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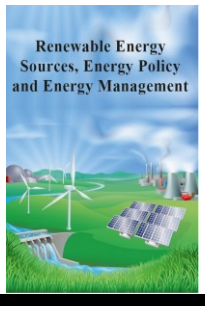

Original Review Article

Biomass and Bioenergy Crops

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ABSTRACT

Humanity started using energy with fire, and discovered burning with biomass. Did you pay attention to the branches, leaves, post-harvest bales in the fields, garbage that is overflowing from the garbage cans when the trees are pruned while walking on the road? However, when we look at it from a different perspective, we can see that they are all energy sources such as coal, oil and natural gas. Biomass is an environmentally friendly and renewable energy source with a wide variety of resources and is a valuable chemical. It is also a valuable chemical. It is most commonly used in the production of biomass heat, electricity, biofuels and biogas.

Keywords: Biomass, Bioenergy, Crops, Energy, Energy production.

1. Introduction

The demand for energy is an important problem in many countries due to the increase in the emerging population and the industrial development in this direction. Turkey is 78% of its energy needs from abroad. We use fossil fuels to meet this need and minimize it. However, these innocent-looking fossil fuels cause serious damage to the environment with the harmful gases they emit and also trigger global warming. As a result of realizing this and creating the necessary awareness, the eyes are turned to clean and harmless energy sources. In other words, these renewable energy sources are the energy sources that are always present in our environment, can carry the characteristics of the energy concept and can be found exactly the next day as a result of its use. Renewable energy sources; hydraulic energy, solar energy, wind energy, geothermal energy, wave energy, biomass energy. If evaluated in terms of energy, the concept of biomass; it is formed by various plant species, containing many plants in land and water, created by urban, forest and food waste, it refers to the energy released by the processing of organic substances. In other words, it is defined as biomass energy obtained from biomass. Biomass is organic, meaning it is made from material from living organisms such as plants and animals. The most common biomass materials used for energy are plants, wood and waste. These are called biomass raw materials. Energy from these organisms can be converted into usable energy, directly and indirectly. The biomass can be burned (directly), converted into electricity (direct) or processed as biofuels (indirectly) to generate heat. Intentionally grown energy crops (*Miscanthus*, *Pennisetum*, *Panicum* sp., etc) , wood or forest residues, waste from food plants (*Triticum aestivum*), horticulture (garden waste), food processing (corncob), animal husbandry (fertilizer; nitrogen, phosphorus) or human waste from sewage plants.

It releases CO from plant-based biomass, yet it is classified as a renewable energy source. Because according to legal frameworks, CO_2 returns in photosynthesis cycles. A large part of the negative CO_2 generated is carried to the soil during the cycle. In other

words, this situation is considered as edible energy since it provides less CO release.

2. Material and Methods

2.1. Biomass conversions

Combustion: It is the process of releasing heat as a result of combustibles burning in the presence of air or oxygen. It is the simplest method that biomass can be used for energy. In its basic form, combustion is used for space heating, but it can also be used to heat steam for electricity generation.

Gasification: As a biomass conversion into a combustible gas mixture, it is a producer gas. The process uses to generate synthesis gas that can be used after gasification instead of heat, pressure and partial combustion, natural gas, etc.

Pyrolysis: It consists of thermal decomposition in the absence of oxygen. It is the precursor to gasification and takes place as part of both gasification and combustion. Pyrolysis products include gas, liquid, and sold coal, and the proportion of each depends on the parameters of the process.

Anaerobic: digestion (or bio-digestion): It is a process in which bacteria break down organic material in the absence of air, giving biogas containing methane and a solid residue. Methane can then be captured to produce energy. Similarly, solid sediment can be burned to produce energy.

Fermentation: It involves the conversion of a plant's glucose (or carbohydrate) into an alcohol or acid. Yeast or bacteria are added to the biomass material that feeds sugars to produce ethanol and carbon dioxide. Ethanol is distilled and dehydrated to achieve a higher alcohol concentration to provide the purity required for use as automotive fuel. The solid residue obtained from the fermentation process can be used as cattle feed. In the case of sugar cane, boilers are kept for gasification later and can be used as a fuel. [1]

2.2. How Practical Is Biomass Energy?

Roughly 3-4% of energy comes from biomass and 84% comes from fossil fuels such as natural gas, coal and oil. Obviously, biomass has a long way to go before it is considered an energy source. Despite these challenges, the increased use of biomass energy has many advantages. A clear advantage that biomass fuels have over other energy sources is that biomass is renewable: we can grow more plants, but no one can produce more oil. Another advantage is that some biomass sources, such as manure, and garbage storage litter, use a fuel source that would otherwise be wasted. Therefore, these resources reduce our dependence on fossil fuels and nuclear energy, while also reducing the negative effects associated with soil fillings.

2.3. Biomass Energy and Environment

Biomass is a renewable energy source in each product cycle, wood harvest or fertilizer pile. But it is not perfect. Since it comes from a variety of sources, biomass fuel is not always consistent in quality or energy efficiency, and yet there is no network of well-developed biomass refineries and distributors as for gasoline and natural gas. In addition, it produces potentially hazardous pollutants, such as burning biomass fuels, burning fossil fuels, volatile organic compounds, particulate matter, carbon monoxide (CO) and carbon dioxide (CO_2). CO_2 is a greenhouse gas, one of the leading causes of global warming and climate change. However, the renewable nature of biomass energy can greatly reduce this environmental impact. The burning of biomass releases CO and CO_2 into the atmosphere, while biomass catches carbon from trees that are grown as energy sources and during the photosynthesis. This process is often called "carbon separation" or "carbon banking".

2.4. Biofuels

Derived from biomass biofuels in many world countries today It is used. This kind of alternative energy biofuels production easy, known and technologically established is prominent because it is. Storage of biofuels and transport to other renewable energy sources is much easier and simpler. Biofuels use directly today's oil it can be placed on its infrastructure. This is this the cost of infrastructure work in the field significantly reduces and biofuels compared to other alternative sources makes it attractiv. [2] More biofuels of the transportation sector, whose use is based on oil turn into biofuels and can compete can contribute to the situation. The raw materials of biofuels are mostly agricultural products and wastes. Biofuels are formed by converting these wastes into energy with certain technologies. The importance of biofuels, which are also important in environmental protection, is increasing day by day. Biomass; biodiesel, such as biomass energy such as solid, liquid and gas, especially agricultural wastes, namely vegetable residues, such as biodiesel, biogas and bioethanol as well as domestic and industrial wastes they form biofuels. In order to produce biofuels economically, it is necessary to cultivate plants from which biofuels are obtained. Therefore, plants with the highest yield are preferred for biofuel production. Biomass plants are also energy plants. As energy plants; sugar and starch based products, oilseeds, forest products, cellulose products are known. [3]

2.4.1. Biodiesel

Biodiesel, a renewable energy source equivalent to fossil fuels, is derived from vegetable and animal oils and such oil waste. Biodiesel can be produced with different methods using modern technologies. The most commonly used of these methods is the transesterification method, which is carried out by reacting fatty acids with catalysts such as ethanol and methanol. The biodiesel obtained by this method can be added to diesel fuels at certain and low rates and can be used in motor vehicles without any modification. Some changes in vehicles are required for higher rates of biodiesel use. [4]

2.4.2. Bioethanol

The most common of biofuels are bioethanol and biodiesel. Bioethanol is a high octane number of biofuels originated from starch and obtained from agricultural products. Bioethanol is obtained as a result of the fermentation process applied after the conversion of starch present in agricultural products to sugar. It can be mixed directly with gasoline. Ethanol engines are used in countries with very large agricultural areas. In the USA, E80 fuel, which is a mixture of 80% ethanol and 20% gasoline, has been used as fuel in automobiles for many years. In Brazil, where sugar cane is abundant, automobiles have been working with ethanol for more than 25 years. [5] One of the most important features of bioethanol is the gas emission that causes very low amounts of greenhouse effect. CO_2 produced during bioethanol production and use is reused by the plant through photosynthesis and the net CO_2 emission is neutral or very low. Reducing greenhouse gas emissions, integrating into the infrastructure in the transportation sector and having versatile usage shows that bioethanol production is the best alternative to oil. [6] In today's world, where sustainable agriculture studies have gained great importance, efforts to develop sustainable energy resources are developing rapidly. [7] Today, an agriculture type called energy agriculture has emerged. In recent years, studies on renewable energy plants (sweet sorghum, elephant grass, branched millet, sugar cane) cultivation have been intensified in the world, and many countries are rapidly progressing in this regard. Energy crops can generally be bought from the unit area with a high amount of fertilizer and water in arid and not very good soil conditions. In this respect, energy crops are very important.

2.4.3. Biogas

Biogas (biomethane); It is a mixture of gaseous and combustible gas that emerges as a result of fermentation of organic substances and contains methane, carbon dioxide, water vapor, hydrogen sulfide, ammonia, nitrogen and hydrogen. [8] Organic materials used in biogas production; The feces of animals such as cattle, sheep and chickens consist of animal product processing plant waste, agricultural and vegetal waste and residues, and urban and industrial waste (garbage, sewage sludge, industrial waste). Therefore, agricultural and animal wastes are at the top of organic materials used to obtain biogas. Animal feces, which are used as fertilizer with traditional methods in the fields, especially in rural areas, are the most preferred organic raw materials for biogas production due to the very low thermal value. In developed countries, small and medium-sized farms obtain biogas by subjecting animal feces to anaerobic degradation and this gas is used to provide the energy (cooking, heating, electricity, etc.) that the farm needs. The biogas obtained in larger enterprises can be converted into electrical energy and sold abroad as well as used in farms. [9]

Biogas is regarded as an environmentally friendly and economical fuel due to the availability of by-products produced during and after the production process. For example, animal feces burned for the purpose of heating with traditional methods leave ash residue as a result of the burning process and these ashes harm the environment. However, while producing biogas that can be used in many areas where natural gas is used from these feces, which are used as inputs in biogas plants, organic fertilizer and solid fertilizer can be used as a by-product to increase soil yield. Due to the fact that it is subjected to anaerobic fermentation, in this liquid fertilizer, pathogenic microorganisms disappear and provide 10% more yield to the soil than the untreated raw form of the fertilizer. This organic fertilizer can be applied directly to the soil in liquid form or it can be used by bringing it into granular form [10].

2.5. Bioenergy Plants

Biomass consists of living plant species around us. As it grows, plants store solar energy in their leaves, stems, shells, fruits, seeds, and roots. Bioenergy plants are so diverse that they grow almost anywhere in the world. It is understood that the types of energy crops mean annual and perennial species that can be grown to produce solid, liquid or gas energy raw materials. Organic residues and wastes from the widest variety of crop production types that are also used to produce energy do not fall within this term, but still represent great potential. All plant types that store mainly carbohydrates or fats are suitable for producing liquid energy sources. Cellulose, starch, sugar and inulin can be used to produce ethanol. Vegetable oils can be used as fuel. Parts of plants containing lignocellulose can provide energy directly as solid fuel or indirectly after conversion. Getting alcohol from vegetable raw materials has a long tradition in agriculture. From an

agricultural point of view, the species available for ethanol production include starch plant species and cereals containing corn and cereal sorghum, as well as potatoes, pears and sugar crops (sugar beet, root chicory, sweet sorghum and sugar cane). Most of them are given below. Targeted use of biomass containing cellulose from agricultural products to produce alcohol has not been implemented at a large-scale engineering level, but the potential for the future is enormous. Oil crops are well distributed across the world from north to south, but only a few have a high oil yield per unit area (tons per hectare) and this is a disadvantage compared to other fuel stocks such as ethanol or solid biofuels. The main products that produce oil are rapeseed, sunflower and soybeans. A few oil crops and potentials are given below. Many need further improvement in breeding and agricultural practices to increase yield [11].

Table 1: Productivity of ethanol crops

Plant	Yield (T/ha)	Sugar/starch (%FS)	Content efficiency (t/ha)	Ethanol Efficiency
Barley (*Hordeum vulgare*)	5 .8	58.0	3.36	2150
Cassava (*Manihot esculenta*)	9.0	35.0	3.15	2900
Fodder beet (*Beta vulgaris* var. *rapacea*)	98.5	8.2	8.08	4923
Corn (*Zea mays*)	6.9	65.0	4.49	2874
Potato (*Solanum tuberosum*)	32.4	17.8	5.77	3693
Root chicory (*Cichorium intybus*)	35.0	16.0	5.60	3248
Sugar beet (*Beta vulgaris var. altissima*)	57.4	16.0	9.18	5600
Sugar cane (*Saccharum officinarum*)	80.0	10.0	8.00	5400
Sweet potato (*Ipomoea batatas*)	12.0	25.0	3.00	2400
Sweet sorghum (*Sorghum bicolor*)	90.0	10.0	9.00	5400
Jerusalem artichoke (*Helianthus tuberosus*)	30.0	15.0	4.50	2610
Wheat (*Triticum aestivum*)	7.2	62.0	4.46	2854

The number of plant species that can be used as solid biofuels is much higher than those that can be used for ethanol and oil production. The level of production of these crops is greatly influenced by the presence of water and other external inputs, as well as genetic potential, but the current water competition between food crops and energy crops is increasing from north to south. Depending on harvest time and methods and methods and the current economy, energy plant species may include roots, tubers, stems, branches, leaves, fruits and seeds, and even whole plants. [12]

2.5.1. Major Energy Plants

Sweet Sorghum [Sorghum bicolor (L.) Moench]: Sweet sorghum [*Sorghum bicolor* (L.) Moench] is a one-year energy plant from the Graminea family, originating in North and East Africa, with C4 photosynthesis. In addition to its high photosynthesis efficiency, sweet sorghum is a one-year C4 plant with a high potential to be used in second generation biofuel production with its ability to grow in areas not suitable for agriculture, drought resistance and high biomass yield. It also has a very effective root system. Thanks to this root system, it is drought-resistant and its water requirement is low. C4 plants are important in reducing greenhouse gas emissions and improving the soil with their high photosynthesis capabilities. A growth period of 90-140 days is required to mature. It has a high growth rate and also a very effective root system. Thanks to this root system, it is drought-resistant and its water requirement is low. It has good adaptation ability, high biomass yield (50-90 t / ha wet biomass) [13] . It can be fully adapted to different soil types and can be grown in sandy, clayey, salty alkaline soils [14] The first studies on genetic breeding started in the USA since the 1850s. Crossbreeding studies took place in the early twentieth century [15] It has been determined by agricultural and industrial studies in European Union countries, America, Brazil, China, India, Ethiopia, where the sweet sorghum can be used very successfully in bioethanol production thanks to its high stalk yield and high sugar content in its stalk (5-15%). Under hot and dry conditions, sweet sorghum is a good raw material for bioethanol production, it is more resistant to salinity and drought compared to corn and sugar cane used for ethanol production in the world, its stems with high carbohydrate content are similar to sugar cane but the demand for fertilizer and water is more for the production of biofuels in hot and dry countries. It is reported that it can be recommended [16].

Sugarcane (*Saccharum officinarum* L.*):* Sugarcane, a member of the Geneae family, is perennial and is physiologically included in the C4 group of plants. The sugar obtained by squeezing the sugar cane stems grown in hot climates has a high rate of sugar (20-25%) and this sugar can also be crystallized. 70% of world sugar production is provided from sugar cane. Sugar cane reproduced with seeds or steel varies between 3-30 tons depending on ecological factors such as green grass yield, temperature and precipitation (irrigation) and fertilization and harvest time. A tropical climate with a minimum annual rainfall of 600 mm is required to grow sugar cane. Sugar cane is one of the most important photosynthesisers in the plant kingdom and has the ability to convert up to 2% of solar energy into biomass. Sugar cane is propagated by pruning rather than produced by seed. Each pruned piece should contain at least one bud, and these pruned pieces should be planted manually. Once planted, cane sugar can be harvested many times. After each harvest, the reed gives new stems. Generally, fewer crops are obtained at the end of each successful harvest, and the product, which eventually decreases, signals the re-planting. Depending on agricultural practices, it may be possible to make 2 or 10 harvests for each planting (sowing). The average product obtained is 100 tons of cane or 10 tons of sugar per hectare. Sugar cane is harvested by hand or machine. More than half of the world's sugar cane production is done by manual harvesting. This situation is more common in developing countries. When harvesting is done manually, the field is burned first. The flame spreads rapidly, burns the leaves, but stems and stems rich in water are not damaged. Harvesters then prune reeds on the soil with a knife. A skilled harvester can prune 500 kg of cane sugar in 1 hour.

Switchgrass (*Panicum virgatum* L.): Switchgrass, which is a member of the Gramineae family, is a group of C4 plants perennial, herbaceous and physiologically. The branched millet, which takes its gene center from North America, spreads in a wide area from the southern parts of Canada to the steppe pastures in the inner parts of Mexico. Because it is used both as a forage source and has a high bioenergy capacity, branched millet was chosen as a model species among 37 plants by the American Bioenergy Program. From the second year, 1 ton per decare and from the third year more than 1.5 tons of dry grass can be obtained from the branched variegates planted with 70 cm row spacing and 50 cm row spacing. Switchgrass and sorghum types in Turkey with the production of biofuels to be integrated into agricultural areas, such as animal feed and soil conservation, allow for multipurpose use [17] [18] determined in their study in Canada that different soil types and seed origin were effective on the root biomass of branched maize. In the study of interest, the root biomass was approximately 36 tons / ha in clay loam soil and 15 tons / ha in loamy sand soil. The highest root biomass was determined in Cave-in-Rock and Alamo origins (18.1 and 17.6 ton / ha), while the lowest root biomass was in Kanlow (14.7 ton / ha).

Elephantgrass (*Miscanthus giganteus*): Miscanthus x giganteus, a member of the Buckwheat (Gramineae) family, is known in our country as the "Fleet" or "Elephant Grass". *Miscanthus giganteus* is a perennial energy crop with a C 4 photosynthesis mechanism which has potential as important source biomass energy for Turkey. Symbolizes forage and renewable energy plants [19] [20] also started to be used as solid and liquid fuel source. Its origin is the tropical regions in the south of central Japan. Physiologically, C4 (hot climate) and a perennial plant, its fleet can be produced very easily in a vegetative way, although it is not sterile can become. In Mediterranean climatic conditions, more than 2.5ton / da dry biomass yield can be obtained from the plant. Also; Its annual yields and energy balance were determined for the central Anatolia region for 3 years. The highest yield was obtained with 100 kg N ha fertilizer application, 7825.69 MJ t energy consumption [21] The propagation techniques of its fleet provide ease in terms of manufacturability with its tuber-shaped rhizomes, siblings or thick aboveground stems [22] Considering the seeds and other expenses spent for the production of annual plants such as corn or sorghum, it is economically important that the fleet can be easily reproduced and perennial with different production techniques. Nitrogen fertilization is among the most important factors affecting biomass yield and quality in the production of energy crops. It plays a vital role in production by taking an important place in plant production, such as nitrogen, protein and chlorophyll synthesis, which are needed more than other plant nutrients [23]

Giant Grass (*Pennisetum hybridum*): Plant of tropical African origin, usually about 3-4m from its giant grass, a member of the family of gramineae. Its height can reach up to 7 m in tropical conditions [24]**.** The fact that its policy is multi-year, in other words, low production cost and high biomass yield reveals that it is a good biofuel raw material. Low fertilizer requirement, easy growing and easy conversion to biofuels such as pellets symbolize other positive features of the plant. The fact that the giant herb is perennial, in other words, the production cost is low and it can generate high biomass yield reveals that it is a good biofuel raw material [25]. Leaf blade is hairy or glabrous, 30-120 cm in length and 1-5 cm in width. Leaf scabbard is glabrous or densely pilous and spreads with short rhizomes. The stems on the outer edge of the ball formed by the plant, which has a very dense tillering properties, lie on the earth and

the nodium on the stem is rooted and behaves like a stolon. The giant king grass, which is fertile, can form an ear of grain that is 10-30 cm height, 1.5-3 cm width, thin and yellowish brown colored ear of grain. The dense root system can go up to 4.5 m deep. For the production of the giant king grass, 2-3 internodes, little root or rootless stems are needed. 50-100 cm row spacing and 30-100cm on the rows are planted. 15-30 kg / da azide is needed per year. The crude protein content of the plant changes according to the development period. 6 weeks after the onset of sprouting, the crude protein ratio is around 10%. After 10 weeks this value go down 7.6%. Crude Protein in its leaves is 9.5-19.7%, digestion rate is 68-74%. Annual dry matter yield is generally 1-3 t / da and it is stated that it can increase to 8.5 t/da. Thanks to the deep root system in the plant, the drought-resistant plant should be watered for yield (> 1000 mm), but is sensitive to long-term water ponds. However, the growth starts again with the soil temperature rising above 0 degrees and humidity. *Pennisetum hybridum* is a fast-growing poaceae plant that grows over 4 meters. It can mow 4 times in tropical and some subtropic regions and produce 35 ton / decare wet biomass yield. Cattle and small cattle eat loving it. This plant can also be used by pelletizing in poultry feed and fish feed production. It also reported that bioethanol yields from P.hybridum, Miscanthus and maize (grain + stem) plants were 3325 l / da, 1425 l / da and 760 l / da respectively. It is also used for biogas production. It reaches 4 meters 195 days after its planting. In these dimensions, it is generally used in biofuel production. In a 12-month period, 375 tons of Giant King Grass (*Pennisetum hybridum*) is obtained with 70% moisture content per hectare. Its dry mass is as high as 100 tons per hectare *Pennisetum hybridum* contains 7900 BTU per kg, 4400 kcal energy. Therefore, it is a plant frequently preferred in biogas production. 43% is glucan, 22% is xylan and 3% is arabinan. The lignin rate is 17%. It is one of the preferred lignocellulosic raw materials in ethanol production due to its low cost, possibility of harvesting more than one year and high ethanol yield.

Sunn Hemp (*Crotalaria juncea L.*) : *Crotalaria juncea* L. is known as Sunn hemp, Indian hemp or Madras hemp. It is a tropical Asian plant of the legume family. It is generally thought to be of Indian origin.

Crotalaria juncea L. is a tall, upright-stemming and one-year herbaceous legume plant that grows widely in tropical areas, can grow 2.5-4 meters tall. Leaves that are longitudinal and lanceolate are simple and spirally arranged along the stem, 0.5-3.0 cm wide, 4-12 cm long and bright green color. The plant has strong pile root and very well developed lateral roots. The stem diameter can be 2 cm thick. It takes about 8 weeks from planting until flowering when it is fastened under short day conditions. The flower is 8-20 cm long and in the form of a cluster; dish leaf 1.5 cm long and pubescent; the crown is 2-5 cm long and bright yellow. Fruit, cylindrical pods, short velvety pubescent, contains 6-12 seeds; seeds can be curved heart-shaped, 6-7 mm in length and dark brown-black. The grain weight of the seeds is around 35-50 grams [26] [27] [28] [29] [30] [31].

Nowadays, in tropical and subtropics regions forage crops, green manure, cover plants, fiber, biodiesel etc. It is widely cultivated for the purpose of. When the plant is 80% flowering, it consists of about 35-40% biomass leaves. (700 kg / da dry matter in 2 months period) Clean biodiesel can be produced from biomass based agricultural oils. *Crotalaria juncea* L.; Biodiesel can also be produced using methanol and different catalysts with bio oil obtained from the seed [32].

Conclusion

The two main problems that human beings face today are difficult to overcome, the need for energy is gradually increasing and CO_2. Global climate change due to excessive accumulation of greenhouse gases in the atmosphere. By using biomass-based energy sources such as bioethanol, these two problems can be resolved and thus sustainable development can be achieved. Despite its high domestic source of renewable energy sources, Turkey is dependent on foreign supplies to meet the energy needs have socio-economic and environmental disadvantages in context. Energy plants are an important potential to meet future energy needs in the world. In this context, cultivation of alternative energy crops in areas not suitable for agriculture offers different alternatives. High efficiency, as well as for aquaculture and soil improvement properties of low energy inputs and fertilizer needs to be integrated farming of alternative energy crops, biofuels production in Turkey will have an important role in terms of raw material recovery. Biomass energy represents 70% of the electricity produced from biomass from Europe and North America and about 10% of the global energy supply. This is because large and sustainable forests can continuously support the supply of wood pellets.

And recently, biomass energy is accepted in Asia and Africa, where decentralized biomass plants supply electricity to communities that are not connected to a national power grid.

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