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Soil Management in Sustainable Agriculture

Koç Mehmet Tuğrul

Abstract

People need food to live, and this is largely due to natural resources. However, time is also required to meet these limited resources and increased consumption demands, and for a renewal cycle. This cycle can be traditional, industrial and commercial, as well as be sustainable. So, what is sustainable agriculture? Sustainable agriculture is the way to increase productivity in agriculture and to increase the level of economic prosperity by protecting all living things on earth, living spaces and natural resources. It is clear that the continuity of all the living things is possible with the food provided by natural resources. At this point, sustainable production, consumption and preservation of the natural balance are of great importance. Today, the world population is rapidly increasing and resources are consumed at the same rate; creating awareness about sustainable food, transferring this consciousness to future generations in a more permanent way, increasing the number of conscious producers and consumers, strengthening awareness for sustainable foods, respecting the natural balance, and gaining a sense of responsibility, saving consumption habits should be our main target.

Keywords: sustainable agriculture, new approaches, natural balance, soil management, cultivation

1. Introduction

Today, the greatest success in agriculture will be to achieve the desired increase in production by reducing the negative environmental conditions. This can only be achieved by implementing sustainable methods and sustainable solutions in agriculture. The fact that the agricultural activities and practices are compatible with the environment and being permanent is great importance in terms of contributing to the sustainability of the ecology. There are many definitions and explanations about sustainable agriculture [1]. Sustainable Agriculture includes all of the systems and practices that will improve the protection of the environment and natural agricultural resources necessary to ensure the production of adequate and high quality foodstuffs at affordable costs which the rapidly growing world population needs. To be fully self-sufficient for sustainable agriculture is not a requirement. Long-term stability and efficiency is required. For this purpose, the minimum and most economical and fastest way of implementation of each application in agriculture is one of the priorities that should be focused on the protection of agricultural areas and natural resources.

If an awareness of sustainable practices is to be created, it is necessary to rethink in detail what the concept of agriculture means first. The questions such as: What is agriculture and how should a production be made to meet increasing agricultural demands? Is agriculture only an activity on the field, or is it possible to produce

more qualified by applying new production techniques? What methods should be applied to obtain sufficient product without damaging nature? are required to find answers firstly [2].

All of the work done on soil in order to grow the necessary and useful plants and animals for the survival of the people and to obtain the products is called agriculture. In order to meet the growing agricultural needs in a healthy manner, water resources should be protected and soil should be developed and original seeds should be stored and reproduced for the future. At the same time, an increase in soil fertility, protection of water, protection of valuable seeds and biodiversity need to be taken into account.

In general, many methods are applied under the definitions of traditional, organic, industrial, ecological, smart and integrated, and each method differs from the others [3]. Sustainable agriculture mainly focuses on increasing the productivity of the soil and reducing the harmful effects of agricultural practices on climate, soil, water, environment and human health. Reduces the use of non-renewable sources and inputs from petroleum-based products and uses renewable resources to generate production. In general, it focuses on the needs, knowledge, skills and socio-cultural values of the local people.

2. Principles of sustainable agriculture

Some general principles of sustainable agriculture can be listed as follows:

- Soil must be protected and developed: Soil is absolutely necessary for good and healthy products. Soil should be enriched with natural fertilizers such as organic and green manure and compost. Natural fertilizers are healthier for soil, plants, water, air and people than chemical fertilizers.
- Water and water resources should be protected: As in life, it needs absolute water in agriculture. In arid regions, the best way to protect water is to grow plants that are suitable for the ecology of the region or that only need water during the rainy season. Green manure and mulch are useful in keeping water in soil. The contour barriers protect the water by preventing the water flow. Another method for preserving water is to apply drip irrigation instead of traditional irrigation methods and to make irrigation time planning.
- To control pests and diseases naturally: Instead of chemical control, natural or integrated protection management should be applied to balance nature, products, pests, diseases, weeds and soil. In this regard, techniques such as choosing durable varieties, keeping proper distance between plants in planting, determining the timing of agricultural practices correctly, using natural predators and crop rotation are important for the success of the method.
- Cultivate different agricultural products: This is called product rotation. According to the characteristics of the products, for 3–6 years rotation or cultivating multiple crops are the methods of preventing diseases and pests. Thus, nutrients are kept in the soil and diversity in agriculture is ensured and healthy food is provided.
- Start with small changes first: Most agricultural techniques have been developed over a long period of time. However, new methods may not always be successful. New ideas should first be tried in small areas, and should be applied when it becomes clear and successful.

3. Why sustainable agriculture is important?

The world population is growing at a great pace. There are countries with a population expressed in billions of Asian countries, and in Europe and the Americas it is estimated that the population will soon find billions. This will certainly create a serious need for food in the future. One of the main objectives of industrial agriculture is to ensure that everyone has access to basic needs in the present and future years.

Industrial agriculture, on the one hand, uses more chemical input to meet the increasing demand, on the other hand, agricultural and soil resources are polluted by chemical residues and production potential is reduced. In fact, this is a contradiction. At this point, the sustainable farming method protects both the soil and the environment and ensures the production and the long-term agricultural production. In summary, the benefits of sustainable agriculture are as follows:

- With sustainable agriculture method, it is possible to produce more than one product in small areas and high efficiency.
- An enterprise with sustainability will have a positive impact on the ecosystem. Efficient soils will have a habitat for animals, but will also contribute to agricultural production.
- The fertilization of the soil will ensure long-term use and increase of productivity.
- In addition to the benefits to agriculture, contributes to the creation of new areas of employment.

4. Sustainable agriculture practices

As a result of long years of practices and scientific studies, several common sustainable agricultural practices have been put forward in **Figure 1**.

4.1 Precision chemical application

It can be defined as a set of methods that include mechanical and biological controls to reduce the use of pesticides and control pest populations [5]. In this method, Variable Rate Application Technologies (VRA) is applied and unlike traditional agriculture, instead of homogeneous input, it is the application of measurement of productivity differences in the field and appropriate input according to the spatial needs resulting from these differences.

4.2 Conservation reserve program (CRP)

CRP is a land conservation program administered by the Farm Service Agency (FSA). In return for a contract with farmers involved in the program, it is an incentive for farmers to make agricultural production that is sensitive to the environment and improves the environmental health and quality [6]. Contracts for land enrolled in CRP are 10–15 years in length. The long-term aim of the program is to restore valuable land cover to help improve water quality, prevent soil erosion and reduce loss of wildlife areas.

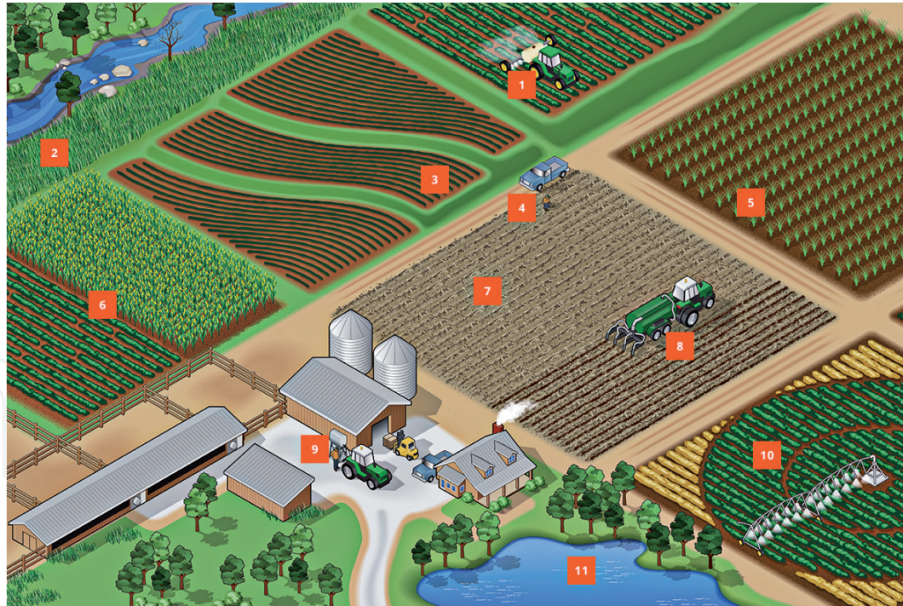


Figure 1.
Common sustainable agricultural practices [4].

4.3 Terraces

In particular, in order to make agriculture in high slope areas, it is the name given to the arrangement of the land in the form of steps and supported by walls. Thus agricultural applications are possible in these areas.

4.4 Scouting

Scouting is the most fundamental act of traveling in crop fields and make observations. The farmer is required to identify how different areas of development change in his land. If there are problems during the growing season, these problems affect the yield at the time of harvest, so the farmer tries to reduce them. If the problems are not noticed or resolved during the growing season, they may limit the yield, thus reducing the revenue generated. Traditional methods include walking in the field and observing plants manually, while methods such as global positioning systems (GPS) and drones (UAVs) help to make a more accurate decision by making fast and reliable measurements with the help of special equipment and precision sensors.

4.5 Cover crops

Cover plants (alfalfa, vetch, etc.) can be cultivated during off-season periods when the soil is bare and can be grown between the main plant rows. These products prevent soil erosion, renew soil nutrients, keep weeds under control, and protect soil health by reducing the need for herbicides [5].

4.6 Crop rotation/diversity

It is the process of producing various products in the field one after the other from year to year respectively. Thus, different parts of the soil are utilized with different products, and pests and diseases that are specific to each product are prevented from spreading.

4.7 No-till/conservation tillage

Intensive or traditional agriculture causes physical and chemical degradation of soil, loss of organic matter, reduced biological activity in the soil and consequently a decrease in crop production. On the contrary, the method of sustainable agriculture envisages a sustainable and profitable farming system based on three basic rules, including soil-free agriculture, continuous soil surface covered with plant or plant debris, and crop rotation [7, 8].

4.8 Precision nutrient management

Fertilization, which constitutes 10–15% of the costs of agricultural inputs, is critical for increasing product productivity by up to 50%. The application time and method are of great importance in the fertilization process which is applied to soil in order to meet the basic nutrients (nitrogen, phosphorus, potassium etc.) which are not enough in agricultural soils. Data's such as climate and weather conditions, soil characteristics and product types are important in determining the appropriate fertilization time.

4.9 Reducing fuel use

Mechanization tools that reduce labor requirements in agriculture generally use fossil fuels. Nowadays, the use of fossil fuel energies directly or indirectly in agriculture has not been economically profitable for producers. In developing countries, large amounts of fossil fuels are used in agricultural production, in particular fertilizer production and machinery use. It is not possible to carry out modern agricultural production processes without using fuel. However, the use of combined agricultural tools and machinery in one pass and the use of renewable energy sources instead of fossil fuels will reduce both the cost of fuel in agriculture and reduce the carbon emissions and make the agriculture sensitive to the environment.

4.10 Irrigation

Effective irrigation is possible by determining the optimum water amount using different parameters such as soil humidity, effective precipitation rate and evapotranspiration and by determining the correct irrigation time with climate, weather forecasts and real-time weather data. In this way, effective and economical irrigation will be provided by protecting the limited water resources and the environmental and agricultural negative effects of leaching, salinity and fungal diseases caused by excess water will be prevented.

4.11 Water storage ponds

Agricultural ponds are important water sources for irrigated areas. These structures collect water from small sources and allow for efficient storage and use of large flow rates when needed and help to regulate water flow.

5. Sustainable soil management

Sustainable land management includes many components. The multiplicity of components and the different prescriptions are due to the delicate but complex structure of the method and its applications. According to the FESLM: An

International Framework for Evaluating Sustainable Land Management definitions by FAO, sustainable land management combines socio-economic principles with environmentally sensitive technologies, policies and activities [9]. In order for sustainable land management to be feasible, five objectives have been identified as Efficiency, Security, Protection, Vitality and Acceptability, and the implementation and findings of the SLM regulation have been identified as the main pillars to be tested and monitored. Each target has its own characteristics and can be explained as follows:

- **Efficiency:** The return obtained from SLM is more than just evaluating with financial gains, it is evaluated to include the benefits that will be obtained from the protective, health and esthetic purposes of land use.
- **Security:** The management models that support the balance between land use and the existing environmental conditions reduce the production risks, whereas only those approaches that emphasize commercial anxiety increase this risk.
- **Protection:** Soil and water resources should be taken under strict protection for future generations. Locally, there may be additional protection priorities, such as the protection of genetic diversity or the need to protect specific plant or animal species.
- **Vitality:** If the applied land uses do not match the local conditions, the use cannot survive.
- **Acceptability:** If the social effects of land use methods are negative, it is inevitable to fail over time. The part directly affected by social and economic impact is not always clear.

Considering this framework, it should be produced safely in the field, established a production model that will protect the natural resources, the model should be economically feasible and socially acceptable. However, it should also be accepted that the system cannot be sustainable with the practices where the agricultural structure is not properly managed and the land is constantly destroyed. This method requires, in principle, to protect and improve soil fertility, to prevent and correct soil degradation and to prevent environmental damage.

5.1 Maintaining and improving soil productivity

5.1.1 Managing soil nutrients

In agriculture, healthy nutrition of the plants and increasing the use of fertilizers depends on the application of nutrients at the time of need, with sufficient and correct methods. Correct plant nutrition management is in interaction with many factors. For example, increasing fertilizer usage efficiency depends on reducing the losses of plant nutrients from soil due to leaching, denitrification, evaporation, surface flow. In fertilizer applications not suitable for the technique, the nitrogen is leaching from the soil or away from the gaseous state and the nutrients such as phosphorus and potassium are transformed into non-volatile forms. As a matter of fact, while 50% of the nitrogen applied to the soil is lost in various ways, 90% of the phosphorus cannot be taken by plants [10, 11]. Studies have shown that fertilizer nitrogen use efficiency is very low for wheat, paddy and corn, and nitrogen

utilization rate is between 29 and 42% [12]. High nitrogen losses lead to significant environmental problems such as groundwater pollution, lake and river water eutrophication.

On the other hand, soil quality, soil organic matter and nutrient availability also show significant differences between methods such as minimum soil tillage, conventional tillage, conservational tillage and no-till agricultural systems. Totally used soil quality indicators in minimum data sets include total organic carbon, volume weight, aggregate resistance, usable moisture content, pH and EC [13]. Soil water retention capacity, soil water movement in soil, soil compaction and soil temperature also show significant changes depending on the agricultural system. Therefore, soil management has a special place in terms of fertilizer usage efficiency. In this respect, soil management includes more factors such as chemical fertilizers and the use of organic fertilizers (applied fertilizer type, dose, fertilizer application time, method) and irrigation. Fertilizer application methods are extremely important in terms of fertilizer economy. With the method to be applied, the efficiency of the fertilizers is increased and the larger areas can be fertilized with less fertilizer. In the case of slow and controlled conversion of fertilizers into a useful form, the loss of nutrients, especially nitrogen, is prevented and the plant will be used for a longer period of time and increased usage efficiency.

Soil analysis and soil sampling technique are very important in terms of fertilizer usage efficiency. In fact, it is a known fact that the physical and chemical properties of soils are highly variable in agricultural areas. Regionally, even on field level, soil properties show significant differences depending on distance. In fertilization without considering this feature of the land, some parts of the land will be applied more than the need and in some places less fertilizer will be applied. In this case, fertilizer will be deposited or washed in the soil in areas where fertilizer is given, and in areas where less fertilizer is needed, the yield will be low. Increased fertilizer use efficiency and the decrease in nutrient loss are proportional to each other [14]. Therefore, precision farming practices are one of the most important components of sustainable soil fertility and plant nutrition management.

The aim of this course is to evaluate the soil conditions, product characteristics and the variable productivity related to agricultural conditions within the boundaries of agricultural land in variable rate fertilization technologies in precision farming and to determine the time and amount of fertilization. Variable Rate Fertilization Maps used in this direction indicate the variable applications to different geographical coordinates based on the analysis of these conditions. This technology is also effective in deciding the nature of the fertilizer to be used. Different areas within the field can be evaluated separately and variable nutritional needs can be calculated. With the use of advanced technologies, the topographic structure of the field (different slope levels and depressions), the soil color which varies according to the organic matter content and the temporal yield variability in the field are taken into consideration. With the inclusion of land sampling data, all information is classified and analyzed in different databases; accordingly, the need for qualitative and quantitative fertilizers of the field subfields is determined.

5.1.2 Managing soil physical conditions

The soils under natural vegetation normally support the population of organisms and soil animals in an active biological activity. They live in plant roots and trash, digging and loosening the soil and use it as a nest. The vegetation is normally compressed by exposure to the effects of rain and soil processing and the effects of humans, animals and machinery. A certain proportion of compaction makes it suitable for the growth of plant roots in the soil and increases the ability of plants

to retain the water they need to survive. Exposing the soil to compressing and then drying may cause the surfaces to crust. This reduces the water penetration rate and may cause water to flow from the surface and soil erosion.

Larger land resources were needed to supply food to the growing population, and soils were put under intensive use for overproduction. On the other hand, as a result of the pressure of increasing population, the deterioration in the fertile soil resources and the result of the structuralization show the effects of the loss of the area. As a result of the increase in the need for land resources, many countries around the world need to map their land in detail and use the land according to their capabilities. When the sustainability of natural resources is mentioned, first of all, soil erosion and its negative effects on the environment are one of the first issues that come to mind. Under normal conditions, climate, soil, topography and vegetation are the main elements that complement each other. Soil erosion is the result of this interaction. It is clear that the risk of erosion in agricultural areas is high, and if the conservation measures required by sustainable agricultural techniques are not taken, it will be possible to reach irreversible levels. Moreover, our resources, which are already limited by accelerated soil erosion, may be under great threat in the future.

Managing the physical properties of the soil includes the protection of the soil structure necessary for agricultural production, as well as the application of agricultural techniques and processing techniques to increase the long-term efficiency of the soil. Under these conditions, environment-friendly, healthy, economic and quality production conditions will be provided. Soil cultivation is also important for weed control, and this is usually one of the most important reasons for cultivating the soil. However, the introduction of herbicides has resulted in zero or minimum soil tillage techniques that eliminate the need to soil cultivation. Zero and minimum soil tillage techniques protect the soil from the direct impact of rain and wind by leaving crop remains on the surface. Surface residues prevent soil aggregates from being dispersed, transported by water or wind, the infiltration capacity of the soil is preserved, consequently there is no flow on the soil surface and erosion problem decreases. Generally, 56% water and 28% wind erosion are effective in soil degradation types. Among these reasons, agriculture has an important place with 28% (Figure 2) [15].

Intensive and timeless machine operations cause compression on the soil surface, especially in deeper layers and deterioration of the soil structure. Soil compaction is a state of degradation of soil aggregates and reduced pores between aggregates. Reduction of pore density reduces soil aeration, water drainage and water penetration into the deep layers, causing surface flow in rainy conditions. Soil compaction also complicates germination of the seed, limits the growth of plant roots, affects the biodiversity of the soil and causes the surface soil crusting.

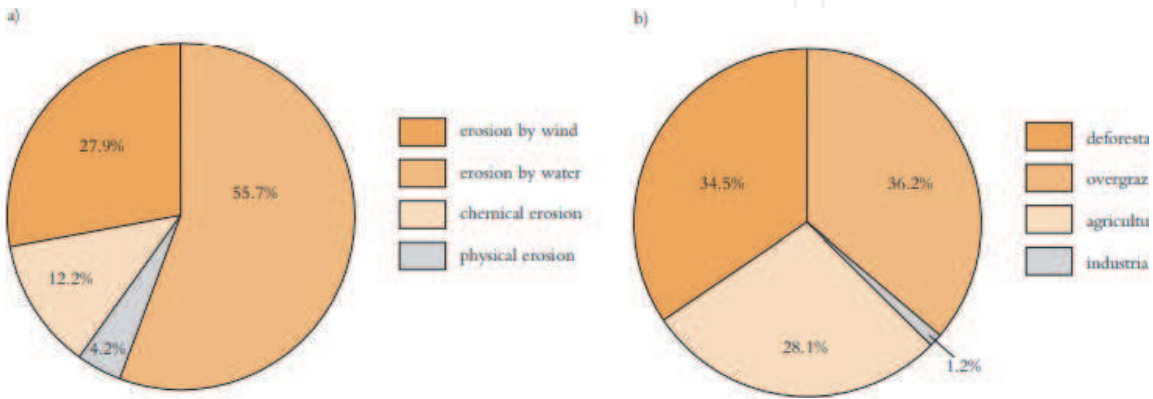


Figure 2.
Types and causes of soil degradation [15].

Some of the issues to be taken into consideration for the protection of soil physical structure can be listed as follows [15];

- Reduce the number and frequency of vehicle traffic, avoid unnecessary operations.
- Select suitable machines for the soil properties and the work to be carried out, check the tire pressure to reduce the pressure on the surface and reduce it if necessary.
- Agricultural practices that will increase soil organic matter and encourage soil structure, such as soil aeration, water leakage, heat transfer and root growth should be favored.
- In grazing systems, grazing intensity and timing should be planned well.

5.1.3 Water management

The most important means of ensuring healthy growth of the plant in sustainable agriculture is the sufficient amount of moisture in the root area of the soil during the plant's growing season. The first source of this moisture is the natural rainfall. In cases where sufficient water cannot be met by rainfall, the water needed should be given by irrigation water. Inadequate or too much soil moisture in the plant root area usually results in a decrease in yield.

The sustainability of water resources is a social, physical, economic and ecological concept. Sustainable water management encompasses the water needs of future generations, drinking and using, irrigation, industrial and recreational water conservation and ecosystem conservation services. In order to ensure sustainability, the following points should be taken into account:

- Irrigation system should be continuously controlled, pumps should be operated at optimum performance, water amount should be measured and water distribution evenness should be ensured.
- The irrigation time and amount should be planned by determining the plant water requirement and the most effective use of water should be ensured.
- Irrigation should be avoided in the middle of day and windy weather, irrigation should be done at night, and if possible drip irrigation method should be used.
- The system should be operated at optimum pressure, pipelines should be checked and leaks should be prevented.
- In any case, water, water sources and drainage channels should be avoided contamination.
- To reduce waterborne erosion; it should be ensured that the water is infiltrated to the soil with the principle of agriculture and irrigation method which is perpendicular to the direction of inclination.
- Production planning should be made considering the water quantity and the distance of water resources.

- Discharge of untreated farm wastes and wastewater into natural surface waters should be avoided. Measures should be taken to reduce the negative effects of irrigation on the ecosystem.

In addition, drone and sensor technologies can be used to collect necessary data for the development of an effective irrigation methodology. According to this:

- Determination of soil water potential with soil moisture sensors,
- Thermal images obtained from drones concerning soil and crop moisture content,
- Nitrogen deficiency can be measured by multispectral camera,
- A variable-rate irrigation program is created in line with weather data and weather forecasts.
- Variable rate applications can be done in optimum timing in fields varying in the field in terms of water requirement.

5.1.4 Pests and diseases management

Integrated Pest Management (IPM), as one of the effective methods used in modern agriculture, takes into account all plant protection methods available in the application. IPM implies the integration of appropriate measures that minimize the risks for human health and the environment by preventing the development of pest populations and by ensuring the use of plant protection products and other forms of intervention at economic and ecologically justified and reduced levels.

A well-designed integrated pest management program (IPM) includes three main steps for maximum effectiveness and minimum environmental impact in pest, weed and disease control [16]:

Find: Producers should first identify pests, diseases or weeds. Then, physical, chemical, biological and regulatory compliance options should be decided.

Watch: Reproduction rates are noted after the identification of harmful species. The determination of the effects of the protection methods and the limit threshold where the plant protection products will be used should be determined.

Select: When the density of harmful species reaches the threshold, many protection options are activated. With other protection methods, the use of pesticides that cause the least damage to the environment is the most effective protection method with harmful species. In addition, early harvesting or other physical protection methods can help minimize crop damage. When deciding on the protection method, the existence of useful species should be taken into consideration, and harmful species can be fought with the species which are the enemy of the pests without any application.

IPM for the prevention or suppression of harmful organisms as well as chemical control; crop rotation, use of appropriate breeding techniques (planting dates and densities, protected cultivation, pruning and direct sowing), use of tolerant varieties and certified seed and planting materials, use of balanced fertilization, liming and irrigation/drainage applications and prevention of spread of harmful organisms by hygiene measures (regular cleaning of machinery and equipment), which can be considered as a number of methods are important for sustainable agriculture [16]. Energy-based innovative cultural techniques: leguminous rotations, use of organic wastes as well as farm based by-products, integrated pest management

(IPM), pest and disease prediction, biological and cultural pest control, mulching and mechanical weed control, conservational tillage or no-till, mixed sowing and trap crops should be applied within the system [17].

5.1.5 Cover crop and rotation

Covered plants provide important contributions to agricultural production at the point of protection of soil, temperature, humidity or light at the desired level, pest and weed control. The reduction of soil cultivation in sustainable agriculture has brought with it the weed problem. Many plants such as clover, vetch, trefoil, oats, rye, sorghum vary widely according to usage and production purpose. For example, cereals are preferred for weed control, and legumes cultivation is preferred for providing nitrogen to the crop plant. The most important point in the cultivation of cover plants is to know the balance between the cost and the benefits of the system.

The system should both reduce the input cost and increase the product efficiency. Apart from its main purpose, cover crops have many other contributions to agriculture and production. The use of these plants allows increasing the amount of organic matter in the soil by protecting plant biomass and vegetative waste in the field. In this way, soil weathering improves, root growth of plants is encouraged and surface water flow decreases and aggregate formation increases. In addition, an increase in the population of living things such as microorganisms and worms, which contribute to the improvement of the nutritional cycle and soil structure, is achieved.

On the other hand, it is possible to reduce soil tillage, increase soil organic matter, benefit from different depths of nutrients, protect soil moisture, increase soil water holding capacity and weed control. For this reason, cover crop and crop rotation in sustainable agriculture is one of the important applications to reduce production inputs and to make economic agriculture.

6. Conclusions

The management of agricultural areas by traditional methods, the evaluation and processing of soil characteristics using traditional habits alone are not sufficient for the past, present situation and future productivity of the soil. Therefore, an evaluation of the tillage systems where soil tillage is appropriate to the management objectives and the effects on soil functions can be determined precisely. In determining the soil tillage system, the most suitable tillage system should be selected by evaluating the soil structure and quality, not only for the purpose of loosening and aerating the soil and destroying weeds. In order to compare soil management and processing systems, different indicators can be used in soil quality assessments according to soil conditions.

Today, the most important issue of researchers is the question of whether or not food can be produced enough to feed so many people in parallel with the rapidly increasing population. As a matter of fact, while focusing on this issue, it should not only be focused on the subject to feed of human, and should not be overlooked for the healthy and sustainable feeding. In particular, the non-cultivation agricultural system and protective agriculture in general are facing an ecologically and economically large potential for cultivated areas, whose productivity is decreasing day by day and becoming more open to erosion every day. On the other hand, the relationship between fertilizer, pesticide, tillage and crop rotation issues in sustainable systems and their effects on product yield and income should be well established.

According to most of the researches, agricultural production programs will begin to decrease as a result of rapid soil deterioration with the applied agricultural production programs, carbon balance will deteriorate and it will be difficult to obtain a healthy, sufficient and qualitative product in the not too distant future. Therefore, it is now necessary to increase the agricultural production in a way to protect nature and it is inevitable that sustainable agricultural techniques will be applied to reduce soil erosion, salinization, pollution of water resources and other damages. When planning production growth in agriculture, we are faced with the need and the necessity to develop new methods that guarantee natural resources instead of intensive input techniques, which cause irreversible microorganism losses in agricultural areas.

By applying the yield mapping system in agricultural production, it is necessary to determine the changes in the product characteristics in the land and thus the effective and economic planning of the amount of agricultural inputs to be used. In this direction, precision farming and variable rate applications are the most suitable methods to achieve maximum output by using the optimum and limited input. In contrast to traditional agricultural activities, this practice does not apply the amount of input to be applied to the field equal to each point, and applies variable rate according to the input maps created in line with the yield map. This application determines the need of appropriate input considering the specific conditions and the requirements of the land and weather conditions. Data maps are generated with the help of geospatial data, geographic information system (GIS) technologies and software which are acquired by various sensors on the harvesting machines. Drone and satellite technologies facilitate the creation of visuals that provide important information about land, soil and product structure. In this context, high resolution terrain and plant structure visuals, high resolution relief, slope and product maps can be obtained and thus it is possible to create drainage maps, to evaluate the effect of the slope factor in land efficiency and to obtain various data and base map that can be used in farm management.

Nowadays, with the introduction of Industry 4.0 technology, it is possible to reduce the costs of using natural resources at the required level by ensuring the communication of objects in agriculture. Similarly, all the factors necessary for production with smart systems in the farm are analyzed and presented to the manufacturer simultaneously. With the machines that are in contact with each other and working synchronously, a quick decision can be taken, resource wastage is prevented and quality products are produced. With systems equipped with digital sensors, it is aimed to maximize productivity by providing detailed and real-time information such as the type and amount of fertilizer to be given to the regions, weather conditions, plant mineral need, irrigation time, soil condition, estimated harvest time. Workload and cost are reduced with machines that work together and work synchronously. The producer is given the opportunity to manage and observe the whole farm from a tablet or telephone and by reducing the labor force, efficient, fun, high quality and natural production facilities are created.

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