

## Review

# Sustainable agricultural practices: energy inputs and outputs, pesticide, fertilizer and greenhouse gas management

Yue-Wen Wang PhD

*Department of Agronomy, National Taiwan University, Taipei, Taiwan*

The food security issue was addressed by the development of “modern agriculture” in the last century. But food safety issues and environment degradation were the consequences suffered as a result. Climate change has been recognized as the result of release of stored energy in fossil fuel into the atmosphere. Homogeneous crop varieties, machinery, pesticides and fertilizers are the foundation of uniform commodities in modern agriculture. Fossil fuels are used to manufacture fertilizers and pesticides as well as the energy source for agricultural machinery, thus characterizes modern agriculture. Bio-fuel production and the possibility of the agriculture system as a form of energy input are discussed.

**Key Words:** fossil fuels, solar energy, biofuels, climate change, sustainable

## ENERGY INPUT OF MODERN AGRICULTURE AND CLIMATE CHANGE

Food production has been greatly increased in quantity to meet the demand from population increases after the World War II. New crop cultivars teamed up with machinery, chemical fertilizers and chemical pesticides; and have transformed centuries-old traditional agriculture production into “modern agriculture”. Land was cleared and irrigation systems laid to provide a uniform environment for homogenous crop varieties. In order to prevent crop damages by pests, an array of fungicides, insecticides and herbicides were generously applied to the fields. Chemical fertilizers have also made a great contribution to the productivity of agricultural land by providing abundant nutrients to the crops. Uniformity in terms of size and shape of the produce for trading symbolized the era of the “modern agriculture”.

These beautiful agriculture produces we consume are driven by energy. Energy that drive the machines to clear and eroded lands, energy to combine chemical molecules to make pesticides and pollute the lands and air, energy to convert the gaseous nitrogen into pelletized fertilizers and contaminated the water. The price of these beautiful agriculture produces are costing the land, air and water, key elements that life depend on.

These beautiful agricultural produces labelled as safe by agencies merely pacify the consumer at the moment of purchase. The impact to the environment from production is persistent and accumulated. Now the world is suffering irregular extreme weather anomalies which were considered to be a phenomenon of climate change, as evident by the rapid raise of ambient temperature globally in the past decades. Although agriculture is not the only sector that consumes energy, it is the key to storing energy. Fossil

fuel is the greatest source of energy that sustains the modern human society. It is solar energy captured though photosynthesis by plants millions of years ago. This buried energy was excavated and released in a few decades. The inefficiency of our machines and systems lose great amounts of energy in the form of heat and coupled with the rate of energy release floods the eco-system causing catastrophic disasters.

## BIOFUELS AS AN ALTERNATIVE

The people are realizing the impact of massive utilization of fossil fuel and proposed biofuel as an alternative. The transportation system in the current human society is depending mainly on liquid fuels including gasoline and diesel. Alcohol produced by fermentation of starch-grains and biodiesel by extraction of oil-crops were deployed in several countries and compromised in its early stage by considerations for food security. A protest that broke out on Feb 1<sup>st</sup>, 2007 in Mexico City as a result of soaring price of tortillas in response to the American’s corn bio-fuel project is one of the incidences worldwide.

The production of biofuel from farm land seems to be a solution for mitigating climate change to many politicians. The food security issue is the bottom line for agriculture and biofuel production must be compromised for it. The direct use of the food and feed for biofuel produc-

**Corresponding Author:** Dr. Yue-Wen Wang, Department of Agronomy, National Taiwan University, 1 Roosevelt Road, Section 4, Taipei, Taiwan 106, ROC.

Tel: +886-2-33664765; Fax: +886-2-23620879

Email: ywang@ntu.edu.tw

Manuscript received 27 July 2009. Initial review completed 27 July 2009. Revision accepted 29 October 2009.

tion will meet the head-on challenge of food security. On the contrary, the use of the waste and residuals from the agriculture system for biofuel is welcomed and engaged by researchers.

Other than using existing farmland for biofuel crop production, new lands could be cleared out for it. Most likely, these lands will come from deforestation which is currently depositing solar energy. Once it is converted into crop lands and starts to receive energy input from fossil fuel, the deficiency will worsen and climate change might be overwhelming.

### **BIO-ENERGY IS NOT JUST BIOFUEL**

People are focusing on biofuel because it is the vehicle they are familiar with using. Liquid form of biofuel has obvious advantage of storage and popularity. But the efficiency in terms of conversion of crop to biofuel is rather low. For example, in the fermentation process, micro-organism will consume a certain amount of energy stored in the feedstock in exchange for the production of ethanol. The theoretical conversion rate of sugar beet and sugar cane to ethanol was estimated around 50% and 44%, respectively. Other than bio-chemical conversion, thermo-chemical conversion is another conversion platform for the utilization of energy stored in the biomass of crops. The two major thermo-chemical conversion systems: gasification and pyrolysis could yield conversion rates of 50-70% and 70%, respectively.<sup>1</sup> The biomass can be converted into heat, electricity and possibly liquid fuels in the thermo-chemical conversion system. The human society will take a long time to abandon liquid-fueled vehicles to adopt vehicles using other forms of power sources. But daily electricity and heat consumption of majority population can be resourced on the thermo-chemical conversion of the biomass by integrating gasification and pyrolysis into existing power plants.

### **ENERGY INPUT IN FARM PRODUCTION**

Solar energy is the ultimate source of energy on the farm and it comes in two forms: light and heat. Light energy is captured by photosynthesis and heat drives the enzymatic systems of the plant and its surrounding environment. In modern agriculture, greater energy input in the form of mechanical force, fertilizers and pesticides are required. Such inputs created modern agriculture. Even though food security was answered in modern agriculture, the environment is suffering from the pollutions which impose a greater threat to food safety and human health. To avoid the consequences of modern agriculture is to stop the energy input from fossil fuel and acquire it from other sources. Many of the renewable energy, such as wind, solar panel, ocean current are available and could be integrated into the agriculture.

### **AGRICULTURE AS A SOURCE OF RENEWABLE ENERGY INPUT**

The agriculture system is one of the industries taking great acreage. The crops grown in the field can capture solar energy. They can also be used as feedstock for the bio-energy conversion system, both in terms of residuals as well as primary production. If the plants can grow taller and bigger, it will be able to capture and store more solar energy. If the plants can cover the field longer, it will also be able to capture more solar energy. The extra energy captured could be used to offset a certain amount of fossil fuel input as in modern agriculture.

### **AGRICULTURE AS A SOURCE OF NITROGEN INPUT AND CARBON SINK**

Fertilizer input in modern agriculture is supplied to meet the demand of the crops. Legumes have a naturally occurring nitrogen-fixation symbiosis system that has worked for millions of years. If the legumes could be integrated into the production system with the addition of manure through recycling farm waste, the amount of nitrogen fertilizers from outside the agriculture system could be reduced.

The agriculture system is the most important system to reduce the amount of carbon dioxide in the atmosphere through photosynthesis. The soil organic matter content is the primary carbon sink and it was estimated that grasslands can store from 200 to 480 Pg in all ecosystems. The soil carbon content both in the grasslands and forests were estimated at 70 t ha<sup>-1</sup>.<sup>2</sup> Since most of the crop fields and grasslands are degraded, the recovery of carbon from the atmosphere into these lands could mitigate climate change to a certain degree. The organic matter in soil contains many micro-organism containing phosphor, potassium and many nutrients and could benefit crop production without input from chemical fertilizers.

### **REDUCTION IN PESTICIDE USAGE**

Modern agriculture is characterised by uniformity of production which is based on homogeneity of crop variety. The homogeneity of crop variety grown on a large scale will provide the adapted pest an abandon food supply and the host an outbreak of disease or insect attack. The application of pesticides is one of the primary measures taken in the modern agriculture system. If the crop varieties are diversified, the chance of an outbreak in terms of pests could be greatly reduced. Thus pesticide use could be reduced or even eliminated.

### **AUTHOR DISCLOSURES**

The authors report no conflicts of interest.

### **REFERENCES**

1. Wim C. Turkenburg. Renewable energy technologies. In José Goldemberg, editor chair. World energy assessment: energy and the challenge of sustainability. United Nations Development Programme. 2000. pp. 219-67.
2. Robert M. General trends in carbon sequestration in soils. In Michel Robert, editor. Soil carbon sequestration for improved land management. FAO. 2001. pp. 1-7.

Review

## **Sustainable agricultural practices: energy inputs and outputs, pesticide, fertilizer and greenhouse gas management**

Yue-Wen Wang PhD

*Department of Agronomy, National Taiwan University, Taipei, Taiwan*

### **永續的農業實施：能量輸入與輸出、農藥、肥料及溫室氣體管理**

二十世紀透過「現代農業」技術的發展，回應了糧食安全的考量。但同時，食品的安全與環境劣化兩大議題卻被犧牲了。近年來的氣候變遷已被認定是肇因於將儲存在化石燃料中的能量釋放到大氣中。現代農業產生的均一產品築基於同質性作物品種、機械化、農藥與肥料的使用等。農業機械直接使用化石燃料為能源，而化石燃料也用於生產農藥與肥料，因此化石燃料是現代農業的主要推手也是造成氣候變遷的重要殺手。本文對利用農業系統作為生質燃料生產與能源供應的可能性進行討論。

**關鍵字：**化石燃料、太陽能、生質燃料、氣候變遷、永續的