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ESM 121 Final Paper

June 4 2015

Crop Substitution for Improved Water Efficiency

Introduction:

California's population is currently the largest in the nation and is still growing exponentially. Unfortunately, California is undergoing one of the worst droughts in the state's history and the state's need to rethink its current water usage is imperative. Agriculture necessitates a massive water demand, but is also a critical part of California's economy and history. Agriculture uses over 50% of the state's water resources during a dry year, and the pressure is increasing for farmers to improve their water efficiency practices (ITRC 2003). Farming techniques play a large role in efficiency, and switching irrigation methods certainly decreases water use; however, the inefficiency of farming is still too great, to the point our current irrigation methods do not allow for adequate groundwater recharge (ITRC 2003). To truly make a sustainable difference, the crops cultivated in California should be reconsidered and planted based on the amount of water required to grow them. California is known as "The breadbasket of America", yet it has depleted its most important resource, water, as it still continues to grow non-native water-intensive crops with no end in sight. We decided to consider potential food substitutes that could be grown with significantly less water, yet still provide similar nutritional value.

For our project, we chose three critical components of a daily human diet – calories, protein and fat. All three of these are critical components of a daily diet according to the USDA. We then looked at crops that satisfied these dietary needs and then looked and how much water these crops required. We selected two crops for each dietary component, one that is commonly eaten and one replacement that requires less water to cultivate for the same amount of nutrition. Most of human water demand is utilized for agricultural purposes, and with climate change expected to increase extreme weather patterns, our current levels of crop production are unsustainable, proven by the current California drought (ITRC 2003). Supporting the growth of crops that yield the same nutritional value with less of a negative impact on the environment seems crucial for reliable food generation in the future.

Objective:

The main objective of this project is to compare the nutritional value of six different food products and their respective water uses to discover how to maximize nutrition while minimizing water use. The first main task of our project was to choose which three crops we would decide to be our common crops. We decided on corn, almonds, and green beans because of their widespread use in California (FAO 2013). We then had to decide on three crops to compare to these that showed similar nutritional characteristics, in order to stay consistent when replacing one crop with another. The decision was made for the comparison crops to be potatoes, walnuts (English), and soybeans (National Nutrient Database 2011). After this decision was made, the next main task was to then find the water use in gallons per pound of production for each crop

comparison. We then calculated the gallons of water needed to produce 100 grams of each crop. After deciphering how much nutritional value was contained in 100 grams, for each crop, we then prepared a cost-benefit analysis. Finally, we recommended which crops would be the most efficient while maintaining quality nutritional value, based on the water use and nutritional value of each crop.

Data Sources:

We utilized the FAO website for background information on cultivation to select six crops. Then we referenced the USDA and National Nutrient Database to find the different values of our chosen nutritional components (calories, protein, fats) for our chosen crops. Based on their data we calculated the nutritional value per 100 grams of each food item. Next we used a study done by the Twente Water Centre at the University of Twente in Enschede, Netherlands to find the different water requirements per mass of crop produced. We then verified this data with California information from the ITRC and Ecology Global Network to make sure that the information was pertinent and legitimate.

Methods:

- Research to find 3 crop examples that best represent the three main components of the human diet (fats, calories, and protein)
- Research to find 3 crops to compare their nutritional values to the water use
- Find water use, in gallons, per 100 grams of production for all six crops
- Analyze the monetary costs and benefits, solely affiliated with water demand, of all 6 crops and decipher whether it would benefit farmers to substitute their current ones

Assumptions/ Limitations:

As with many scientific investigations, we soon realized that our project could be examined at many different depths, and many factors that we had not previously considered proved to be substantial roadblocks. Our largest limitation was time, and the fact that we had no way of collecting our own research. There were lots of conflicting numbers when looking at varying water usages, so we attempted to gather information from unbiased sources. Unfortunately, the sources with the most information usually promoted the industries of the foods so impartial sites were difficult to find. Because water usage is heavily dependent on farming techniques and soil types, we chose to look at average water demand of each crop and that cost, instead of actual costs that individual farmers may encounter (ITRC, 2003).

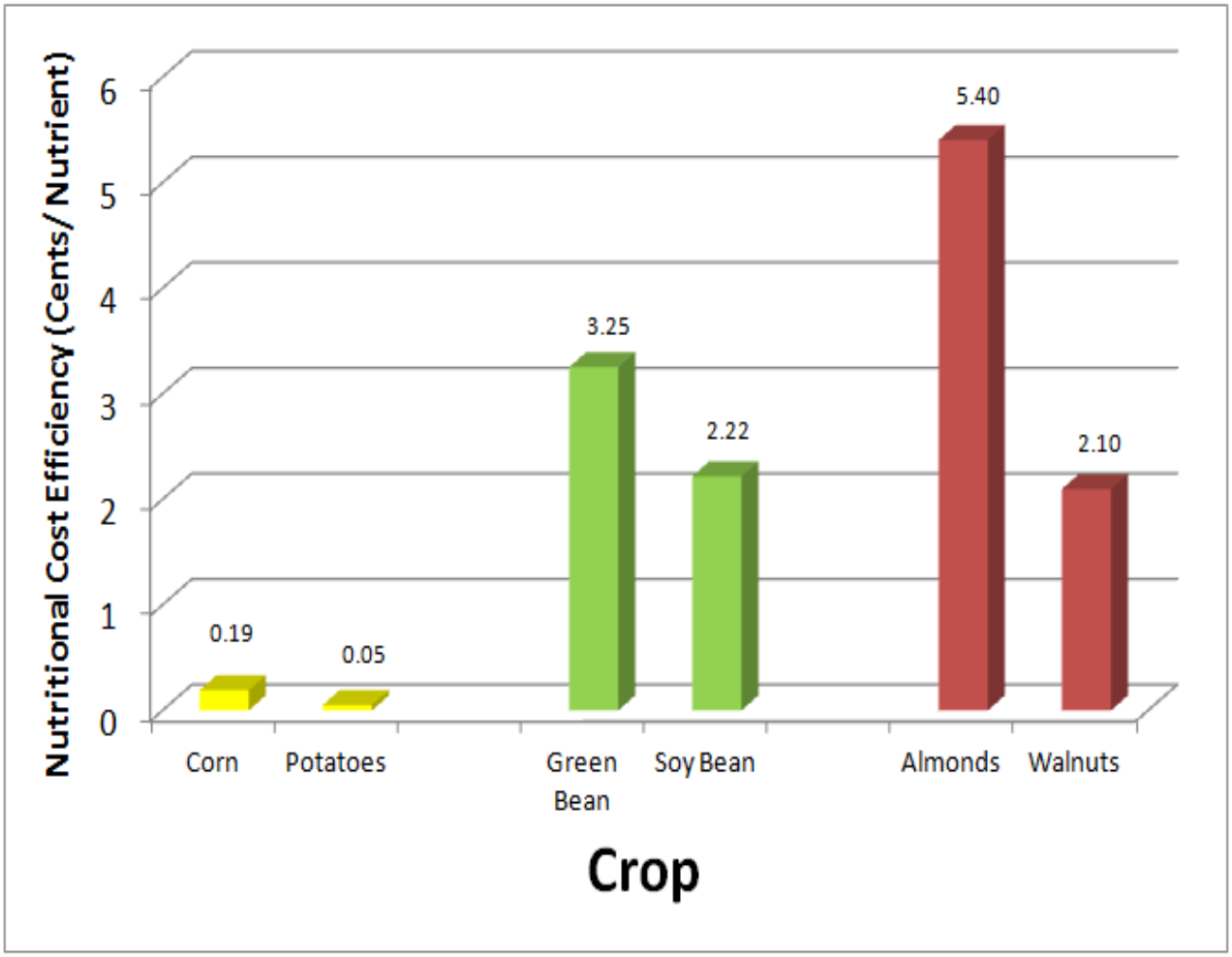
We also encountered potential points of error because we studied six different crops, so we had to make sure that the only nutritional data we looked at had to do with fats, protein, and calories. When deciding whether the water-efficient crop was the better option, we did not consider market prices, whether the crops were low or high value, and the speed at which said crops grow. All of these factors obviously have an effect on what farmers choose to grow.

Another assumption we made in our analysis was that we compared only the raw production and use of each crop. For example, a crop such as corn, our analysis only considered the raw corn product and not the countless other products corn is used for (ethanol, cosmetics, and toothpaste). This could have skewed our data because all these

other uses have values that our data did not consider when only looking at nutritional values.

Calculation/Results:

Crop		Nutritional Benefit (per 100g)	Water Use (gal/100g)	Water Efficiency (Benefit/gal)	Water Rates (¢/gal)	Nutritional Cost Efficiency (¢/Benefit)
Corn (raw)	Calories	86 Kcal	35.5	2.42 Kcal/gal	0.46¢	.19 ¢/Kcal
Potatoes	Calories	77 Kcal	8.4	9.19 Kcal/gal	0.46¢	.05 ¢/Kcal
Green Bean	Protein	2.31g	16.3	.14 g/gal	0.46¢	3.25 ¢/g
Soybean	Protein	12.95g	62.4	.21 g/gal	0.46¢	2.22 ¢/g
Almonds	Fats	33.93g	468.7	.09 g/gal	0.46¢	5.4 ¢/g
Walnuts	Fats	59.33g	270.3	.22 g/gal	0.46¢	2.09 ¢/g



After our calculations, we discovered that by *planting potatoes instead of corn, .0496 gallons of water/100g of product could be saved*. Although this appears to be a small number, almost 200,000 acres of corn is harvested in California every year, so the water savings would be significant, while still providing very similar amounts of calories. Similarly, by switching from *green beans to soybeans, .0614 gallons of water/ 100g of product would be saved*. Soybeans also provide almost six times more protein than green beans. Finally, by planting *walnuts instead of almonds, .904 gallons/ 100g of product would be saved*. Walnuts demand significantly less water and contain 58.33 grams of fat per 100g to almonds' 39.93 grams.

Conclusions:

We hypothesized that there were water-efficient crops of similar nutritional value that could be substituted for the more popular ones grown today. We were not surprised in finding that crops of similar nutritional value greatly vary in their water demands. We found that while almonds are incredibly popular, for similar fat content, walnuts are a much more efficient in water usage. We also concluded that for similar amounts of calories, potatoes should be planted instead of corn, and soybeans should be cultivated instead of green beans for the same amount of protein (National Nutrient Database, 2011). While the drought has greatly intensified the awareness of the importance of water efficiency, water should be properly managed at all times. California's water use is unsustainable, as is the extravagant luxury of eating whatever we want, regardless of the season or impact on the environment. Our suggested crop substitutions are only a brief beginning of all the potential water-wise farming that could be taking place worldwide to improve water security for humans, agriculture, and the environment. While California's agriculture is commonly blamed for its large water demand, it is extremely unlikely that a change in crops planted would actually occur. Due to costs, traditions, and public demand, it seems that water-efficient agricultural changes will only happen when there is literally no more water to sustain current crops, a fear that is quickly becoming reality.

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