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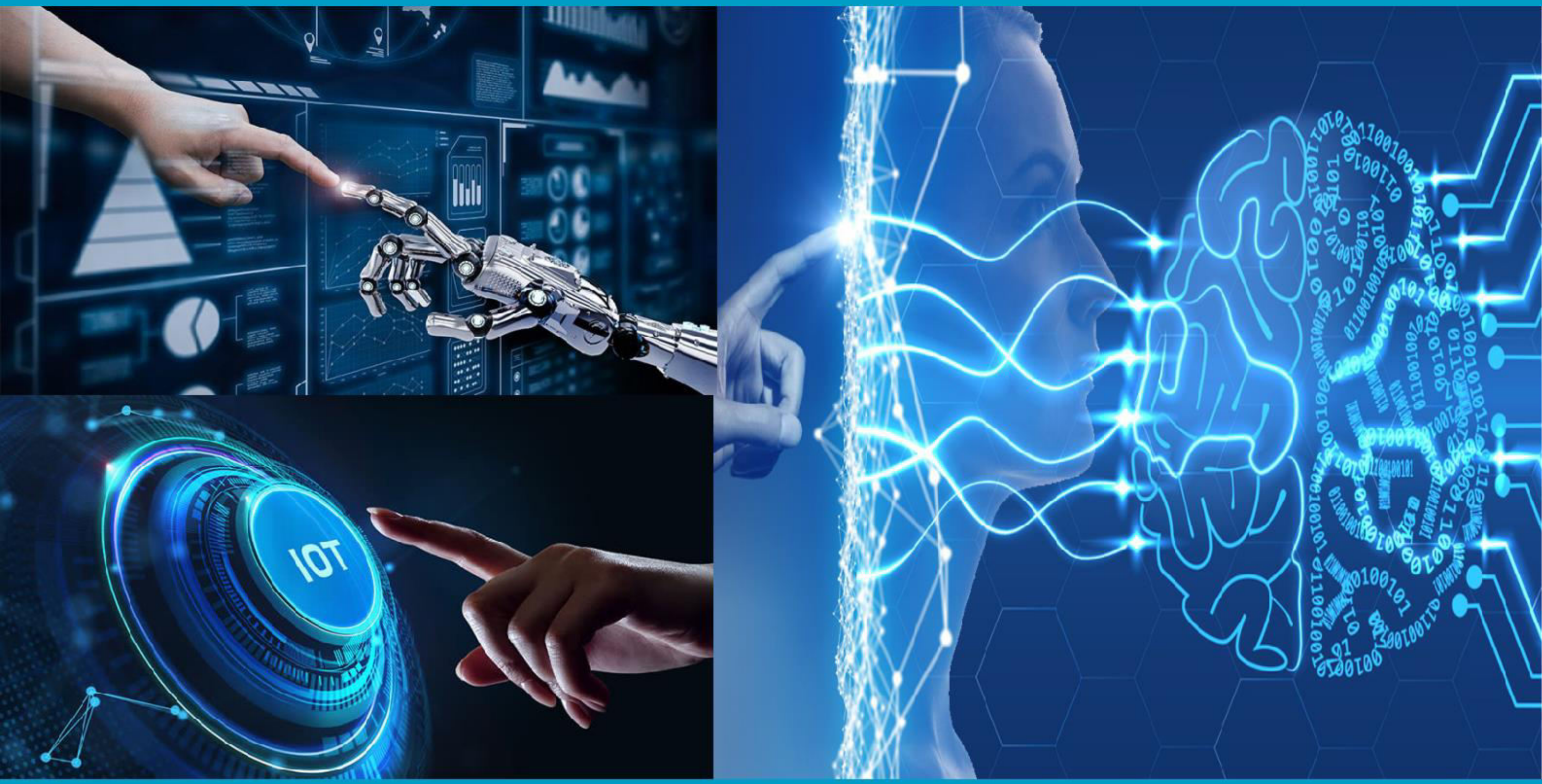

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Solarization Impact : Boosting Crop Health And Yield Through Soil Solarization

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ABSTRACT: Soil solarization is a non-chemical environmentally friendly method for controlling pests using solar power to increase the soil temperature to levels at which many soil-borne plant pathogens will be killed or greatly weakened.[1] Soil solarization is used in warm climates on a relatively small scale in gardens and organic farms. Soil solarization weakens and kills fungi, bacteria, nematodes, and insect and mite pests along with weeds in the soil by mulching the soil and covering it with a tarp, usually with a transparent polyethylene cover to trap solar energy. This energy causes physical, chemical, and biological changes in the soil community.[2] Soil solarization is dependent upon time, temperature, and soil moisture.[1] It may also be described as methods of decontaminating soil or creating suppressive soils by the use of sunlight.

KEYWORDS-soil, soilarization, crop, yield, boosting

I. INTRODUCTION

Soil solarization is a hydrothermal process of disinfecting the soil of pests, accomplished by solar power (referred to as solar heating of the soil in early publications) and is relatively a new soil disinfestation method, first described in extensive scientific detail by Katan in 1976.[3] The mode of action for soil solarization is complex and involves the use of heat as a lethal agent for soil pests from the use of transparent polyethylene tarps.[4] To increase the effectiveness of solar heating requires optimal seasonal temperatures, mulching during high temperatures and solar irradiation, and moisture soil conditions.[5] Soil temperatures are lower when decreasing in soil depth and it is necessary to continue the mulching process to control for pathogens. Soil solarization practices requires soil temperatures reach 35-60 degrees Celsius (95 to 140°F), which kills pathogens at the top 30 centimeters of soil.[6] Solarization does not sterilize the soil completely. Soil solarization enhances the soil towards promoting beneficial microorganism.[1] Soil solarization creates a beneficial microbe community by killing up to 90% of pathogens.[6] More specifically, a study reported after eight days of solarization 100% of *V. dabliae* (a fungus that causes farm crops to wilt and die) was killed at a depth of 25 centimeters.[4] Soil solarization causes a decrease in beneficial microbes, however beneficial bacteria like the *Bacillus* species are able to survive and flourish under high temperatures in solarized soils.[6] Other studies have also reported an increase in *Trichoderma harzianum* (fungicide) after solarization.[6] Soil solarization allows for the recolonization of competitive beneficial microbes by creating a favorable environment conditions.[7] The number of beneficial microbes increases over time and makes solarized soils more resistant to pathogens.[6] The success of solarization is not only due to the decrease in soil pathogens, but also to the increase in beneficial microbes such as *Bacillus*, *Pseudomonas*, and *Talaromyces flavus*.[1] Soil solarization has been shown to suppress soil pathogens and cause an increase in plant growth. Suppressed soils promote rhizobacteria and have shown to increase total dry weight in sugar beets by 3.5 times.[8] Also the study showed that plant growth promoting rhizobacteria on sugar beets treated with soil solarization increased root density by 4.7 times.[8] Soil solarization is an important agricultural practice for ecologically friendly soil pathogen suppression.[1,2]

Soil decontamination

A 2008 study used a solar cell to generate an electric field for electrokinetic (EK) remediation of cadmium-contaminated soil. The solar cell could drive the electromigration of cadmium in contaminated soil, and the removal efficiency that was achieved by the solar cell was comparable with that achieved by conventional power supply.[9]

In Korea, various remediation methods of soil slurry and groundwater contaminated with benzene at a polluted gas station site were evaluated, including a solar-driven, photocatalyzed reactor system along with various advanced oxidation processes (AOP). The most synergistic remediation method incorporated a solar light process with TiO_2 slurry and H_2O_2 system, achieving 98% benzene degradation, a substantial increase in the removal of benzene.[10]

Attempts were made to use solar energy for controlling disease agents in soil and in plant material already in the ancient civilization of India[In 1939, Groashevoy, who used the term "solar energy for sand disinfection", controlled *Thielaviopsis basicola* upon heating the sand by exposure to direct sunlight[

Soil solarization is the third approach for soil disinfestation; the two other main approaches, soil steaming and fumigation; were developed at the end of the 19th century. The idea of solarization was based on observations by extension workers and farmers in the hot Jordan Valley, who noticed the intensive heating of the polyethylene-mulched soil. The involvement of biological control mechanisms in pathogen control and the possible implications were indicated in the first publication, noticing the very long effect of the treatment. In 1977, American scientists from the University of California at Davis reported the control of *Verticillium* in a cotton field, based on studies started in 1976, thus denoting, for the first time, the possible wide applicability of this method.

The use of polyethylene for soil solarization differs in principle from its traditional agricultural use. With solarization, soil is mulched during the hottest months (rather than the coldest, as in conventional plasticulture which is aimed at protecting the crop) in order to increase the maximal temperatures in an attempt to achieve lethal heat levels.[2,3]

In the first 10 years following the influential 1976 publication, soil solarization was investigated in at least 24 countries[11] and has been now been applied in more than 50, mostly in the hot regions, although there were some important exceptions. Studies have demonstrated effectiveness of solarization with various crops, including vegetables, field crops, ornamentals and fruit trees, against many pathogens, weeds and a soil arthropod. Those pathogens and weeds which are not controlled by solarization were also detected. The biological, chemical and physical changes that take in solarized soil during and after the solarization have been investigated, as well as the interaction of solarization with other methods of control. Long-term effects including biological control and increased growth response were verified in various climatic regions and soils, demonstrating the general applicability of solarization. Computerized simulation models have been developed to guide researchers and growers whether the ambient conditions of their locality are suitable for solarization.

Studies of the improvement of solarization by integrating it with other methods or by solarizing in closed glasshouses, or studies concerning commercial application by developing mulching machines were also carried out.

The use of solarization in existing orchards (e.g. controlling *Verticillium* in pistachio plantations) is an important deviation from the standard preplanting method and was reported as early as 1979.

II. DISCUSSION

The yield gap is a hiatus between actual production and the best yield achievable using genetic material and available technologies and management. It strongly depends on the possibility of farmers to access most appropriate genetic resources (seeds, plants), natural inputs (suitable soil and water), knowledge (practices and information), and technology (pest management, mechanization) (Godfray et al., 2010). This gap is not irrelevant and, in many areas worldwide, represents one of the main factors that prevent the achievement of food security (Pinstrup-Andersen, 2009). In parts of Southeast Asia, where water for agricultural purposes is usable, it has been estimated that average production of rice is just more than half of potential production using optimized input (Cassman, 1999).

Plant protection represents one of the strategies to fill the yield gap. Control of pests and microbial pathogens, at least applying agronomic methods, is de-facto mandatory, and the role of chemicals in agriculture in the last century is crucial. Worldwide, the pesticide consumption is about two million tons per year. India, with its average pesticide usage rate of 0.5 kg per hectare, contributes 4% to the world's total pesticide consumption. More than 80% of the agrochemicals used in India are classified as insecticides, while 15% are herbicides and 2% are fungicides (Agarwal et al., 2015).[3,4] Though the pesticide consumption rates are high in the most productive areas of India and comparable to the high amounts used per hectare in the other parts of the world (Europe or United States), vast territories of poor crop production areas with nil or very low pesticide consumption pulls down the national average.

With the emphasis on food security, these territories are the focus of the Indian government for realizing the objectives of National Food Security Act. Even in the high productivity areas, higher yielding varieties and better management practices are being deployed to further improve the marginal gains in rice, wheat, maize, pulses, and other crops. India has started reaping benefits of these efforts (Ray et al., 2013). Pesticides have played a significant role in realizing these benefits. But this increased pesticide usage has led to the accumulation of pesticide residues in the aquatic and other ecosystems. Contamination of drinking water sources with these pesticide residues is becoming a significant threat in India[4,5] (Pillai and Rao, 1974; Khan et al., 1997, 2000; Gill and Garg, 2014; Agarwal et al., 2015). Moreover, beside economic costs for their application (not irrelevant for many populations, such those of developing countries), the environmental impact of agrochemicals are assuming a central role in public debate worldwide and the search of environmental friendly protection techniques is primary (Gill and Garg, 2014).

Among plant protection techniques, soil solarization (also called plasticulture) may play a significant role in the next years because it could be considered a sort of paradigm of sustainable crop protection method, particularly useful for countries such as India. The low environmental impact (mainly due to plastic film disposal, avoidable if biodegradable films are used), the wide-spectrum of actions against pathogen and the environmental requirement for effective solarization treatments seem fit perfectly with the Indian needs of plant protection. Moreover, the low costs of investment and application (mainly limited to soil mulching machine), the no-need of high-tech infrastructures or farm ability, the yield increase and perspective in climate changes could strongly support underdeveloped productive areas of India and sustain their food security.[5,6]

Soil Solarization: A Brief Compendium

First reports of soil solarization practice date back to late ‘800 in German Empire and United States, where it started being used commercially. Solarization is a chemical-free way of controlling pests such as pathogenic microorganisms (mainly fungi, bacteria, and nematodes), insects, and wild plants in the soil before crops planting (Katan, 1987; McGovern and McSorley, 1997; Gill et al., 2009). Solarization technology does not release any dangerous chemical residue in the ground; it is a safe, simple, effective, and eco-friendly tool for the home gardens and fields (Kapoor, 2013). This pre-plant method involves soil heating by capturing solar radiations for 4–6 weeks during the summer time when the soil receives the maximum sunlight. Soil intercept the energy radiated from the sun and its temperature rise to the level that is deadly to many soil-borne pathogens. It improves soil texture and the nutrients availability in the soil which are essential for plants growth and development. Unfortunately, in India,[6,7] most of the farmer and rural people are not aware of the applications of soil solarization technology. There are a need of training workshops and mass awareness programmers for popularizing this technology among the farmers and rural communities (Kapoor, 2013). The primary commercial use of solarization involved sunny and warm lands. The mechanism of action is based on the increased soil temperature (commonly in the range of 45–55°C) at soil depth of 5-cm underneath transparent polyethylene sheets causes plant pathogens mortality (Katan, 1981). Besides the reduction in soil-borne pathogens, soil solarization also leads to increased growth response (IGR) of plants (Katan, 1981; Horiuchi, 1984). Soil solarization also integrates well with other techniques such as mulching, and soil amendments to enhance its overall effectiveness against pests and, increase crop yield (D’Addabbo et al., 2010).[7,8]

Diversity of soil, climate, and social and economic values of the human population leads to the variety of the cultivated crops in India. Rice, wheat, barley, maize, cotton, groundnut, sugarcane, pulses, tobacco, pigeon pea, soybean, sorghum, cherry, strawberry, apple, and tomatoes are most commonly cultivated crops in India. However, different crops are grown in different states of India depending on the soil type, climate conditions, temperature, and rainfall, etc. More information on the main crops grown in India can be accessed at these web links[1,2]. Few commonly associated weeds in these cultivated crops include *Phalaris minor, Cyperus rotundus, Cynodon dactylon, Acrachne racemosa, Avena* spp., and *Orobanche* spp. Most common soil-borne fungal and nematode pathogens include *Sclerotinia* spp., *Rhizoctonia* spp., *Phytophthora* spp., *Macrophomina* spp., *Fusarium solani, Fusarium oxysporum, Pythium* spp., *Sclerotium* spp., *Meloidogyne incognita, Heterodera* spp., *Pratylenchus* spp., and *Rotylenchus* spp.[8,9]

Weeds Control

The literature points to the success of solarization in managing weeds even up to 98% in corn (Ahmad et al., 1996), while on the other hand 90% crop damage due to weeds alone is also reported in unsolarized control plots (Elmore et al., 1997). Worldwide, solarization has managed to control annual weeds such as annual bluegrass, *Ageratum* spp., *Amaranthus* spp., barnyard grass, cogongrass, common purslane, *Digitaria* spp., *Portulaca* spp., redroot pigweed, *Setaria* spp., and many others (Daelemans, 1989; Benlloglu et al., 2005). The weeds elimination also prevents the growth and widespread of pathogenic microorganisms or insects which may spend their lifecycle on wild plants (Stapleton and DeVay, 1986). Generally, winter wild plants are easier to eliminate, whereas summer wild plants such as *Cyperus* spp. or *Convolvulus arvensis* showed a good resistance against the disinfection treatment (Katan, 1981).

Microbial Pathogen Control

Damping-off, root rot, and wilt are economically damaging plant diseases. Soil solarization has managed to manage the causal organisms (fungus or bacteria) of these diseases. Few successfully managed soil-borne fungal and bacterial in different cropping systems include *Rhizoctonia* spp., *Fusarium* spp., *Sclerotinia* spp., *Macrophomina* spp., *Phytophthora* spp., *Verticillium* spp., *Agrobacterium tumefaciens, Clavibacter michiganensis, Pythium* spp., and *Streptomyces scabies* (Ahmad et al., 1996; McGovern and McSorley, 1997; Chellemi and Mirusso, 2006; Gelsomino et al., 2006).

Nematodes and Insect Control

Solarization can manage broad range of nematodes (roundworm or threadworm) like spiral nematode (*Helicotylenchus digonicus*), root-knot nematode, reniform nematode (*Rotylenchulus reniformis*), ring nematodes (*Mesocriconema* spp.), pin nematode (*Paratylenchus hamatus*), lesion nematode (*Pratylenchus* spp.), cyst nematode (*Heterodera glycines* Ichinohe), sting nematode (*Belonolaimus* spp.), dagger nematodes (*Xiphinema* spp.), stubby root nematode (*Paratrichodorus minor*), stem and bulb nematode (*Ditylenchus dipsaci* Kuhn.), potato cyst nematode (*Globodera rostochiensis*), northern root-knot nematode (*Meloidogyne hapla*), and sugar beet cyst nematode (*Heterodera schachtii*) (Abdel-Rahim et al., 1988; Stapleton and Heald, 1991; Elmore et al., 1997; McGovern and McSorley, 1997). Insects (mainly stored grain pests) have been controlled by soil solarization to some extent as well. Soil solarization was observed to change soil chemistry which may weaken or kill some kinds of soil organisms (McFarlane, 1989; Elmore et al., 1997; Lale and Ajayi, 2001; Minarro and Dapena, 2003; Gill and McSorley, 2010; Summers et al., 2010).[9,10]

Effects on Soil Chemistry and Microbial Ecosystem

Generally, the highest temperature (more than 50°C) can be achieved during daytime only in the upper 5 cm of soil. At lower depth (10–15 cm) soil temperature may pass 40°C in warm environment and during summer, and more than 35°C can be achieved up to 30 cm depth (Stapleton, 1997). However, the effect of energy emitted by sun on soil temperature is strongly dependent to climate and weather.

Plasticulture enhanced the availability of useful constituents (potassium, nitrogen, magnesium, and manganese) in easier to assimilate compounds that can increase pathogen tolerance, and eventually increase the yield of crops by altering chemistry of soil and its physical characteristics through increased breakdown of organic material (Ahmad et al., 1996; Elmore et al., 1997; Chellemi and Mirusso, 2006). Nitrogen transformations (nitrification and ammonification) were found to be greater in treated fields compared with non-solarized ones (Stevens et al., 1991), while integration of manure with soil solarization found to be greatly increased the C, N, and P pools. This integration could be used as key plan to defend farming lands from soil mistreatment and to enhance pest control while maintaining soil fertility (Gelsomino et al., 2006). Plasticulture helped at increasing the concentration of NO_3^- and NH_4^+ up to six times compared to non-solarized soils. It also increased the P, Ca^{+2}, Mg^{+2}, and electrical conductivity, which was linked to the greater quantity of ions released following decomposition and mineralization of organic matter (Chen and Katan, 1980) and increased yield of many crops as observed in solarized plots (Stapleton et al., 1985).

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Most of the soil microorganisms are beneficial and enzymatic activities are considered as biosensors of soil health (Aon and Colaneri, 2001; Aon et al., 2001; Poll et al., 2006; Velmourougane et al., 2013) thus impact of soil treatment on microbial ecosystem is crucial. Effectiveness of soil solarization was also related to effect of treatment on availability of chemical compounds originated from degradation of mesophilic microorganisms. This increment of nutrients can lead to an increased growth of benefic antagonists of plant pathogens that were commonly reported in treated soils (Stapleton and DeVay, 1995; Weller et al., 2002). Desirable effects are also associated with shifts in soil microflora caused by reduced pressure on soil microbiota by microorganism-grazers which are stressed by plasticulture (Gupta and Yeates, 1997). Generally, heating treatment caused significant changes in biodiversity of soil microflora (D'Addabbo et al., 2010), while studies on the fungi and bacteria communities of plasticulture-treated soils showed lower cumulative carbon metabolic activities than untreated ones (Luvisi et al., 2015). Thus, plasticulture causes shifts in microflora composition which can consume carbon substrates at lower efficiency as control. The measurement of carbon source utilization richness (which reflect different microorganism metabolism) and the Shannon's index of carbon source utilization (related to functional diversity) were also slightly affected by solarization (Luvisi et al., 2015). Furthermore, soil composition may also interfere with soil biota during solarization due to decomposition of organic material that can produce fizzy chemicals poisonous to microorganisms in soil (Gamliel et al., 2000). Contrasting reports (positive or negative shifts) in soil bacteria were reported, with *Bacillus* species as predominant surviving after soil solarization treatments (D'Addabbo et al., 2010), while reduction of soil rhizobia was generally followed by quick recover (Linke et al., 1991).

The integration of soil biofumigation with plasticulture (biosolarization) is considered a sustainable option for crop protection (Mauromicale et al., 2010; Domínguez et al., 2014), and biofumigation may also increase growth of beneficial microorganism (Camprubí et al., 2007). Further study conducted in southern Italy, documented that integration of soil solarization with organic amendments keep microbiota and soil enzymatic properties protected from deleterious heating effects (Scopa and Dumontet, 2007).[10,11]

Applications of Soil Solarization in India

An incredible amount of work is being done on solarization throughout the world with humid and hot climate. Compared to this, in India, less work is being done so far, and if it is done, it did not get in the limelight.

III. RESULTS

Biosolarization is an alternative technology to soil fumigation used in agriculture. It is closely related to biofumigation and soil solarization, or the use of solar power to control nematodes, bacteria, fungi and other pests that damage crops.[1] In solarization, the soil is mulched and covered with a tarp to trap solar radiation and heat the soil to a temperature that kills pests. Biosolarization adds the use of organic amendments or compost to the soil before it is covered with plastic, which speeds up the solarization process by decreasing the soil treatment time through increased microbial activity.[2] Research conducted in Spain on the use of biosolarization in strawberry fruit production has shown it to be a sustainable and cost effective option.[3][4] The practice of biosolarization is being used among small agricultural operations in California.[5] Biosolarization is a growing practice in response to the need for methods for organic soil solarization. The option for more widespread use of biosolarization is being studied by researchers at the Western Center for Agricultural Health and Safety at the University of California at Davis in order to validate the effectiveness of biosolarization in commercial agriculture in California, where it has the potential to greatly reduce the use of conventional fumigants. Biosolarization can also use as organic waste management practice. Recent studies showed the potential of food industrial residues as soil amendments that can improve the efficiency of biosolarization

The influence of soil temperature on plant growth is related to the fact that warmth promotes crop development through increased water and nutrient uptake, while cold inhibits water uptake due to lower water viscosity and slows down the process of photosynthesis.

Furthermore, a lack of warmth is unfavorable for earth-dwelling microorganisms since their metabolism slows down, leading to less nutrient release and less nutrient dissolution. Thereby, plant growth is stunted in colder climates. As for shoot growth, the cold ground and air are slowing it down because of inhibited cell duplication.[11]

Does soil temperature affect root growth?

It affects the speed and thoroughness of root system development, including the roots' initiation and branching, orientation, turnover, and growth direction. As the ground warms down, plant roots can easily reach those warmer areas .

Even though the warmer ground is beneficial for root development, excessive heat reduces land quality by speeding up the decomposition of organic matter and the evaporation of moisture. So it's crucial to keep the ground at an optimal level of warmth for healthy plant growth.

Impact Of Soil Temperature On Soil Properties

The ground's thermal conditions can either decrease or increase the biological, chemical, and physical characteristics of various types of soil. To effectively control thermal conditions in light of your objectives, you must have a firm grasp of these influences on the following properties.

Biological Properties

The average soil temperatures for bioactivity range from 50 to 75°F (10-24°C). These values are favorable for the normal life functions of the ground biota that ensure proper organic matter decomposition, increased nitrogen mineralization, uptake of soluble substances, and metabolism. On the contrary, conditions near freezing slow down the activities of soil-dwelling microorganisms, while macroorganisms can't survive below freezing points. Decreased microbial activities are the reason for reduced organic matter decomposition and its excessive accumulation.

Chemical Properties

Due to decomposed organic matter, high soil temperature regimes show higher cation exchange capacity. The warmer the ground, the more water-soluble phosphorus it contains for plants. Vice versa, low-heated earth is poor in phosphorus available for vegetation. As to pH levels, the acidity rises to a greater degree due to organic acid denaturation.

EOSDA Crop Monitoring

Performing fields analytics based on relevant satellite data to ensure effective decision-making![10,11]

Physical Properties

Increased soil temperatures induce the dehydration of clay and cracking of sand particles, eventually reducing their content and increasing the concentration of silt. The warmer the earth is, the more carbon dioxide it releases. Heat is the reason for land cracking due to evaporation and, thus, insufficient water penetration into the ground profile.

Ideal Soil Temperature For Planting

We already know that plants cannot grow normally at low temperatures because the intensity of the biological and chemical processes in the ground is reduced. Furthermore, these processes cease when thermal readings reach freezing points.

Considering this, it becomes vital to know the ideal soil temperature for plant growth and certain beneficial conditions for crop germination and development. The key aspects contributing to success are the analysis of historical soil temperature data for a specific region, monitoring the current thermal conditions and vegetation, and weather forecasting.

Either too low or too high thermal degrees kill soil-dwelling organisms and plants. In particular, crops develop slowly at 90°F (32°C), while 140°F (60°C) is critical because bacteria in the ground can't survive the heat. At 100°F

(38°C), plants cannot absorb enough moisture since as much as 85% is lost due to evapotranspiration. Irrigation at exceeding air heat is extremely undesirable, as most water inputs would turn into waste due to excessive evaporation rates. Besides, refracted water drops acting as magnifying glasses will burn vegetation.

In the extreme dependence of harvest prognosis on soil temperature ranges, the secret of high yields lies, to a great extent, in the successful match of cultures planted, the timing of their seeding, and further weather conditions to ensure their sufficient performance .[8,9]

Keep in mind that the optimal ground's warmth varies depending on the stage of plant growth. For instance, pre-emergent herbicides work best under 50-55°F (10-13°C). The optimum soil temperature for seed germination ranges between 68 and 86°F (20-30°C). Additionally, various plant species have different thermal requirements for planting and throughout their development.

The minimum soil temperatures for planting common crops are the following:

- *spring wheat* – 37°F (3°C);
- *soybeans* – 59°F (15°C);
- *spring canola and sugar beat* – 50°F (10°C);
- *sunflower and millet* – 60°F (16°C);
- *dry beans* are the most demanding, requiring 70°F (21°C) for their successful germination and rooting.

The optimal soil temperature for growing vegetables varies from 65 to 75°F (18-24°C). For example:

- *tomatoes and cucumbers* – 60°F (16°C);
- *sweet corn* – 65°F (18°C);
- *watermelons, peppers, and okra* are the last ones to sow at 70°F (21°C).

How to increase soil temperature for planting?

Plastic coverage is a proven way to rapidly warm up your beds, especially after a wet spell in winter.

When deciding on the ideal planting time, it is also important not to put seeds too deep to reach enough moisturized layers since shallow seeding means quick sprouts. Also, with quick sprouts, farmers not only save time but also get strong plants vigorously competing with weeds.

How To Measure Soil Temperature

Once farmers noticed the correlation between the ground's temperature while planting and crop productivity, they started to follow certain seeding rules, such as waiting for the earth to get warm enough.

The first primitive method of measuring the ground's warmth was manual (through palpation). Subsequently, soil temperature sensors and thermometers, accurate over a wide thermal range, were developed. To ensure the ground is warm enough for your crops, take a soil temperature probe at night or in the early morning.[7,8]

What depth to measure soil temperature?

Make readings 1 to 2 inches (2.5-5 cm) deep into the ground for seeds, and at least 4 to 6 inches (10 to 15 centimeters) deep — for transplants. Degrees below 45°F (7°C) are not suitable for planting.

Remote sensing and satellite monitoring are the latest and most convenient scientific findings to define the ground's warmth. These soil temperature measurement methods are based on assessing the reflectance properties of our planet's surface, either by active or passive remote sensing.

Online platforms made a huge step forward in checking soil temperature, allowing farmland owners to keep ahead of the game at affordable costs when they have an idea of what is happening in their fields, even without getting there personally. Soil temperature data is also useful for other agribusiness stakeholders, e.g., insurance agents and traders.

EOSDA Crop Monitoring And Soil Temperature Measuring

Since most plants can't efficiently grow in the cool ground, soil temperature monitoring is a significant aspect of farming. Its assessment and soil temperature forecast are possible by analyzing vegetation indices provided by online tools like EOSDA Crop Monitoring.

Because of the earth-cooling effect of vegetation cover, we can measure soil temperature using GIS data that enables inspection of vegetation in the fields. In this context, EOSDA Crop Monitoring is an efficient tool that elaborates four vegetation indices, namely NDVI, MSAVI, NDRE, and ReCl. Each index is best applied at particular stages of crop development. Reports derived can help agriculturalists in decision-making.

Crop monitoring on early stages of development with MSAVI index.

Another important correlation is the one between soil moisture and water content in plants (their leaves, buds, and stems), assessed with the NDMI index. The normalized differentiated moisture index is available at EOSDA Crop Monitoring and shows whether water content is sufficient for proper plant development. As suitable water saturation is possible under certain thermal conditions (at low degrees, it decreases), the vegetation's water content allows the ground's warmth/temperature to be judged.

NDMI index map on EOSDA Crop Monitoring.

If irrigation or moisture is abundant, but plants suffer from stress due to water deficiency, it means that the earth's warmth degree is still critically low. A decrease in soil temperature causes a decrease in water uptake. However, optimal warmth for root and shoot growth is different and varies not only in different plants but at different growth stages. This is the case when different vegetation indices are useful.[6,7]

IV. CONCLUSION

Knowing the expected levels of solar radiation, cloud cover, and precipitation is also crucial because weather conditions impact the ground's warmth. EOSDA Crop Monitoring provides up to 14-day forecasts as well as historical weather, allowing farmers to schedule their field activities and prepare optimal growth conditions for crops.

This way, online software can provide valuable information for the most accurate planning and estimations. With access to soil temperature historical data and current readings, you can create a thermal regime best suited for crop growth and development.[5,6]

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