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# Economic Analysis for Forage Agronomic Crops Grown Using Treated Wastewater in Kherbeh Als-Samra Region, Jordan

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***Authors' contributions***

*This work was carried out in collaboration between all authors. Author MM designed the study, performed the economical analysis, wrote the protocol and first draft of the manuscript. Authors NB and AAS managed the analyses of the study. Author KK managed the literature searches. All authors read and approved the final manuscript.*

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***Case Report***

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## ABSTRACT

Regarding Jordan's apparent climate change, the urgent need to use treated wastewater for irrigation and the production of forage crops has become an imperative. The possibilities for growing highly profitable forage crops using treated wastewater are discussed in the case of extension demonstrations in Kherbeh Als-Samra region. The economic analysis for extension demonstrations of Kherbeh Als-Samra region is presented. The case report has been prepared in the Zarqa Extension Unit, National Center for Agricultural Research in Jordan between June 2011 and January 2018. Treated wastewater is a very important non-conventional water source of Zarqa

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River Basin in Jordan. The main source is the effluent from Kherbeh Als-Samra wastewater treatment plant. The effluent route sided with several types of forage crops. Alfalfa, Egyptian clover, wheat, barley, triticale, rye grass, forage sorghum, silage corn, sweet corn, and Sudan grass are the most planted forage crops. Wadi Dlayl has located in the Zarqa River Basin also, this area is the best for rearing livestock and mainly the dairy cows. Data about economic analysis are presented because of its importance for the profitability and efficiency ratio evaluations. The economic analysis for the forage crops irrigated with treated wastewater in Jordan indicates that rye grass is the highest profitable forage crop for growers. Chemical weed control is used to improve the marketing price of forage crops. However, irrigation modeling, drought-tolerant hybrids, using machinery, and crop rotations must be introduced to improve the efficiency ratio.

*Keywords: Agribusiness; agronomy; Jordan.*

## 1. INTRODUCTION

Change in climate is mainly attributed to the unabated increase in greenhouse gases, including fluorinated gases, carbon dioxide, methane, and nitrous oxide, which bring changes in rain pattern, temperature, and negative effects on water, and droughts. Climate change is considered to be a global phenomenon; however, its impacts are more widely felt in the developing countries, due to their greater vulnerabilities and lesser ability to mitigate the effects of climate change. Because most developing nations are agriculture-based economies, their agricultural sector is affected the most due to direct exposure to nature. Therefore, the major impact of climate change is on agricultural production due to changes in rain pattern, temperature, soil salinity, droughts, and negative effects on water and land resources [14].

Food security and water availability are highly vulnerable to the rapidly changing climate. Climate change will affect crop productivity, and can thus cause food security problems [9]. It has been expected that global warming will increase yields due to fertilizer effect, but will influence poor growers negatively. For example, countries closer to the equator will have reduced production due to global warming [6]. African countries will experience extreme droughts and a further shortage of food. If climate change affects the productivity of the agriculture sector in the lower-income countries of Asia or Africa, a large number of people will be at risk, and the problem of food insecurity will increase. Climate change is the main driver of food security in the developing world because it affects the productivity of the agriculture sector, its stability, and other components of the food system [18].

Research shows that regional and global water requirements can be altered due to climate change and can trigger a shortage of water for agricultural purposes. Studies reveal that increasing temperature and the changing pattern of rainfall have a substantial impact on food production [9,11]. The Peterson Institute states that agricultural production in developing countries will further fall between 10% to 25% and global warming will decrease the agricultural capacity of India by 40% if it continues unabated [2]. Hence, climate change causes serious threats to food security [5], negative impacts on productivity of different crops, the food supply [1], and the cost of adoption of climate change is high [8].

Increased water shortages will likely worsen forage yields and make livestock-raising more vulnerable [3]. Therefore, food security has remained a prominent policy of Jordan's government. Alfalfa, Egyptian clover, wheat, barley, triticale, rye grass, forage sorghum, silage corn, sweet corn, and Sudan grass are the main forage crops of Jordan. Therefore, food security policy mainly focuses on the production of these crops. Figs. 1 and 2 respectively showed the change in annual precipitation and annual mean temperatures projected in the Middle East and Jordan in 2050 [generated using software 19].

## 2. PRESENTATION OF CASE

Treated wastewater is a very important non-conventional water source of Zarqa River Basin in Jordan. The main source is the effluent from Kherbeh Als-Samra wastewater treatment plant, which handles 70% of Jordan wastewater. It provides with 365000 $m^3$ per day of treated wastewater. The length of the treated wastewater effluent route from the plant until King Talal Dam (KTD) is 35 km sided with several types of forage

crops. However, Wadi Dlayl is located in the Zarqa River Basin, this area is the best for rearing livestock and mainly the dairy cows. In the year 2016-2017, the total number of cattle was estimated at (29820) out of the total of the country (74740) [4].

Due to climate change and anticipations for drought conditions characterized by lower rainfall and less water for irrigation in some regions, for example, eastern arid parts of Jordan with its large dairy cattle industries, there is a vital need for profitable forages that integrates forage production. In Jordan, water policy is driven by the needs of often competing for entities, for example, agriculture, human population, and natural animal and crop species. Forage crops grown under treated wastewater irrigation is an excellent choice for livestock feed in arid and relatively dry regions. This profitability offers potential in areas where climate change is in present and will continue in the future. Thus, for Jordan agricultural national strategy considering forage crops, increasing production of these crops will help to improve both the rural demands and the national economy.

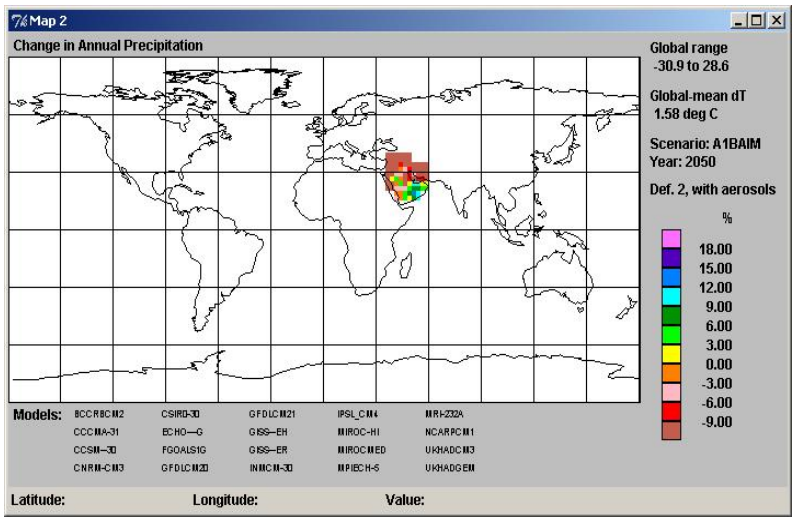



**Fig. 1. Change in annual precipitation projected and expected in the Middle East in the year of 2050**

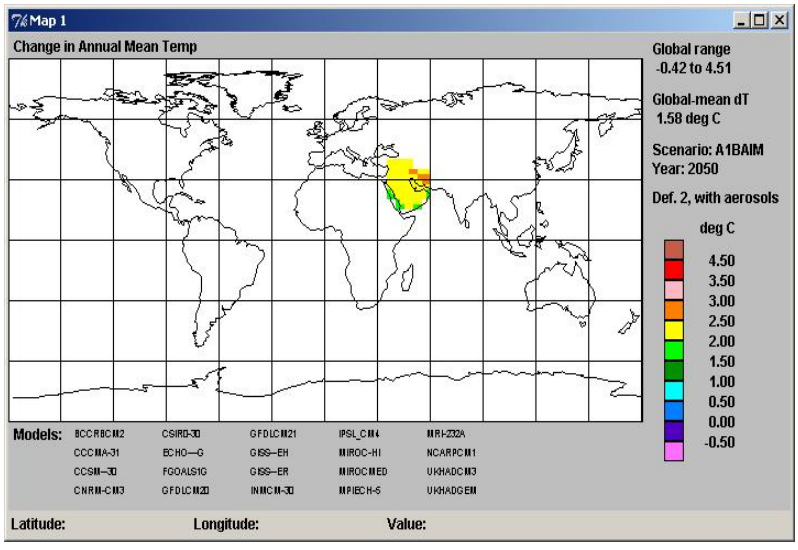



**Fig. 2. Change in annual mean temperature projected and expected in the Middle East in the year of 2050**

Zarqa extension department carried out demonstrations for forage crops. The demonstrations were cultivated among Kherbeh Als-Samra wastewater treatment plant route sides between June 2011 and January 2018. Mechanized tillage was used to prepare the seed beds, recommended varieties and seeding rates were followed, weed control treatments were done through herbicides in order to protect crops, chemical fertilization was used, and the irrigation was applied using treated wastewater. Irrigation was supplied by Kherbeh Als-Samrah Plant. Throughout the cropping season, traditional irrigation was provided based on the crop requirements and weather conditions. Fig. 3 showed the major items of forage crops management including crop rotations.

The economic analysis includes other costs for other inputs for all forage crops, particularly electricity and transport costs. Hand labor costs include seeding, irrigation, spraying herbicides, harvesting, collection, loading and thinning. Threshing costs are used only for triticale, wheat, barley and rye grass.

The efficiency ratio indicates the expenses as a percentage of revenue (expenses/revenue) [20].

## 3. DISCUSSION

Economic analysis showed that alfalfa as a forage crop required the highest input costs followed by rye grass, Egyptian clover, Sudan grass, sweet corn, sorghum, triticale, wheat, barley and silage corn (Graph 1).

Total revenue was the highest in rye grass. It is followed by alfalfa mostly because higher yields were obtained in main perennial and multi harvests forage crop. The least profitable crops were wheat and barley (Graph 2).

Efficiency ratio equals input divided by output, i.e. if expenses are $ 60 and revenue is $ 80 the efficiency ratio is 75%, meaning that $ 0.75 are spent for every dollar earned in revenue. (Graph 3) showed that the efficiency in rye grass is 27.1 %. However, it was 88.79% in sweet corn. It is essentially how much a corporation or grower spends to make a dollar; entities are supposed to attempt minimizing efficiency ratios by reducing expenses and increasing earnings [20].

With the impact of climate change, increasing population, urbanization and limiting resources, crop production sector is facing the challenge of more food production with less water [10]. Water scarcity and deficit in Jordan projected during 2025 is about 630 million cubic meters [16]. Irrigation modeling can be managed preciously to meet crop water demands, holding the promise of increased yield and quality [7].

Climate change indicated that the productivity of forage crops is highly variable in simulated extreme drought conditions of Jordan, where rainfall or irrigation amounts and distribution are highly variable. [13] reported that selection of specific drought-tolerant hybrid of silage corn seeds in Jordan would be an efficient and useful method of improving uniformity, water use efficiency, and providing superior seedling performance with the potential for improved vegetative yields under extreme drought conditions of Jordan.

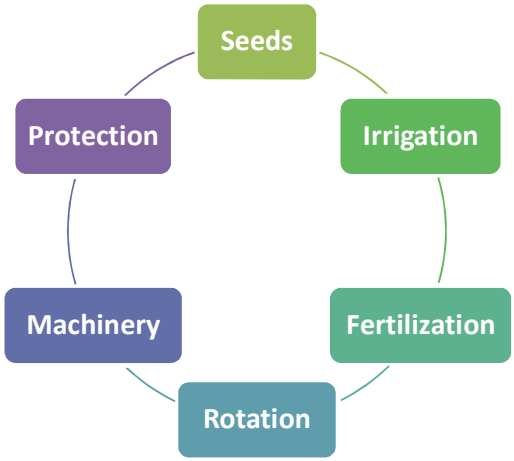
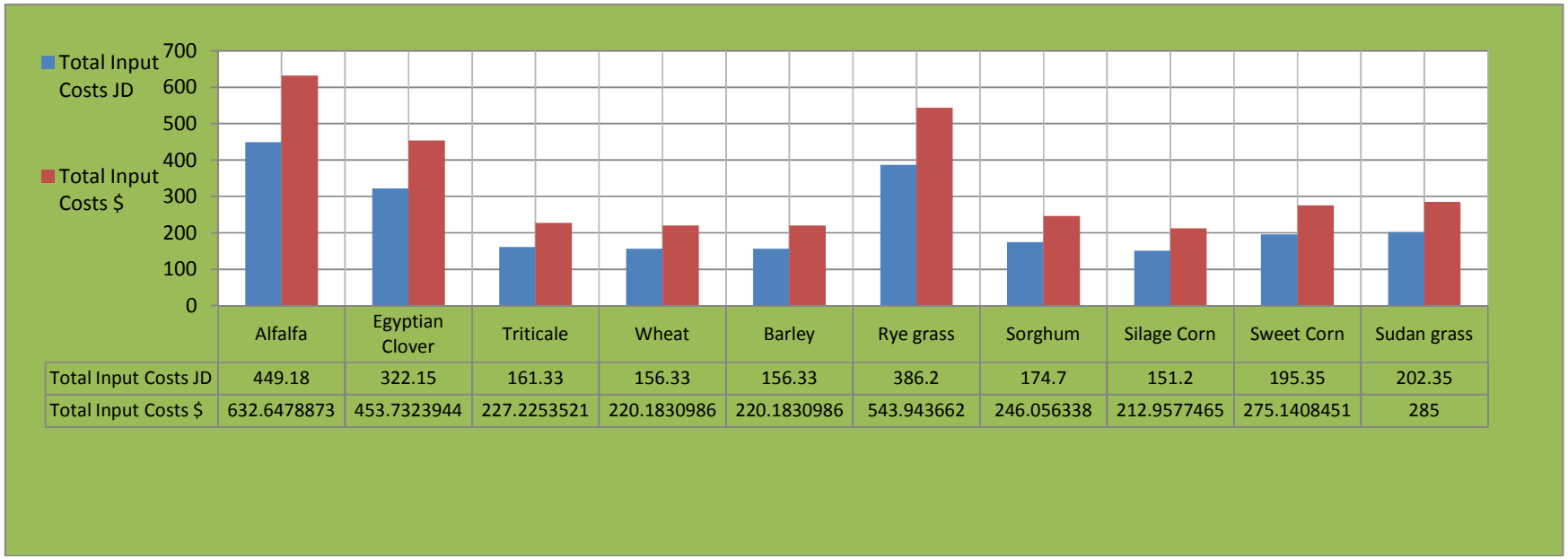
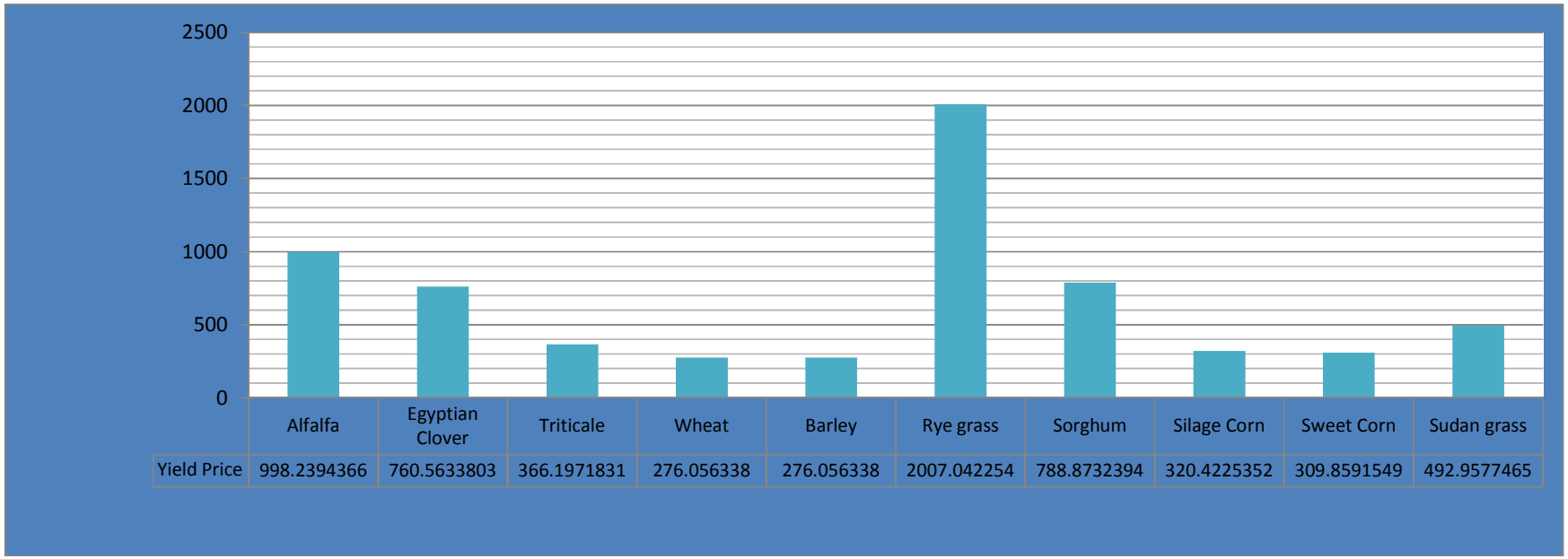



**Fig. 3. Forage crops management and major items**

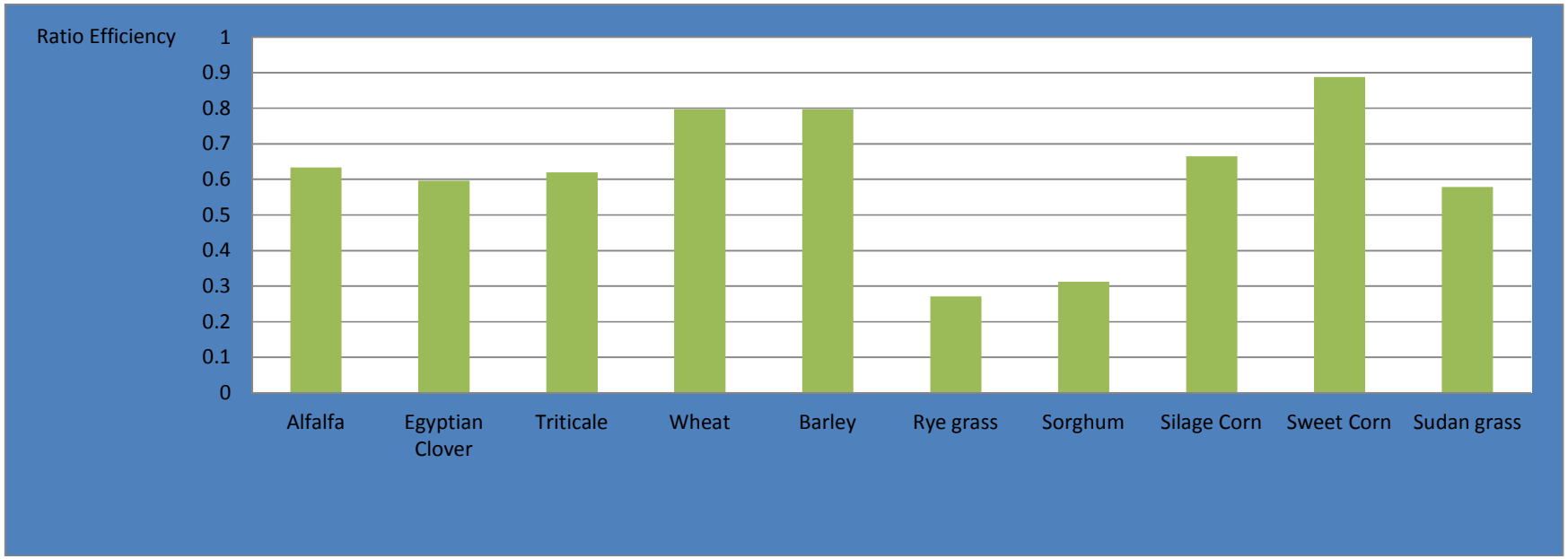



| | Alfalfa | Egyptian Clover | Triticale | Wheat | Barley | Rye grass | Sorghum | Silage Corn | Sweet Corn | Sudan grass |
|---|---|---|---|---|---|---|---|---|---|---|
| Total Input Costs JD | 449.18 | 322.15 | 161.33 | 156.33 | 156.33 | 386.2 | 174.7 | 151.2 | 195.35 | 202.35 |
| Total Input Costs $ | 632.6478873 | 453.7323944 | 227.2253521 | 220.1830986 | 220.1830986 | 543.943662 | 246.056338 | 212.9577465 | 275.1408451 | 285 |

**Graph 1. Total input costs in Jordan Dinar (JD) and American Dollar ($) for all forage crops grown under- treated wastewater in Jordan per 0.1 ha per one season**




**Graph 2. Yield price in American Dollar ($) for all forage crops grown under-treated wastewater in Jordan per 0.1 ha per one season**




**Graph 3. Efficiency ratio for all forage crops grown under-treated wastewater in Jordan per 0.1 ha per one season**

[12] reported that weed control plans typically consist of many methods such as chemical and cultural methods. Selective herbicides kill certain targets while leaving the desired crop relatively unharmed. Herbicides are generally a fast and efficient method in terms of results, costs and time-saving. However, cultural methods mainly the crop rotation is used by rotating crops with ones that kill weeds by choking them out. It is a way to avoid the use of herbicides and to gain the benefits of crop rotation. Rotations can be used to improve water management. For example, rotations provide protection from summer droughts by distributing the critical water-use periods across the growing season. Crop rotations are long-term plans that improve sustainability and profitability [15]. Incorporating forage legumes such as alfalfa and Egyptian clover into a crop rotation requires extra management but the rewards are many. Enhanced soil nutrient status, less reliance on herbicides for weed control and managing diseases are just a few of the many benefits.

The costs of agricultural mechanization and hand labor are very important in the production of forage crops in Jordan. Since the Depression, farmers have had increasing difficulty remaining profitable in competitive markets. The business strategies available to them are limited to raising profits by lowering costs per unit and increasing total units of output. Farmers' ability to increase total output has also been hampered by periods when fewer workers were available. [17] concluded that California farmers have remained competitive in the global marketplace by using technology to reduce their costs and to expand production. Harvest mechanization has reduced labor use by 92% to 97% and has also reduced labor costs, down from half to two-thirds of total costs to less than 20%. [17] reported that mechanization is at least partly responsible for the steady increase in production of rice and processing tomatoes.

Although extension demonstrations and forage growers in Jordan have reduced the input costs in several ways, total revenues for forage crops has risen slowly due to increased production of some crops. Further procedures in production will recommend to reduce waste of water, to reduce labor needs, to introduce drought-tolerant hybrids and crop rotations in their cropping patterns.

## 4. CONCLUSIONS AND RECOMMENDATIONS

The economic analysis for the forage crops irrigated with treated wastewater in Jordan indicates that rye grass is the highest profitable forage crop for growers.

Chemical weed control is used to improve the marketing price of forage crops. However, irrigation modeling, growing drought-tolerant hybrids, using machinery instead of hand labor, and crop rotations must be introduced to improve the efficiency ratios.

Although sweet corn is the only crop grown for food and forage in this study, the report recommends not to grow it under treated wastewater irrigation and recommends giving priority to triticale cultivation instead of wheat and barley within rotations. It is also preferable to cultivate drought-tolerant hybrids of silage corn, and Sudan grass crops.

This study indicates that the economic analysis for forage crops production under treated wastewater irrigation will save the most valuable agricultural resource in Jordan, which is water under climate change conditions. Research, and extension are supposed to attempt minimizing efficiency ratios through enhancement of irrigation modeling, irrigation technology, drought-tolerant hybrids, machinery and crop rotations.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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