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The possibility of bioethanol production from autumn sugar beet

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ABSTRACT

Ethanol is a clean and renewable energy source. The necessity of ethanol usage instead of fossil fuel or mixed with them, in order to reduce environmental pollution, resulted in increase of ethanol production from 50 million m^{-3} in 2007 to 85 million m^{-3} in 2012. The present study aimed to compare the cost of bio-ethanol production from sugar beet with other agricultural crops, and also economical comparison of sugar beet production in spring and autumn seasons, and finally, to estimate the required capital for constructing industrial unit for bio-ethanol production. Previous studies showed that the average cost of producing 2.3-3.3 m^{-3} ha^{-1}bio-ethanol from one hectare of spring and autumn sugar beet fields with average yield of 37 and 48 t ha^{-1} and 17.5 and 13.3% sugar content is 92 and 89 million Rials, respectively. With the implementation of research recommendations in autumn sugar beet production and increasing sugar content, the bio-ethanol production may increase to 5.4 m^{-3} ha^{-1}. In addition, using dried pulp, bio-ethanol production efficiency can increase to 0.25 m^{-3} t^{-1} of dried pulp. To produce about 76000 m^{-3} ethanol per year (with the assumption of producing 90 L ethanol from 1000 kg sugar beet with sugar content of 15%), about 1100 tons sugar beet is needed. In conclusion, with activation of autumn sugar beet planting for bio-ethanol production, not only air pollution will be reduced but also a good source of income for growers and dependent industries will be provided.

Keywords: autumn sugar beet planting; bioethanol; sugar beet.

INTRODUCTION

The occurrence of climate change in the last ten years has made it as one of the most important issues in the world. It has been documented that the Earth is warming at the rate of 0.2±0.05°C/year (Hansen et al. 2006). Climate change is seriously affected by greenhouse gases (GHG). The consumption of fossil fuels in metropolises increased GHG emission and air pollution. For example, air condition in a city like Tehran was unhealthy and too unhealthy in 56and 31% of days, respectively in 2011 (Anonymous 2012). So, it is recommended to use renewable energy source which does not pollute the environment.

Ethanol is a source of renewable energy which can be derived from agricultural raw materials. Agricultural crops account for about 97% of ethanol (Vivekanandhan et al. 2013). Ethanol is mixed with gasoline at different ratios of 5, 10, or 85% denoted by E5, E10, or E85, respectively. It has been established that E20 (containing 20% ethanol) reduces CO emission by 23% and by 13% for other hydrocarbons as compared with ethanol-free fuels (Buddy and Hilton 2009).

The global rate of ethanol production is ascending with 85 million m^3 production in 2012 (Anonymous 2012). Among different sources, sugar crops and molasses account for 39% of ethanol, grains for 48%, and biomass and other crops for 10%, and the remaining 3% is synthetic (Vivekanandhan et al. 2013).

Crops used for ethanol production are determined in terms of surplus production in order to adjust the crop price in the global market. Iran has a warm and arid climate suffering from agricultural water scarcity which forces the import of most of the crops used for ethanol production in other

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countries. Sugar beet and sugar cane crops which are usually grown for sugar extraction do not supply the sugar demand so that about 1800 thousand tons of raw sugar was imported in 2012 despite of 1150 thousand tons sugar production (Anonymous 2010, 2012). Although Iran climate allows sugar beet sowing in autumn in some regions (Fatollah Taleghani et al. 2010), the acreage of autumn-sown sugar beet has declined in recent years because of its low sugar content (about 13%) and subsequently profit loss versus spring sowing. As a result, not only the crop rotation been disrupted, but also the sugar production has decreased whereas mean sugar content can be readily recovered in these regions via applying research-based recommendations (Abdollahian Noghabi et al. 2013).

Table 1. The cost of bioethanol production from some crops and residue (Grassi 2000)

Crop	Cost of ethanol production (USD m^{-3})
Sugar beet	300
Sugarcane	260
Sweet sorghum	200-300
Potato	990
Corn (120 USD t^{-1})	300
Cassava	790
Cellulose compounds (acidic hydrolysis)	450
Cellulose compounds (enzymatic hydrolysis)	180
Synthetic ethanol	540

In this study, national and international data were used to explore the potential of bioethanol production, to evaluate different factors underpinning the bioethanol production cost, to compare ethanol production from one hectare of spring-sown sugar beet with autumn-sown sugar beet from economic perspective, and to estimate the capital demand to found an industrial plant of bioethanol production from sugar beet.

Factors underpinning the cost of bioethanol production

The cost of bioethanol production from crops depends on the crop price, the applied method for fermentation, the industrial methods of bioethanol production, and the production efficiency (Roehr 2001). Production efficiency varies among different crops. Average bioethanol production per unit area is 6.62, 3.55, 3.52, 2.76, 2.23 and 2.03 m^3 ha^{-1} for sugar beet, potato, corn, wheat, triticale, and rye, respectively. Therefore, one kg of fresh sugar beets gives 0.1 L (100 mL) of ethanol which is an agreeable efficiency (Icoz et al. 2008). Table 1 presents the cost of bioethanol production from different crops. The etimated cost is lower for crops containing sucrose (such as sugar cane and sugar beet) since direct fermentation can be applied for them(Grassi 2000).

Table 2 shows the cost of bioethanol production from sugar plants (sugar beet and sugar cane) including crop price and production costs under different regions (USDA 2006). Bioethanol production from corn in US and from sugar cane in Brazil does not cost as much as its production from other crops which returns to the lower price of raw material production.

Economic comparison of ethanol production from one hectare of spring and autumn-sown sugar beet

The costs of bioethanol production can be divided into the raw material production and extraction. Mean production cost per ha (Table 3) depends on land preparation, sowing, harvesting, land rent, rate and value of inputs per ha (seed and fertilizer), labor, and farmer's income (Anonymous 2012).

Comparison of root yield and sugar content of autumn- and spring-sown sugar beet is presented in Table 4 which indicates that autumn-sown sugar beet has higher mean yield with lower sugar content. Although the amount of produced sugar per ha is almost the same for both sowing, autumn-sown sugar beet incurs higher transportation and extraction costs.

Costs of founding bioethanol production unit from sugar beet

Investment in bioethanol extraction from sugar beet is composed of fixed and variable costs.

Table 2. Comparison of the price of bioethanol produced from sugar crops (sugar beet and sugarcane) in terms of USD $barrel^{-1}$

	Bioethanol production sources								
	Fresh corn USD	Dry corn US	Sugarcane US	Sugar beet US	Molasses US	Raw liquid sugar US	Refined liquid sugar US	Sugarcane Brazil	Sugar beet Europe
Crop price	0.4	0.53	1.48	1.58	0.91	3.12	3.61	0.3	0.97
Production costs	0.63	0.52	0.92	0.77	0.36	0.36	0.36	0.51	1.92

Price of produced alcohol	1.03	1.05	2.40	2.35	1.27	3.48	3.97	0.81	2.89

Table 3. Costs of 1 ha of sugar beet farm (000 IRR)

Crop	Land preparation	Sowing	Cultivating	Harvesting	Land rent	Total (000 IRR)
Spring-sown sugar beet	3500	11602	29347	22417	25000	91866
Autumn-sown sugar beet in Khuzestan	4400	11602	23625	19250	30000	88877

Table 4. Comparison of yield and sugar content of spring and autumn-sown sugar beet factories and the produced ethanol

Crop	Mean yield (t ha^{-1})	Mean sugar content (%)	Sugar (t ha^{-1})	Ethanol production (m^3 ha^{-1})	Ethanol production (L t^{-1} sugar beet)
Spring-sown sugar factory*	36.74	17.55	6.45	3.3	90
Ahvaz Sugar Factory during operation**	47.64	13.34	6.35	3.2	67
Sugar beet produced in Dezful Research Center***	67.58	15.88	10.73	5.4	80

* Mean yield and sugar content of sugar beet factories in 2007-2011
** Mean yield and sugar content of Ahvaz Sugar Factory in 2003-2007
*** Mean yield and sugar content of sugar beet produced in Dezful Research Center in 2008-2012.

Assuming the production rate of 90 L ethanol 1000 kg sugar beet roots with an average of 17% sugar content, about 840,000 tons sugar beet root is needed to produce about 75.6 million liters (20 million barrels) of ethanol. The capital requirement of founding a plant with a production capacity of 75.6 million liters per year is about 120 million USD. The costs of processing bioethanol from sugar beet include transportation from field, labor, fuel, chemicals, electricity, raw material, equipment, maintenance, and management costs. The cost of ethanol production from sugar beet in US is estimated to be 2.35 USD per 3.75 liters (one barrel). Meanwhile, 1.35 USD of the total 2.35 USD is paid for the supply of raw material (Yoder, 2009).

The different industrial steps of sugar beet ethanol production can be listed as soil removal, extra leaves removal, weeding, washing, chopping, transportation to diffusion tank, raw juice preparation, fermentation, diluted alcohol, concentration, and storage of the produced alcohol (Yoder, 2009).

Sugar beet pulp is another source of bioethanol. Sutton and Doran-peterson (2001) used Klebsiella oxytoca strain to produce ethanol from the dried pulp of sugar beet. They reported the conversion ratio of 0.2 g ethanol per g of dried pulp (with an efficiency of 20%).

DISCUSSION AND CONCLUSIONS

The rate of ethanol production for autumn-sown sugar beet with an averageyield of 48 t ha^{-1}, average sugar content of 13.35% and white sugar yield of 4.8 t ha^{-1} is calculated to be about 3.2 m^3 ha^{-1}. If the research recommendations are followed, it is expected to obtain 68 t ha^{-1} root yield, 16% sugar content, 9 t ha^{-1} white sugar yield, 6 m^3 ha^{-1} ethanol.

Currently, bulk sugar is priced at 22,500 IRR per kg, and bioethanol (99.5%) at 90,000 IRR per L (Anonymous 2013, Anonymous 2015), which is about four times cheaper than the price of ethanol. Given that 0.5 L of bioethanol can be extracted from 1 kg of sugar, bioethanol production is economical.

Finally, it can be concluded that bioethanol production from autumn-sown sugar beet is more economical than sugar extraction from this crop. In addition to its advantages for crop rotation, soil fertility, and water consumption, the partial replacement of fossil fuels with autumn-sown sugar beet ethanol may contribute to mitigating air pollution in megacities.

REFERENCES

Abdollahian Noghabi M, Sharifi H, babaei B and Bahmani, GA. Introduction of new formula for determination of autumn sugar beet purchase. Journal of Sugar Beet, 2013, Vol. 29, 2, 215-227.

Anonymous, Stats of sugar factories. Iranian sugar factory syndicate, 2012 http://www.isfs.ir/amalkard1.htm

Anonymous. Guaranteed purchase prices for crops in 2013-2014. Iranian Agriculture News Agency, 2012, http://www.iana.ir/keshavarzi/item/8147-1.html.

Anonymous. The price of ethanol confirmed in Iranian factories. Ethanol Manufacturers Association Iran, 2013, www.epa-iran.ir/farsi/news/prices.html

Anonymous. The economic feasibility of ethanol production from sugar in the united state. U.S. Department of Agriculture (USDA). 2009.

Anonymous. Iran Top imports. 2010, http://faostat.fao.org

Anonymous. World Fuel Ethanol Outlook to 2020. Market Evaluation Consumption and World Fuel Ethanol Statistics Committee (Mecas) 2012, 12 (19).

Anonymous. sugar price. 2015, http://www.iranjib.ir/showgroup

Buddy B and Hilton B. The effect of E20 ethanol fuel on vehi-

cle emissions. Journal of Automobile Engineering. 2009; 223 (12): 1577

Fatollah Taleghani D, Sadeghzadeh Hemayati S and Mesbah M. strategic framework for sugar beet research. 2010. Sugar beet seed institute 98/849, 520 pp.

Grassi G. Bioenergy Complex for commercial production of bioethanol towards large potential markets. 1st world conference of biomass for energy and industry 2000, pages 2131-2134.

Hansen j, Sato M, Ruedy R, LO K, Lea D and Medina – Eliza dM. Global Temperature change. Proceeding of the national academy of Sciences, 2006, volume 3(39), 14288, doi: lo.1073.

Icoz E, Mehmet Tugrul K, Soral A and Icoz E, Research on ethanol Production and use from sugar beet in turkey 2008.

Mistry PB. Energy from Biomass and Wastes. Washington DC, 1991, 16th IGT Conf, 669.

Roehr M. The Biotechnology of Ethanol: Classical and Future Applications. Wiley-Vch Verlag GmbH, Weinheim, 2001, ISBN: 3-527-30199-2.

Sutton MD and Doran-peterson. Fermentation of sugar beet pulp for ethanol production using bioengineered klebsiella oxytoca strain p_2. Jornal of Applied Microbiology 2001, 100, 407-414.

Vivekanandhan S, Zarrinbakhsh N, Misra M and Mohanty AK. Coproducts of Biofuel Industries in Value-Added Biomaterials Uses: A Move towards a Sustainable Bioeconomy, 2013, Intech, chapter 17, 491-541.

Yoder, J. Potential for a Sugar Beet Ethanol Industry in Washington State. Report to the Washington treatment of Agriculture, 2009.