znanstvenike i poduzetnike na sudjelovanje, jer svojim stečenim znanjem i stečenim globalnim iskustvom prikazanim u radovima mogu znatno doprinijeti vrijednosti ovog Simpozija.

Kroz tematsko područje *Partnerstvo i međusektorska suradnja* želimo dobiti radove koji daju prijedloge udruživanja u vidu clustera, udruga, zadruga ili partnerstva radi zajedničkog stvaranja brenda naših proizvoda i istupa na svjetska tržišta.

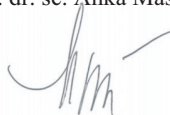
Interesantni su nam radovi koji obrađuju problematiku iseljavanja s prijedlozima kako i na koji način napraviti zaokret u vođenju poslovne politike, stvaranju novog stimulativnog okvira za ulaganja, te povezivanju plave i zelene linije. Sve te prijedloge potrebno je pretvoriti u programe realizacije i konačno „postići točku preokreta“, brzi oporavak i rast. Tada se mogu stvoriti novi uvjeti za povratak iseljenih koji na osnovu stečenog iskustva i znanja mogu dodatno pridonijeti ubrzanom razvoju Hrvatske.

Neophodni su nam strateški dokumenti za razvoj poljoprivrede, infrastrukture, industrije, turizma (s kulturnim sadržajima eko i etno vrijednostima) i svih grana djelatnosti, povezujući ravnomjeran razvoj svih regija, ne samo RH već i makro regije EU.

Svi dobiveni radovi ne bi trebali biti sami sebi svrha, već poticaji i prijedlozi za poboljšanje postojeće situacije, brži gospodarski rast i zapošljavanje kako bi se stvorili uvjeti za kvalitetan život stanovništva.

Ako samo jedan predloženi projekt bude proveden u praksi mi smo opravdali svoje postojanje.

Prof. dr. sc. Anka Mašek Tonković



Foreword

Faculty of Economics in Osijek has continually for years encouraged participants of the Symposium to write papers that will (based on research and data analyses) integrate a development vision of not only eastern Croatia, but also the whole Republic of Croatia and other countries along the Vc Corridor (traffic connection from the Baltic Sea to the Adriatic Sea, and along the Danube River from west to east, with road, river, air and railroad traffic infrastructure). Based on scientific researches, expert and experiential methods numerous projects have been proposed so far that could be embedded into Development Strategy of the Republic of Croatia. Thus we want to help the Government of the Republic of Croatia in creation of stimulating programmes for economic prosperity.

We invite successful and globally proven scientists and entrepreneurs to participate, for they can contribute to the value of this Symposium with their knowledge and worldwide experience reflected in their respective papers.

Through the thematic field “Partnership and Inter-sectorial Cooperation” we wish to get papers which propose connecting together in forms of clusters, associations, cooperatives or partnerships, in order to jointly create our products’ brand and step into global market.

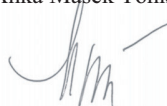
We are interested in papers dealing with the issue of emigration and proposing how to make a turn in managing business policies, creating new stimulating investment framework, and connecting the blue and green lines. All these proposals need to be converted into realization programmes and we finally need to reach the “turning point”, achieving fast recovery and economic growth. Only then can we create new conditions for return of the emigrated who can, with the experience and knowledge they have gained, additionally contribute to expedited development of Croatia.

We need strategic documents for development of agriculture, infrastructure, industry, tourism (with cultural elements, ecological and ethnic values) and all other branches, linking together equal development of all regions, not only in Croatia, but also in the EU macro-region.

All submitted papers should not be purpose for themselves, but encouragements and proposals for making the current situation better, to achieve faster economic growth and increase employment rate in order to create conditions for quality living.

If only one proposed project becomes implemented in practice, we have justified our existence.

Anka Mašek Tonković, PhD.



Tematska područja / Topics

1. Povijesna naslijeđa u razvoju istočne Hrvatske / Historical heritage in a function of the development of the eastern Croatia
2. Novi trendovi u razvoju gospodarstva/ New trends in economic development
3. Ljudski kapital u funkciji društveno-ekonomskog razvoja regije / Human capital in a function of the socio-economic development of the region
4. Uloga prava u razvoj gospodarstva / The role of law in economic development
5. Međusektorska suradnja & Partnerstva / Intersectoral cooperation & Partnerships
6. Ekologija – zaštita prirode i okoliša / Ecology & Environmental Protection
7. Društveno odgovorno poduzetništvo / Social responsible entrepreneurship
8. Značaj civilnog društva za razvoj regije / Significance of civil society for development of the region
9. Regionalni razvoj – izazovi i prilike / Regional development – challenges and opportunities
10. Financijske institucije / Financial institutions

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FODDER AS A BIOFUEL: COST EFFECTIVENESS OF POWERING HORSES IN PLOWING OPERATION**KRMA KAO BIOGORIVO: TROŠKOVNA UČINKOVITOST POGONA KONJA U OPERACIJI ORANJA*****ABSTRACT***

The aim of the research was to compare the cost effectiveness of a fodder with a petroleum diesel fuel in powering the most fundamental soil tillage operation: plowing. Fodder was considered as a biofuel for biological combustion in live work animals, i.e. draft horses, which convert the chemical energy of organic compounds of fodder into useful mechanical work for soil tillage. Consumption either of fodder or diesel fuel per unit of plowed land was multiplied with the purchase price of each "fuel" to project costs and compare cost effectiveness. The projections were calculated for two types of soil considering their easiness for tillage: medium light soil and heavy soil. In both projections (for the medium light soils and heavy soils), the fodder as a biofuel

has shown a greater cost effectiveness due to consistently lower cost per unit of plowed land area. The fodder costs for plowing medium light soils were estimated between 34.78 HRK/ha and 90.61 HRK/ha, while the diesel fuel costs were estimated between 126.42 HRK/ha and 155.33 HRK/ha. Fodder costs for plowing heavy soils were estimated between 90.00 HRK/ha and 158.20 HRK/ha, while the diesel fuel costs were estimated between 287.63 HRK/ha and 363.09 HRK/ha. Projected variations of fodder costs per unit of plowed land area were due to expected variation of purchase price of fodders (meadow hay and oats), and variations in fodder consumption due to various horse breeds employed and nutrition management. Variations in diesel fuel costs per unit of plowed land area were due to different reported values of fuel consumption in the published researches. For the overall appraisal of economics of horse-powered work in agriculture, and for a more reliable comparison of the cost effectiveness between horse traction and diesel-engine powered traction, there should be considered horses' fixed costs too, like a fodder in idle days, depreciation, housing, shoeing, and veterinarian.

Since the research results are based on literature published data for diesel fuel, and for fodder are based mainly on data collected by interviews, there appears a need to continue this research in field trials. This would provide exact measurements of work capacity and fodder consumption of working horses.

Key words: biofuel, soil tillage, cost effectiveness, sustainability.

SAŽETAK

Cilj istraživanja bio je usporediti troškovnu učinkovitost krme i dizelskog goriva u pogonu osnovne operacije obrade tla: oranju. Krma se u smislu ovog rada smatra kao biogorivo za biološko sagorijevanje u živim životinjama, t.j. vučnim konjima, koji pretvaraju kemijsku energiju organskih spojeva iz krme u korisni mehanički rad za obradu tla. Potrošnja krme i dizelskog goriva po jedinici preoranoga tla pomnožena je s kupovnom cijenom svakoga „goriva“ kako bi se projicirali troškovi i usporedila troškovna učinkovitost. Projekcije su izračunate za dva tipa tla obzirom na lakoću obrade: srednje lako tlo i teško tlo. Kod obje projekcije (za srednje laka tla i teška tla), krma kao biogorivo pokazala je veću troškovnu učinkovitost zbog uvijek niže cijene koštanja po jedinici površine pooranog tla. Troškovi krme kod oranja srednje lakih tala procijenjeni su u rasponu od 34,78 HRK/ha do 90,61 HRK/ha, dok su troškovi dizelskog goriva procijenjeni od 126,42 HRK/ha do 155,33 HRK/ha. Troškovi krme kod oranja teških tala procijenjeni su u rasponu od 90,00 HRK/ha do 158,20 HRK/ha, dok su troškovi dizelskog goriva procijenjeni od 287,63 HRK/ha do 363,09 HRK/ha. Projicirane varijacije troškova krme po jedinici površine pooranog tla posljedica su očekivanih varijacija kupovne cijene krmiva (livadno sijeno i zob), i varijacija u konzumiranoj količini uslijed različite tjelesne mase konja korištenih konja i različite hranidbene prakse. Varijacije troškova dizelskog goriva po jedinici površine pooranog tla posljedica su razlika u objavljenim rezultatima istraživanja potrošnje dizelskog goriva po jedinici površine. Za sveobuhvatnu ocjenu ekonomičnosti konjskog pogona u poljoprivredi, te pouzdaniju usporedbu troškovne učinkovitosti konjske i traktorske vuče, bilo bi potrebno razmotriti i fiksne troškove, poput troška krme u neradnim danima, amortizacije životinja, smještaja životinja, potkivanja i veterinara.

S obzirom da su rezultati istraživanja zasnovani na podacima iz literature za potrošnju dizelskog goriva, te na podacima iz intervjua za potrošnju i radni učinak konja, pojavljuje se potreba za nastavkom ovoga istraživanja kroz poljske pokuse. Istima bi se došlo do egzaktnih mjerenja radnih učinaka i potrošnje krmiva kod radnih konja.

Gljučne riječi: biogorivo, obrada tla, troškovna učinkovitost, održivost.

1. Introduction

Biofuels are achieving a great attention during the last few decades because of increased concern of scientists, policy makers and public for the sustainability issues. Almost all of the research attention is currently dedicated to technologically sophisticated solutions that are mainly used to generate biofuels for fueling internal combustion engines. Despite the efforts of science, governments and industry, share of biofuels in total consumption is still minor. Among the obstacles for a broader consumption of biofuels, there is their relatively higher cost of production when compared to conventional petroleum fuels. In order to increase the share of biofuels in total fuels consumption, the policy makers have introduced subsidies to biofuels production (Ivanović et al., 2016), thus enhancing their apparent cost effectiveness. In the shadow of high-tech biofuels, the fodder seems to be overlooked as an ancient “biofuel” that was used to power or “fuel” working animals, which were converting the chemical energy of organic compounds of fodder into the useful mechanical work. Generally, all the fuels are coming at a certain cost and they possess the capability for being converted into a useful work. Aim of this research is to compare the cost effectiveness of fodder with petroleum diesel fuel in powering a plowing operation.

2. Material and methods

According to Luthra (2011), cost effectiveness is relationship between monetary inputs and the desired outcome. Monetary inputs in this research are represented by the projected costs either of petroleum diesel fuel or fodder consumed for powering the plowing operation per unit of land area. Therefore, the unit of plowed land area stands for a desired outcome. In the sense of this research, the cost effectiveness either of fodder or petroleum diesel fuel is considered reciprocally to the Luthra’s (2011.) definition because the values obtained in that way do better reflect the effects of costs in producing the desired outcome.

Expressions used to calculate the cost effectiveness are given below:

1. for fodder: $C_E [\text{ha}/\text{HRK}] = \text{Outcome} [\text{ha}/\text{day}] / \text{Costs of fodder} [\text{HRK}/\text{day}]$
2. for petroleum diesel fuel: $C_E [\text{ha}/\text{HRK}] = \{\text{Retail price of fuel} [\text{HRK}/\text{l}] \times \text{Fuel consumption per unit of outcome} [\text{l}/\text{ha}]\}^{-1}$

The data about feasible outcome from horses’ employment (daily plowed land area in ha), daily fodder consumption and costs of fodder were obtained from literature, e-mail correspondence and personal communication. The data about tractors’ work rate (ha/h) and fuel consumption (l/ha) were obtained from the previously published researches.

Purchase prices of fodder for horses were obtained by personal communication with Mr. Nidal Korabi, the manager of the National lipizzan stud farms in Đakovo and Lipik, and Ms. Viktorija Bulić, the president of the Equestrian club “Hercules” of Vuka with operating a horse-riding school in the village Bilje.

3. Results

3.1. Purchase price of fodder and fuel

Purchase price of fodder in last five years varied with the location of delivery (Table 1.) and source of information, i.e. buyer and his capability to negotiate the purchase price. High prices were obtained in years after drought because of shortage of fodder, while the low prices were in years of abundance.

Table 1 Purchase prices of fodder for horses in HRK/kg (last five years)

Reference	Delivery <i>fco</i>	Meadow hay		Oat grain		Maize grain	
		Low	High	Low	High	Low	High
Mr. Nidal Korabi*	Đakovo	0.50	1.20	1.20	1.68		
Mr. Nidal Korabi*	Lipik	0.74	0.90	1.25	1.40		
Ms. Viktorija Bulić*	Bilje	0.50	1.20	1.00	2.00		
TISUP (2017.)**	Croatia					0.75	1.26
	Expected range	0.50	1.20	1.00	2.00	0.75	1.26

* data obtained by personal communication via phone call in February 2017.
 ** in the last three years. Croatian Market Information System in Agriculture

Source: Author's

The expected range of purchase prices for each fodder will be considered between minimum and maximum presented in the table above (Table 1.).

Purchase prices of agricultural diesel (popularly called “blue diesel”) in February 2017 are found to be between 4.88 and 4.96 HRK/l (HAK, 2017), depending on the seller. There are no available reports on historical prices, but they were likely between 3.00 and 5.00 HRK/l, according to Mr. Franjo Nemet, farmer from the Tenja village (personal communication). There is no forecast for the future prices of agricultural diesel, and therefore the price is deemed to be constant, about 4.9 HRK/l.

3.2. Consumption and costs of fodder

In a working day with plowing, there is required above average consumption of fodder to satisfy the energy needs of working animals (Fouts, 2008.). Feeding practice in such a working day varies according to the source of information (Table 2.).

Table 2 Consumption of fodder in a working day with plowing

Reference	Body weight [kg/horse]	Per a horse			Per a pair of horses		
		Hay [kg/day]	Oat [kg/day]	Maize [kg/day]	Hay [kg/day]	Oat [kg/day]	Maize [kg/day]
Jarić (2014.)	500	10*	5	-	20*	10	-
Grgić (2017.)	800	16	9	-	36	18	-
Dugaja (**)	700	15	2	3.2	30	4	6.4

* pure meadow hay or lucerne hay plus cereal straw (oat, wheat or barley straw)
 ** Personal conversation via phone call on 1st February 2017.

Source: Author's

Relatively lower feed intake in the case presented by Jarić (2014) can be explained by a lower body weight of traditional working horses in east Croatia, which were probably similar to Lipizzan breed (about 500 kg), Croatian Posavian breed (about 600 kg), or something in between them. Relatively greater feed intakes in the examples of Grgić (2017) and Dugaja were due to a very big body weights (700 to 800 kg/animal) of horses of Croatian Coldblood breed used in their examples.

Costs of diet for a pair of working horses in a working day with plowing (Table 3.) can be projected upon the expected consumption (Table 2.) and expected range of prices for each fodder (Table 1.).

Table 3 Projected costs of diet for a pair of horses in a working day with plowing, for the expected range of consumption and purchase prices

Diet example	Body weight [kg/horse]	Hay* [HRK/day]	Oat* [HRK/day]	Maize [HRK/day]	Total [HRK/day]
Jarić (2014.)	500	10.00-24.00	10.00-20.00	-	20.00-44.00
Grgić (2017.)	800	18.00-43.20	18.00-36.00	-	36.00-79.20
Dugaja (**)	700	15.00-36.00	4.00-8.00	4.80-8.10	23.80-52.10

* Values are the products of unit price (Table 1) and daily consumption (Table 2), with respect to the expected range
 ** Personal conversation via phone call on the 1st February 2017

Source: Author's

3.3. Work outcome of horses

The plowing operation in east Croatia about 50 years ago was usually performed by a pair of horses (Jarić, 2014) which were capable of plowing a land area of one Croatian acre (what equals to 0.575 ha), or a little more, per a working day. One horseman was required to lead the horses and direct the plow. According to Mr. Ivan Dugaja of village Čadavica (personal communication, February 2017), his horses are still capable to plow at least 0.575 ha/day in the autumn. The soils of Čadavica village are considered light with relatively low plowing resistance. On heavier soils daily working rate is usually lower because of higher plowing resistance. Thus, according to Grgić (2017) in the surrounding of Kutjevo, on the heavy soil, where the plowing resistance is greater, the work rate of pair of horses in plowing is from 0.4 to 0.5 ha/day. The time required to plow an area of 0.575 ha is relatively long because the traditional horse-pulled plow in Croatia has only one plough bottom with working width of 25 cm (Vojvodić et al., 1992). Therefore the distance required to be passed by a pulled plow is 22.8 km/0.57 ha. With assumed speed of plowing 4 km/h, the required time of effective plowing would be 5.7 hours per 0.575 ha. Practically, the total time required for plowing 0.575 ha is greater than effective plowing time since the plow, upon completing one furrow, has to be turned into another. Therefore the daily outcome (per 8 working hours) is expected to be about 0.575 ha on soils which allow the speed 4 km/ha (medium soils). On heavy soils the daily outcome is lesser because of slower speed of plowing.

3.4. Cost of fodder in powering the plowing operation

According to the projected daily feed costs (Table 3) and expected work rate there were derived projections for costs of fodder per unit of plowed land area (Table 4).

Table 4 Projected costs of fodder per unit of plowed land area

Soil heaviness	Projected daily costs of fodder* [HRK/day]	Expected work rate [ha/day]	Costs of fodder [HRK/ha]
Heavy	36.00-79.20	0.400 to 0.500	90.00 to 158.40
Medium light	20.00-52.10	0.575	34.78 to 90.61

* Data taken from the Table 3.

Source: Author's

3.5. Petroleum diesel fuel consumption and cost of fuel

Many researches have shown that fuel consumption strongly depends on the soil heaviness. Considering the diesel engine powered tractor, findings presented in the Table 5 can be indicative for the Croatian conditions.

Table 5 Projected consumption of petroleum diesel fuel in plowing and its cost per unit of plowed land area

Reference	Location	Soil heaviness	Plowing depth [cm]	Diesel fuel consumption [l/ha]	Projected costs of fuel* [HRK/ha]
Filipović et al. (2005)	Nova Gradiška	Heavy	25	43.8 to 65.9	214.62 to 322.91
			30	58.7 to 74.1	287.63 to 363.09
Momirović et al. (2011)	Beograd	Medium	30	35.7	174.93
Košutić et al. (2006)	Našice	Medium light	30	27.2 to 28.3	133.28 to 138.67
Horvat and Filipović (2006)	Baranja	Medium light	30	25.8 to 31.7	126.42 to 155.33

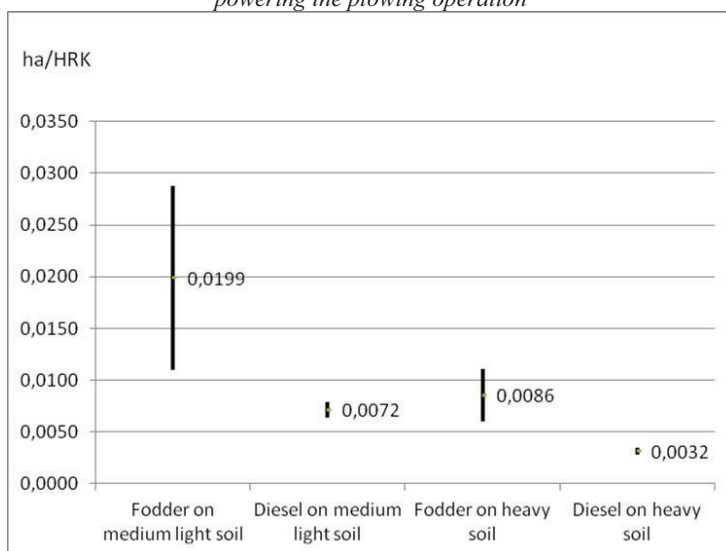
* Values are the products of consumption and unit price of 4.90 HRK/l

Source: Author's

3.6. Cost effectiveness of fodder and petroleum diesel fuel

The projections derived in this research indicate that the same monetary input (1 HRK) will produce varying outcomes in plowing the land (i.e. varying plowed land area). The highest cost effectiveness was projected for the fodder being used to power the plowing operation, on medium light soil (Figure 1), while the lowest cost efficiency was projected for petroleum diesel fuel used to power the plowing operation on heavy soil. The Figure shows projected ranges of cost effectiveness and medium values of the projected ranges.

Figure 1 Projected ranges for the cost effectiveness of either fodder or petroleum diesel fuel in powering the plowing operation



Labeled values denote mediums of the projected ranges. Values are reciprocal to the costs of either fodder (Table 4) or diesel fuel (Table 5) per unit of plowed land area.

Source: Author's

Greater variation intervals for the projected cost effectiveness of fodder were due to the expected variation of fodder purchase prices and animal nutrition management, while the short variation

intervals of diesel cost effectiveness are the consequence of the expected fixed price of agricultural diesel.

4. Discussion

The observed difference between costs of fodder and cost of petroleum diesel fuel per unit of plowed land area indicates that use of horses and fodder for powering the soil tillage can give a certain advantage in the cost efficiency, especially if a farmer is capable to achieve the low purchase prices of fodder. Achievement of the low purchase prices of fodder depends on the farmers' financial capability to purchase the goods when they are cheap – usually at the time of harvest.

The research has included fodder costs for the days when horses are expected to do the plowing work at their full capacity only. Previous research of Jarić (2014) has indicated that there can be many days in a year when horses are idle, but still need to consume fodder, although in a lesser value (grains can be omitted). Costs of fodder consumed in a days when idle may be considered as a fixed costs, similarly to the fixed costs of a tractor (costs of maintenance, registration, depreciation, housing, etc.). For the overall appraisal of economics of horse-powered work in agriculture there should be considered horses' fixed costs too, like a fodder in idle days, depreciation, housing, shoeing, and veterinarian). This indicates that a broader investigation has to be undertaken to provide for a more reliable comparison of the cost effectiveness between horse traction and diesel-engine powered traction.

For the long-term economic appraisal there should be considered a beneficial effects of healing the soil compaction induced by a heavy machinery and consequent improvement of the soil's water holding capacity for the drought periods and overall fertility (Gantner et al., 2014).

5. Conclusions

Fodder as a biofuel has shown a greater cost effectiveness due to consistently lower costs per unit of plowed land area. The fodder costs for plowing medium light soils were estimated between 34.78 HRK/ha and 90.61 HRK/ha, while the diesel fuel costs were estimated between 126.42 HRK/ha and 155.33 HRK/ha. Fodder costs for plowing heavy soils were estimated between 90.00 HRK/ha and 158.20 HRK/ha, while the diesel fuel costs were estimated between 287.63 HRK/ha and 363.09 HRK/ha. Projected variations of fodder costs per unit of plowed land area were due to expected variation of purchase price of fodders (meadow hay and oats), and variations in fodder consumption due to various horse breeds employed and nutrition management. Variations in diesel fuel costs per unit of plowed land area were due to different reported values of fuel consumption in the published researches. Since the research results are based on literature published data for diesel fuel, and for fodder are based mainly on data collected by interviews, there appears a need to continue this research in field trials. This would provide exact measurements of work capacity and fodder consumption of working horses.

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