Sustainable soil utilization and agriculture production: recommendations towards achieving sustainability

ABSTRACT

The modern-day agricultural practices have an effect on the surroundings namely nutrient cycle, soil erosion, carbon sequestration, and many different ecological styles. Organic farming is influential exercise to minimize the environmental and ecological effect of sustainable development. Utilization of extra organic subjects in agricultural practices can lessen the adverse effects on the environment by maintaining its herbal cycles on restoration procedure and organic farming can also improve the food quality. The organic farming may additionally largely exclude the use of chemical fertilizers, insecticides, increase hormones and feed additives of farm animal activities. A mixture of organic farming and new technology is of maximum significance to lessen the restrictions and demanding situations of natural farming. The innovative methods and new tactics making new tendencies closer to sustainability farming system and enhances the rural productiveness, and upliftment of life of many farmers in an environmentally pleasant manner. Soil not most effective offer food and nutritional assist but also plays many environment capabilities and offerings. Soil is taken into consideration as a non-renewable resource, however it takes centuries to shape one millimetre of soil. One of the most popular clauses in agriculture is the term "Soil health". The health of soil determines agricultural sustainability. 'Soil health' has been threatened by numerous challenges which include soil fertility depletion/degradation, lack of soil natural carbon/biodiversity, salinization, acidification, contamination, soil erosion & degradation. Consistent with FAO "Soil management is sustainable if the assisting, provisioning, regulating, and cultural offerings supplied with the aid of soil are maintained or improved without drastically impairing both the soil capabilities that permit the ones services or biodiversity".

Keywords: Sustainability, Organic farming, Soil health, Soil, Agriculture and Production, etc.

Introduction

Land productivity ability or land quality is a comprehension, on the identical time a specific concept in phrases of agricultural activities (Dengiz and Saglam, 2012). Agricultural intensification and huge infrastructure development in the recent years without thinking about the range of entire manufacturing system enhance the danger of soil erosion and fertility depletion (Singh et al., 2007). Soil is a component of the lithosphere and biosphere system. It is a considerable natural useful resource on which the existence assisting structures and socio-financial improvement relies upon. Organic matter is one of the most crucial elements of soil, appropriate quantity of organic carbon / matter in soil improves soil fertility. The core constraints in terms of land use consist of depletion of organic carbon, soil micronutrients and macronutrients, elimination of top soil by using erosion, modification of physical properties and increased soil salinity (Kumar et al., 2017).

The term “soil health” originates inside the observation that soil quality impacts the fitness of animals and humans through the quality of crops (Warkentin, 1995). “Soil fitness, additionally called as soil quality, is defined as the continuing capacity of soil to characteristic as a critical living surroundings that sustains flora, animals and humans.” Certainly, the definition of Mader et al. (2002) that a fertile soil “offers important nutrients for crop plant growth, supports a numerous and energetic biotic community, exhibits a standard soil structure, and lets in for an undisturbed decomposition” went beyond the provision of yields. Consistent with this, the renovation of “natural soil fertility” is at the coronary heart of organic farming (Rusch, 1985). The concept of soil quality as introduced via Larson and Pierce (1991) and Doran and Parkin (1994) became closely criticized in a chain of papers (Letey et al., 2003; Sojka & Upchurch, 1999; Sojka et al., 2003) for being subjective and ill-defined. The selected recommendation changed into to speak of soil use rather than soil features, in order that the duty to keep the high-quality of the soil can be surely assigned to the user of the soil. Mainly, it changed into claimed to elevate recognition and decorate conversation among numerous stakeholders regarding the significance of soil assets (Karlen et al., 2001).

Characteristics of a healthy soil

- **Good soil tilth:** Soil tilth refers to the complete physical character of the soil within the context of its suitability for crop production. Soil with exact tilth is crumbly, well structured, dark with organic matter and has no massive and hard clods.
- **Sufficient depth:** Sufficient intensity refers back to the extent of the soil profile through which roots are able to develop to find water and nutrients. A soil with a shallow intensity due to a compaction layer or past erosion is extra vulnerable to harm

in extreme climate, as a consequence predisposing the crop to flooding, pathogen attack or drought pressure.

- **Good water storage and good drainage:** At some stage in a heavy rain, a healthful soil will absorb and retain more water in medium and small pores, however will even drain water more hastily from large pores. Thus, a healthful soil keeps more water for plant uptake for the duration of dry instances, however may even permit air to hastily circulate back in after rainfall, so that organisms can maintain to thrive.
- **Sufficient supply, but not excess of nutrients:** The sufficient and accessible availability of nutrients is vital for most fulfilling plant boom and for retaining balanced cycle of nutrients within the system. An extra of nutrients can result in leaching and capability ground water pollutants, high nutrient runoff and greenhouse gas losses, as well as toxicity to flora and microbial groups.
- **Small population of pathogens and pests:** Plant pathogens and pests can reason sicknesses and damage to the crop. In a wholesome soil, the populace of those organisms is low or is much less lively. This may result from direct competition from other soil organisms for nutrients or habitat, etc. In addition, healthy plant life is higher able to guard towards a ramification of pests.
- **Large population of beneficial organisms:** Soil organisms assist with cycling nutrients, decomposing organic matter, preserving soil structure, biologically suppressing plant pests, etc. A wholesome soil could have a large and diverse populace of useful organisms to perform these functions and thus help preserve a healthful soil standard.
- **Low weed pressure:** Weeds compete with plants for water and nutrients which might be critical for plant growth and development. Weeds can block sunlight, interfere with stand established order and harvest and cultivation operations, and harbour disease causing pathogens and pests.
- **Free of potentially harmful chemicals and toxins:** Wholesome soils are both without extra amounts of harmful chemical compounds and pollutants, or can detoxify or bind such chemical substances. These procedures make these harmful compounds unavailable for plant uptake, due to the soil's richness in stable organic matter and diverse microbial groups.
- **Resistance and resilience to degradation:** A wholesome, nicely aggregated soil, is resilient, complete of diverse organisms and is extra immune to degradation from

wind and rain erosion, extra rainfall, severe drought, vehicle compaction, sickness outbreak and different potentially unfavourable affects (Schindelbeck et al., 2020).

Principles for sustainable soil management

1. **Protect soil from physical, chemical and biological degradation, limit erosion and avoid deforestation.**

   Hold our cutting-edge soil quality. Prevent soil loss, erosion, toxicity and compaction and dispose of deforestation:

- Maintain soil protected.
- Keep away from the needless disturbance of soils; encourage conservation agriculture, no-till, and the proper drainage of soils.
- Choose geographically and agro-ecologically suitable cropping structures, and encourage crop rotation.
- Employ established practices that manage erosion and make investments within the improvement of latest procedures to prevent erosion.
- Restrict the likelihood of soil contamination from all assets.
- Take away deforestation and permit our forests to evidently sequester carbon, whilst investing in reforestation.
- Discourage the cultivation of bodily marginal soils.
- Establish sustainable grazing styles to save overgrazing and capacity desertification, and construct buffers to limit the expansion of deserts.
- Minimize the urbanization of agricultural land.

2. **Restore soils on degraded, stranded and marginal lands.**

   Get better the stranded, idle, economic and environmental belongings which might be degraded and marginal lands:

- Conduct survey of soil and land degradation.
- Apprehend to what degree soils have degraded, take a look at the timeline involved and prepare accurately for what it is going to take to carry the soil returned to the productivity.
- Rebuild soil shape, actively increase or maintain soil carbon and organic matter counted ranges, and rebuild nutrient content material and stability.
- Repair topsoil to ancient depths.
- Encourage complete systems control at the worldwide, countrywide and local levels.

3. **Maintain soil-based ecosystem services, water availability and quality.**

   Recognize and manage and preserve the surroundings services and habitat that soil gives and contributes to:

- Maintain soil and water in tandem.
- Use the perfect stability of fertilizers at the proper time of year, within the proper amount even as keeping off ecologically sensitive regions of the field.
- Inspire and defend beneficial microbial and biochemical interest in soil.
- Establish soil resilience as a gateway to climate resilient agriculture.
- Built buffers and riparian margins among agricultural land and water resources.
- Pick out geographically suitable and sustainable irrigation practices.
- Promote 'crop stability assessments', 'environmental impact assessments' and 'excessive conservation value assessments,' particularly when thinking about land use alternate.

4. **Enhance soil productivity according to its natural capacity.**

   Make sure worldwide food security through 'sustainable intensification', narrowing the 'yield hole' and replacing the nutrients we cast off from the soil:

- Sustainably strengthen productive agricultural systems.
- Adopt an integrated approach to soil fertility control and refill nutrients removed via the crop harvest.
- Promote the organic cycle, making use of natural and mineral fertilization as appropriate and observe the proper stability of crop nutrients – both macro and micro.
- Choose the appropriate crop selection for climate and soil kind.
- Preserve crop residue cover.
- Maintain the combination of livestock as a nutrient management tool.
- Lessen soil salinity and accurate soil pH as it should be.
- Promote the usage of pyrolitic stoves among smallholders and the usage of biochar.

5. **Develop extension services, knowledge systems, and promote innovation.**

   Rebuild our global agricultural extension device to satisfy the needs of the twenty first century:

- Promote extended funding in personal zone and public extension offerings.

- Make sure that women and younger humans are specifically targeted by way of extension services.
- Confer arms-on training for farmers and agri-sellers.
- Promote funding in innovation and the improvement of accountable and ecologically sustainable new technology along with improved farming practices, fertilizers, crop safety systems, seed varietals and species.
- Take a look at, classify and map soils. Integrate existing statistics and offer precise fertility and control guidelines with the aid of crop and soil kind.
- Built knowledge sharing systems to promote best practices, make soil information extensively reachable and develop long-time period soil monitoring structures.
- Promote suitable mechanization while fending off soil compaction.

6. Communicate the importance of soil.

For the majority, farmers, coverage makers, commercial enterprise and civil society:

- Advertise the significance of soils, economically, socially and environmentally.
- Encourage knowledge sharing and partnership between government, business, academia and civil society that units a minimum standard for soil focus, management and protection.
- Offer training and advice for policy makers in an effort to make informed selections.
- Set up an agricultural curriculum in schools and encourage young humans to explore advanced schooling and a profession in agriculture.
- Take the strain off soil to provide so much meals via teaching the value chain from purchaser to farmer on a way to lessen meals waste (United nation international Compact, February, 2016).

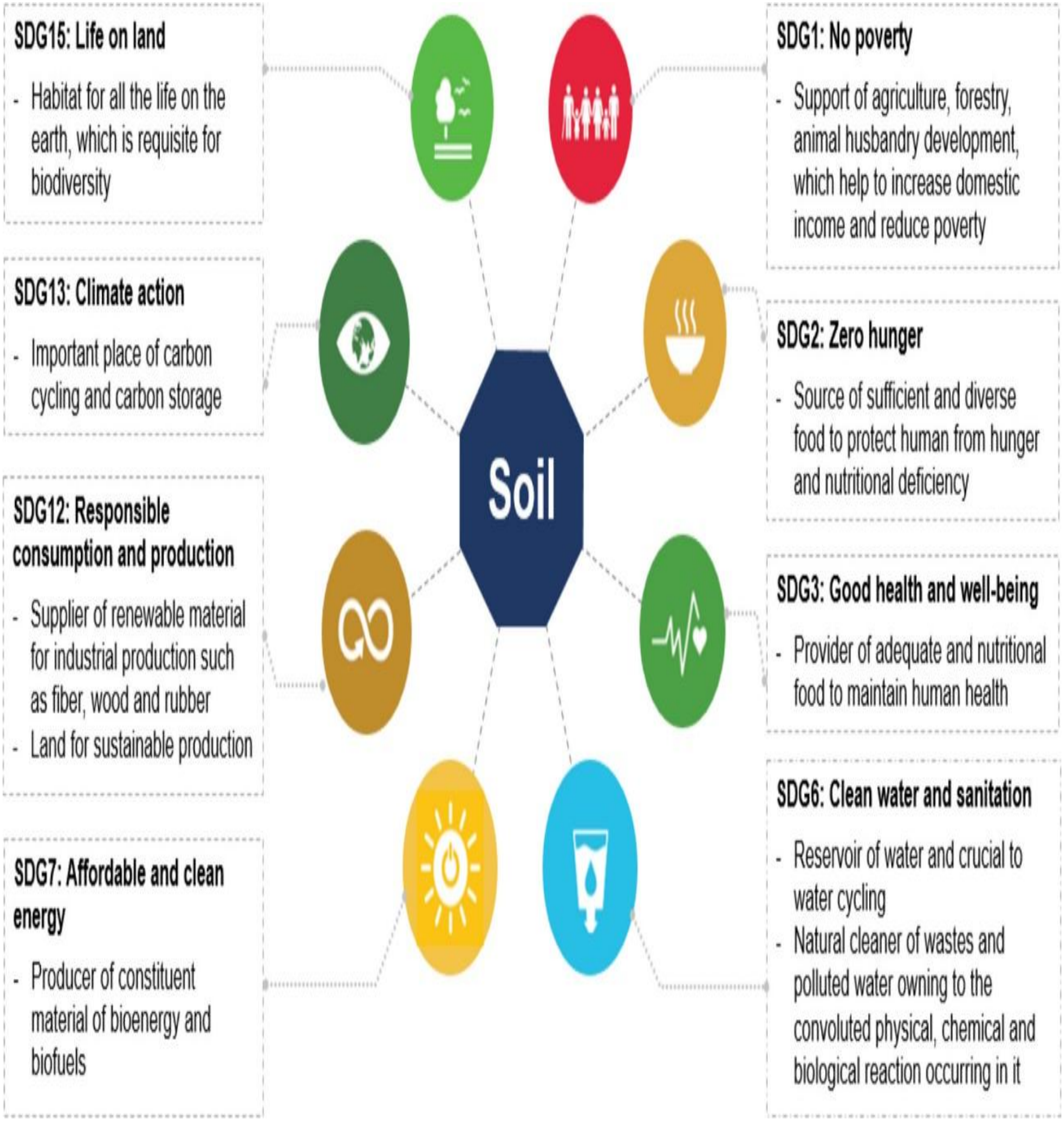

Figure: Sustainable development goals of United Nation.

Why sustainable agriculture is important?

The world population is developing at a top notch tempo. There are nations with a population expressed in billions of Asian international locations, and in Europe and the Americas it is expected that the population will soon locate billions. This can truly create a critical want for food in the future. One of the major objectives of commercial agriculture is to make sure that everyone has access to fundamental wishes in the present and destiny years.

Commercial agriculture, on the only hand, makes use of more chemical input to fulfil the growing call for, however, agricultural and soil sources are polluted through chemical residues and production capacity is reduced. In truth, this is a contradiction. At this point, the sustainable farming technique protects both the soil and the environment and guarantees the production and the lengthy-term agricultural production. In precise, the advantages of sustainable agriculture are as follows:

- With sustainable agriculture approach, it is miles possible to produce multiple products in small areas and excessive performance.
- An employer with sustainability will have a nice effect on the ecosystem. Efficient soils can have a habitat for animals, however will also contribute to agricultural production.
- The fertilization of the soil will make certain lengthy-term use and growth of productivity.
- Similarly to the benefits to agriculture, contributes to the advent of latest regions of employment (Tuğrul, 2019).

Discussion of measures

1. Structural landscape elements/ biodiversity refuges

Structural elements in agricultural fields consist of hedgerows, live fences, shelterbelts, ponds, nonproductive trees, flower strips, buffer strips, perennial wooden systems, or stone or terrace partitions. Structural factors have been additionally often linked to the prevention of wind and water erosion, in addition to stopping organic matter decline. To a lesser volume, advantageous outcomes of structural factors on water purification and retention and carbon sequestration had been cited.

Studies confirms that structural elements shape essential soil biodiversity reservoirs (Barthel et al. 2013) and are crucial for habitat connectivity and for the renovation of species which can be incompatible with agriculture (Grass et al. 2019; Savić et al. 2021). Linear elements such as hedgerows, or flower strips can reduce soil erosion (Marshall and Moonen 2002), contribute to soil sediment and nutrient interception (Garratt et al. 2017), and for that reason benefit water quality (Tamburini et al. 2020). They can also drastically increase organic matter content and carbon content in adjacent fields (Van Vooren et al. 2017; Wojewoda and Russel 2003). Structural landscape factors are important for the intrinsic and practical variety of agricultural landscapes (Van Den Berge et al. 2018; Grass et al. 2019) and consequently make contributions directly and in a roundabout way to soil multifunctionality.

While crop yield has been discovered to be more constant and extra resilient to severe activities on fields with structural factors (Redhead et al. 2020), the overall yield is substantially reduced in close proximity to hedgerows and only barely increased at farther distances (Raatz et al. 2019; Van Vooren et al. 2017).

For that reason, improved investment schemes for structural factors may additionally improve the adoption of this measure. It is able to easily be incorporated into present farming schemes, requiring handiest mild adjustments to management, together with respecting protective distances to structural elements whilst applying insecticides and fertilizers. Improved expertise transfer approximately the long term beneficial outcomes of diversely dependent landscapes for yield balance and resilience might also foster a greater advantageous mindset of farmers toward structural factors.

2. Organic fertilizer

This degree refers to an extended use of organic fertilizer or the addition of organic amendments. This includes the incorporation of straw and other crop residues, green manure, farmyard manure, solid dung, compost, sewage sludge, fermentation residues, horn manure and horn silica, or biochar. Even as a few stakeholders endorsed the usage of mineral fertilizer as an additional choice, others advocated completely averting mineral fertilizers. Organic fertilizers have been taken into consideration to make a contribution to the development and protection of soil fitness, allowing appropriate crop performance.

Using organic fertilizer/ adding numerous organic amendments to the soil has useful outcomes on soils, which include stepped forward biological functions, extended organic carbon, progressed soil aggregate balance, more balanced release of N fertilizers, reduced nitrate leaching, pest and pathogen suppression, and advanced crop yields; in particular when often implemented over lengthy durations (Bailey and Lazarovits 2003; Crystal-Ornelas et al.

2021; Diacono and Montemurro 2011; Vida et al. 2020). Additionally, farmers also frequently lack expertise of and experience with biobased fertilizers, e.g., regarding the timing of N availability to meet crop demands (Tur-car-dona et al. 2018; Sanchez et al. 2004). Tur-Cardona et al. (2018) found that farmers are much more likely to pick out organic fertilizers whilst they are surely cheaper than mineral fertilizers. With the drastic increase of the energy prices due to the fact early 2022, organic fertilizers may additionally grow to be extra appealing to farmers. But, stable sorts of fertilizers and fertilizers that make certain a quick launch of nutrients are commonly preferred by using farmers. whilst unprocessed manure is usually price-loose for them, processed organic fertilizers (e.g., digestates) are available a greater handy shape (e.g., pellets, much less odorous) and without uncertainties regarding their nutrient content.

The expected beneficial effect on soil quality and related co-advantages may feature as a driver for implementations of this measure. The choice to increase organic fertilizer use can also inspire specialised crop farms to interchange to a blended system that consists livestock, ensuing in a entire redecorate of the farming system (Wezel et al. 2014). Greater research is wanted, e.g., on the linkage among organic input and pests, diseases, and weeds (Hijbeek et al. 2019), to lessen farmer uncertainty regarding the effects of organic amendments.

3. Diversified crop rotation

Precise recommendations had been to alternate leafy and cereal plants, wintry weather and summer season vegetation, and humus-reducing and humus-improving crops; integrate catch crops, legumes, and deep-rooting vegetation; now not grow corn directly after corn; and combine rotational fallow land, rotational grazing, or planted set-aside regions for soil regeneration. A couple of advantages have been associated with various crop rotations, which include accelerated biodiversity in agricultural landscapes and a discount in pest pressure. This would reduce pesticide use and the related risks of soil contamination and cause extra resilient crops. Moreover, this degree turned into regularly linked to erosion control. Sooner or later, various rotations also come with diverse root systems. This turned into taken into consideration to improve soil structure, boom fertility, reduce the chance of compaction and make a contribution to carbon sequestration and soil organic matter rely upkeep.

Many studies verify the positive results of various crop rotations on soil biodiversity, microbial activity, soil structure, and aggregation, and consequently, on long-time period fertility, habitat excellent, erosion risk mitigation, and water retention (Ayalew et al. 2021;

D'Acunto et al. 2018; Kay 1990; Kollas et al. 2015; Munkholm et al. 2013; Tiemann et al. 2015). However, effects depend on the unique management. As an instance, increases in carbon sequestration rely upon crop choices, site-specific factors, and management (FAO and ITPS 2021; Scheffler and Wiegmann 2019). For beneficial results on soil microbial communities and decreased pesticide use, rotations of 5 or greater vegetation, such as exclusive plants and cultivation types which includes winter and summer cereals, roots and tubers, legumes, or set-aside, were recommended (Andert et al. 2016; Tiemann et al. 2015).

Ordinary, implementing more different crop rotations would require widespread systemic adjustments for most farms in Germany. To inspire the implementation of this degree by means of German farmers, Andert et al. (2016) propose supplying more specific information on the benefits of crop diversity, as well as a better layout of financial and political incentives, rather than the usage of command and control measures.

4. Permanent soil cover

This can be executed through catch crops, under sown crops, mulching (e.g., with crop residues), and optimization of the crop rotation (minimizing the time among harvest and sowing of the succeeding crop). Extra particular recommendations for catch crops have been using seed mixtures and optimized seeding time to limit the chance of crop failure because of pests, diseases, or weather extremes (e.g., dry intervals). Furthermore, keeping off row crops (e.g., substituting corn with alfalfa or clover grass in biogas production) or appearing mulch sowing for row crops, as well as perennial crops or dense sowing (e.g., deciding on greater dense cereals over wintry weather wheat), was recommended. Viable financial disadvantages were noted for some of these control alternatives, however additionally the opportunity of reduced herbicide demand due to the weed suppressing function of soil cover. Continuous soil cover was on the whole connected to the prevention of erosion.

Soil cover is a key element in reducing the threat of wind and water erosion (Deumlich et al. 2006). Within the prevalent soil loss equation (USLE), soil cover management is represented by the C-factor, that is the simplest component that farmers can control (Auerswald et al. 2021). Cover crops are particularly favourable, on the grounds that they provide soil cover throughout winter when soils would otherwise be barren. But, they arrive with extra expenses for farmers (e.g., seeds, extra management) and their implementation may also require modifications to the hooked up crop rotations (Sattler & Nagel 2010). In this regard, farmers may lack precise know-how (Werner et al. 2017).

Furthermore, continuous vegetation cover will increase the overall water demand and reduces groundwater recharge (Lischeid and Natkhin 2011). Efficient soil cover also can be executed with the aid of under sown crops (i.e., sowing a cover crop into the primary crop after its established order), even as yields can be unaffected or even boom (Bergkvist et al. 2011; Johnson et al. 2021). Imparting soil cover through mulching with crop residues (e.g., wheat straw) is a commonplace exercise in conservation tillage systems. Relying on the quantity and quality of residues, mulching can increase soil fertility, lessen fertilizer want, boom soil organic matter and contribute to maintaining stable soil ecosystems (Kollas et al. 2015; Tiemann et al. 2015). But, mulching can also add to the persistence of residue-borne pathogens (Koivunen et al. 2018). This trouble is likely to get worse with ongoing climate change (Fareed Mohamed Wahdan et al. 2020).

However, enforcing the exclusive soil cover management alternatives also calls for systemic change. For cover crops, rotations might also need to be tailored, while for the combination of under sown crops, like minded crops need to be selected and specialized equipment, including for combined harvesting and sowing, can be required (Sattler and Nagel 2010). In which water is a restricting element, mulching may be premier to continuous vegetation cover. In this case, assorted crop rotations may be essential to keep away from increased pest pressure (Buhre et al. 2009). As an alternative, farmers may additionally consider switching to conservation tillage systems.

5. Conservation tillage

Conservation tillage practices talk over with control wherein mulch seeding, strip-till, or direct seeding replace traditional plowing to decrease mechanical disturbances of the soil. These practices had been considered to enhance the soils' wearing ability; boom carbon sequestration; lower water losses; increase biological activity; prevent erosion, compaction, and capping; and reduce NO_3^- losses. Evaluations differed on the way to control the elevated weed stress related to plowless systems.

Conservation tillage measures can boom soil wearing capacity and reduce soil compaction, although effects differ depending on soil properties and varieties of management (Mirzavand and Moradi-Talebbeigi 2021; Pöhlitz et al. 2018). Alternatively, switching from conventional tillage to conservation tillage may increase compaction, e.g., when crop rotations do now not consist of deep-rooting crops and whilst the situations for bioturbation by earthworms are destructive (Schlüter et al. 2018). For the complete soil profile, Dimassi et al. (2014) record a net decrease in the soil organic carbon stock in reduced tillage systems under wet and warm conditions. Even in which an increase in carbon stock is carried out, the climate benefits may be offset by way of higher N_2O emissions (Guenet et al. 2021; Mei et al. 2018). Conservation tillage practices have additionally been determined to lessen soil erosion (Seitz et al. 2018). Barriers to implementation usually stand up from trade-offs with weed pressure. As mechanical weed management through plowing is now not applied, conservation tillage practices typically result in accelerated herbicide use and the combination of conservation tillage and use of extensive-spectrum herbicides reduces labour requirements and operating prices (Mal et al. 2015), at the same time as results on soil biodiversity may be good or bad for different invertebrate, microbial, and fungal taxa (Chávez-Ortiz et al. 2022; Froslev et al. 2022; van Capelle et al. 2012; Zaller et al. 2014).

Conservation tillage practices require specialised machinery and doubtlessly distinctive timing of farming operations, but they can easily be applied without primary systemic modifications if broad-spectrum herbicides are used for weed control. For multiplied herbicide use to be averted, successful application of conservation tillage requires a high standard of management, which includes thorough crop choice and rotations tailor-made to local soil and climatic situations (Peigné et al. 2007), indicating widespread systemic change. Nabel et al. (2021) recommends that using huge-spectrum herbicide can be avoided in mulch seeding and that tillage might be used as a measure for pest management if all other options fail. In this case, they suggest immediately applying natural amendments to offset the carbon losses as a result of the tillage and permit for a fast fauna recuperation.

Summary

The world populace is anticipated to develop from 7.7 billion today to 9 billion by way of 2050, and, at the same time, agricultural land is being misplaced to increasing city regions and climate change. The World Bank estimates that food production will must increase by using 70% by 2050 to make up the distinction. Sustainable agriculture is a vital piece of the puzzle of a way to feed greater humans and reduce climate change. Moving food and fiber production to a sustainable system enables obtain each target. Sustainable agriculture practices are intended to defend the environment, increase Earth's herbal assets, and maintain and enhance soil fertility. For a planet bedevilled with droughts and challenges in power demand, a change from conventional commercial food systems to sustainable agriculture can be pretty promising, in the long run. At the same time, as modern agriculture produces quite a few agricultural jobs and generates large amounts of output within a harvest season, it comes with numerous devastating problems that require sustainable farming practices to remedy the mess.

Conclusion

A number of the measures cope with a couple of threat or characteristic, and most of the measures have more than one advantages. However, the measures require varying degree of systemic change in the farm system to be carried out, even greater so because the measures should preferably be implemented in mixture. Diversification is one of the key standards behind more sustainable soil management. Our findings assist the not unusual proof that a diversification of procedures and cropping systems is the finest way to maintain and restore soil health and to fulfil future demanding situations of food security and climate change.

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