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Novel and Sustainable Approaches to Combat Climate Change in the Agriculture Sector: A Review

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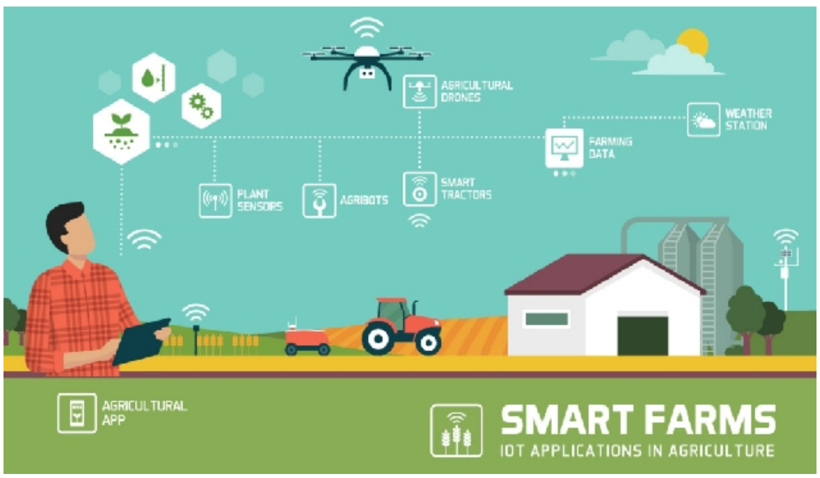
ABSTRACT: Climate change is posing a huge threat for agricultural production at local, national and global level. As a result there is a declined production in agriculture owing to various abiotic and biotic stresses. In this scenario there is a need to follow certain sustainable and innovative agricultural practices to confront several issues like declining food productivity and operational landholdings and also to ensure food security to the ever growing population by mitigating or adopting our agri-food systems to various stresses. The possible interventions *viz.* smart farming technologies, nitrogen fixing cereals, genetically modified crops, improvement in residue management, conservation agriculture, soil health improvement through cover crops, nanofertilizers for increased nutrient use efficiency, bioplastic mulches, urea briquette applicator in rice, silicon application in crops, speed breeding, laser land levelling are some of the sustainable cum innovative practices to improve the resilience in agriculture sector in the current climate change scenario.

Keywords: Climate change, resilience, productivity, technologies, agriculture.

INTRODUCTION

Climate extremes and fluctuations have become more common in recent years as a result of an un-proportional increase in greenhouse gas (GHG) emissions. GHG emissions are steadily increasing, resulting in a 2-4°C increase in Earth's average surface temperature in the 21st century (Stocker *et al*., 2014). Crop production and climate change are intrinsically related in numerous ways because climatic changes are the primary cause of abiotic and biotic pressures, which have negative consequences for farming systems in the global level as well as regional and local too. Climate change could make crop production systems unprofitable and have a significant influence on the agriculture industry in these situations. India is the world's second-largest agrarian economy, yet it needs technologies to assure sustainable food production and climate-change measures as it is confronting several issues, including declining factor productivity, natural resource degradation, and declining operational land holdings. Heat and water scarcity stress affect agricultural output in a variety of ways, depending on how the crop reacts to these environmental conditions. Higher temperatures frequently result in decreased crop productivity since they frequently occur in conjunction with drought. Climate change harms crop yields in major agricultural systems in numerous ways, including differences in the pattern of rainfall and its intensity, heat waves, overall temperature, prone to weed, insect pests and disease infestation in all the growing season. If pests are not properly controlled, crops lose a considerable amount of production (Masood *et al.*, 2022; Yang *et al.*, 2022). To ensure a good harvest, crop protection from insects, diseases, and weeds is required. Promoting innovative agriculture technologies in locations where climate change is having a significant impact is required in this scenario for good revenue and possible food security for rural societies. With a focus on people and nature-focused initiatives, this will improve the lives of rural communities. Some farmers may be familiar with the best methods and techniques for climate change resilience in agriculture through sustainable agriculture practices. Smart farming technologies (Artificial intelligence based robots, Climate smart agriculture, Unmanned aerial systems, and Internet of Things), Nitrogen fixing cereals, Genetically modified crops, Improvement in residue management, Conservation agriculture, Soil health improvement through cover crops, Nanofertilizers for increased nutrient use efficiency, Bioplastic mulches, Urea briquette applicator in rice, Silicon application in crops, Speed breeding, Laser land levelling are all examples of innovative cum sustainable agriculture practices. In a changing climate, adaptation of these technology and strategy will assure agriculture resilience and food security.

Smart Farming: The use of technology in the agricultural sector is the focus of research in the twenty-first century. Technology is used in all phases of smart farming which include preparation of soil, fertilizers and manure, seed sowing, irrigating the water, harvesting, and storage. The agriculture sector currently uses deep learning, data mining, image processing, learning by machine, the internet of things, and wireless sensor networks (Pandey *et al.,* 2022). In recent years, sophisticated equipment such as robots, satellites, GPS, drones, and other sensor-guided vehicles, as well as data-driven technologies, has seen increased use in the agricultural sector. Data analytics is supposed to provide predictive insights into future agricultural results (yield models, feed intake models, and so on), as well as drive real-time operational decisions enabling faster, more innovative action and game-changing agricultural setups. Artificial intelligence (AI) applications would enable real-time monitoring and analysis of agricultural processes, yielding crucial knowledge for fine-tuning strategies for best resource usage while reducing negative environmental impact and promoting smart farming. By 2022, the smart farming industry is predicted to be worth $23.14 billion, with Asia accounting for 40% of the worldwide market share (Statista, 2019). In the Indian government's bid to quadruple farmers' income in the next few years, smart farming technologies are expected to play a transformative role in upgrading agricultural activities (Fig. 1).



(Source: Adopted from Yehia El Amine, 2020)

Fig. 1. Smart Farm

Table 1: Smart Farming Technologies relevant to challenges identified in farming.

Challenges	Concerned Smart Farming Technologies
Resource efficiency of water, nutrients, pesticides and labour	— Sensors and networks — Big data analytic tools — Decision Support System (DSS) — Farm Management Information System (FMIS) — Intelligent water application systems — Variable rate of fertilizer/pesticide application
Management/Prevention of diseases and weeds	— Early warning sensors and networks — Specific farm machinery — FMIS — DSS for infestation management — Variable rate of application spraying system
Risk management viz. food safety, elimination of pesticide residue etc.	— Sensors like weather station, multispectral cameras, thermal cameras etc. — Traceability technology

(Source: Adopted from Balafoutis *et al.,* 2020)

Artificial Intelligence based agricultural robots: In both pesticides intensive and organic systems, robots and autonomous systems (RAS) for pest management have the potential to revolutionise the agriculture sector and revolutionise farmers' ability to scale up production (Aravind *et al.,* 2017). The greatest issue for these RAS, however, is detecting and identifying pests in the wide range of conditions seen in agricultural areas. Few other machine-learning and AI-based robots (such as Swarm Farm® and Terra Sentia®) have higher success rates and are expanding their footprint in several nations. Another sort of high-precision robotic system uses a laser as a control tool to detect weeds in field crops and burn them to death. The 150 W carbon dioxide laser-based robotic systems are suited for non-chemical weed management and organic agricultural systems. Many additional weed robotic systems based on machine learning have been developed and are likely to be marketed soon. In high-value or horticultural crops, robots have also been designed to manage disease and insects. However, once marketed, these technologies are projected to be costly. To save costs, the Indian government should support the local production of these automated systems. Manufacturers should be given subsidies so that farmers may purchase them at a reasonable price.

***Climate Smart Agriculture (CSA)*:** In many places of the world, agricultural production is low, and farmers have limited flexibility to adverse circumstances. Climate change is expected to reduce productivity even further and has increased inconsistency in production. Many countries throughout the world have decided to use the CSA strategy for agricultural improvement. The CSA is a set of technology which improves agricultural productivity and financial return while also improving climate change adaptability and reducing greenhouse gas emissions (GHG). The CSA concept is acknowledging at global levels to meet agricultural-related planning concerns in future. The CSA is a concept that combines the requirement for climate change adaptability with agricultural mitigation techniques to ensure food security (Hussain *et al.*, 2022). For example, agricultural tactics such as the utilisation of renewable energy, such as solar panels, windmills, water pumps and pyrolysis units, are critical for food production. Although the notion of CSA has three primary stakes (production, mitigation and adaptation), but there is scant literature to address them. For poor and emerging countries, adaptation and production were paramount, while mitigation was mostly done for the developed countries. Identification, appraisal, and adopting of CSA portfolios for investment are the most difficult challenges for stakeholders and policymakers to functionalize CSA. CSA's goals are to strengthen farmer resilience, improve agricultural output, attain food security, and reduce GHG emissions in a sustainable way.

Table 2: Climate Smart Agriculture (CSA) practices to overcome the threats of climate change.

Impact of climate change on agriculture	Relevant CSA practices
Higher temperature leads to reduced crop yields	— New crop genotypes with greater tolerance to heat
Less precipitation leads to reduced yields in rainfed agriculture	— New crop genotypes with less water requirements — Advanced irrigation techniques — Improved water storage techniques
Reduced irrigation water due to salt water intrusion	— Barriers to prevent salt water intrusion — New crop genotypes with greater tolerance to salinity
Reduced crop yields due to flooding/waterlogging	— New crop genotypes with greater tolerance to flooding/waterlogging — Advanced drainage techniques
Reduced crop yields due to biotic stresses	— New crop varieties with greater tolerance to biotic stresses — Advanced pest and disease management techniques

(Source: Adopted from Tiamiyu *et al.,* 2018)

***Unmanned Aerial Systems (UAS)*:** In the new age of digital agriculture, UAS have emerged as a promising tool for pest mapping and management. For a variety of purposes, UAS are being utilised to capture RGB (red, green and blue), multispectral, hyper spectral, and thermal data. To detect the crop stress conditioning and plant species, researchers nowadays used multispectral and hyper spectral imaging. Recently, UAS-based RGB photography combined with machine learning techniques has resulted in a high success rate in mapping pests in cropping systems. Apart from these, the use of UAS for pest management with spray treatments is being investigated in many nations, but it is still in its early phases. Due to a lack of comprehensive rules, UAS were formerly prohibited in India for commercial or research reasons (Singh *et al.*, 2019). The recent revisions to India's UAS/drone policy (DGCA, 2021) have opened up new possibilities for crop protection research. The use of UAS in agriculture satisfies the ICAR's goal as well as India's desire for a digital revolution. However, major research efforts in the areas of pest identification, classification, mapping, and management via UAS are required, as little work has been done to combine and automate these procedures.

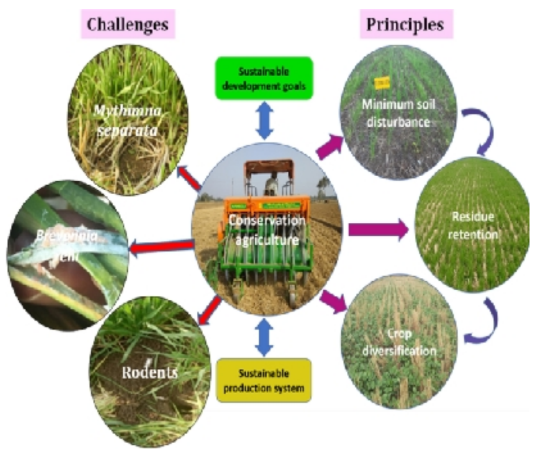
***Internet of Things*:** (IoT) is a worldwide infrastructure that unites various (physical and virtual) technologies to enable enhanced services (ITU, 2012; Sigov *et al.*, 2022). IoT has a broad range of applications, including real-time crop monitoring, data collecting, analysis, and information sharing for pest management. IoT may be utilised to improve the functionalities of existing platforms such as satellites, drones, tractors, sprayers, and planters, and data can be used for large-scale analytics to optimise crop production processes. Irrigation scheduling, yield prediction modelling, harvest management, and other applications of these technologies have been proven (Bamurigire *et al.*, 2020). These technologies can help with decision-making and provide early warnings in the event of climate change, as well as decision-making for various management methods. These technologies, however, provide some social, cultural, and technical concerns. It's also unclear how many farmers would feel comfortable sharing their field data, and whether such data can be protected from commercial use. IoT adoption may be hampered by a lack of infrastructure, technologies with IoT applications, and adoption issues. Currently, the digital tools on the market are not standardised for a given crop or place, and they are not used in conjunction with the system's strategy. Most farmers are uninformed of the digital revolution, and agri-tech businesses are commercialising goods without considering the region's socioeconomic constraints. The promise of smart farming is appealing, but a lack of knowledge and training must be addressed for it to be adopted more quickly.

Nitrogen fixing cereals: While synthetic nitrogen is required for modern agriculture, its production requires a lot of energy, and its use pollutes the environment and emits greenhouse gases. Alternative nitrogen management solutions are required for agriculture's long-term development for providing food for humans as well as feedstock for bio-based fuels and materials. Nitrogen fixation in cereal crops acts as a solution for nearly fifty years (Zhao *et al.*, 2022). Advances in eukaryotic nitrogenase expression with a good knowledge of root nodulation mechanisms have aided efforts to adapt plants for nitrogen fixation, but population growth may outpace for transgenic nitrogen-fixing cereals deployment (Shamseldin, 2022). On the other hand, a root-associated bacterium that can supply and fix nitrogen to cereals could give a better long-term nitrogen management solution. Academics from Oxford University are now collaborating with researchers from the University of Cambridge and the Massachusetts Institute of Technology (MIT) to develop cereals that can obtain nitrogen from bacteria in their roots on their own. The researchers developed a barley variety that generates rhizopine, a signal chemical that controls rhizobia bacteria genes in the roots. Rhizopine-secreting plants can truly control nitrogen fixation in their roots by microbes. Only barley plants that get the rhizopine signal fix and release nitrogen, not any other plants. This breakthrough is a significant step toward creating a synthetic version of the plant-bacteria symbiosis, in which bacteria fix nitrogen for the preferred host plant but not for non-host plants such as weeds. This method can be used by plants to start nitrogen fixation and obtain the ammonia they require. Syngenta Canada has announced that it will offer Envita in Canada for the 2023 growing season. Envita is a nitrogen-fixing bacteria for non-legume crops such as corn, canola, cereals, soybeans, and potatoes. Azotic Technologies' liquid product operates in a symbiotic relationship with the plant, similar to n-fixing bacteria in legume and pulse crops. According to the company, the bacteria begin fixing nitrogen from the air quickly after an Envita treatment, a process that takes place within the cells of the plant's leaves and roots and continues throughout the season as a supplement to nitrogen available from fertiliser applications. According to the company, in field tests done across Canada over the last two years, Envita-treated crops outperformed untreated controls roughly 80% of the time.

Genetically Modified Crops: Genetically modified crops (GMCs) are common in larger agricultural economies because they help manage pests by allowing for insect tolerance, disease resistance, or selective weed control. Due to societal, cultural, and economic concerns, India does not adopt transgenic GMCs. Non-transgenic GMCs, on the other hand, have been commercialised in India in 2021 after being successful in other areas of the world (for example, the United States, Brazil, China, Mexico, Malaysia, and Thailand) (herbicide resistant rice). The acetolactate synthase (ALS) gene in the non-transgenic genetically engineered Pusa Basmati 1979 and Pusa Basmati 1985 has been mutated and no longer possesses binding sites for ALS inhibitors (example, imazethapyr). Weeds can be selectively controlled with broad spectrum herbicides without harming the crop in this way. This approach is particularly effective with direct-seeded rice, as it saves both labour and water. However, because this technology has been thoroughly tested and implemented in many other nations, it is critical to benefit from their experiences. It is critical to follow the stewardship programme to the letter, as well as rotate using an alternative herbicide-resistant technology. However, introducing stacked trait technologies that are now in use in other regions of the world would be more advantageous and provide long-term answers to climate change. Fostering genetic improvements by genetic engineering can result in revolutionary changes in crop production, enhancing food and nutrition while also increasing agricultural output. CRISPR (Clustered regularly interspaced short palindromic repeats) is one of the most recent technologies utilised to improve crops. It's a straight forward gene editing procedure that involves locating a specific bit of DNA in a cell and changing or altering that piece of DNA. CRISPR, on the other hand, can accomplish things like changing the gene sequence without turning genes on or off. This genome editing method has been frequently utilised to improve crop quality, disease resistance, and herbicide tolerance. In Japan, the first genome-edited tomato was released for human consumption. The high quantities of an amino acid called gamma-amino butyric acid (GABA) in this tomato aid to calm the body and lower blood pressure. As a result, CRISPR technology has the potential to significantly improve crop quality, yields, and climatic tolerance.

Improved Residue Management: Farmers typically remove wheat straw for animal feed in rice-wheat cropping systems, but not rice straw because of its high silica and low lignin concentration, which makes it unsuitable for this use. The farmer is compelled to burn rice residue due to the short turnaround time between rice harvesting and wheat sowing. Farmer’s burn rice wastes produced annually between 3-4 weeks in October-November, generating nearly 150 million tonnes of carbon dioxide (CO_2) and over 9 million tonnes of carbon monoxide (CO). Although rice residue burning is prohibited in the region, the severity of fires may be seen in NASA satellite pictures provided every year (Anonymous, 2017). Rice residue burning results in nutrient loss, biodiversity loss, and air pollution, all of which are harmful to human health and safety. Increased soil health, reduced greenhouse gas emissions, canopy temperature regulation during the grain-filling stage to alleviate terminal heat effects, and improved carbon sustainability index is all advantages of using rice leftovers as mulch in wheat. In the realm of residue management, there have been few technological developments. Wheat can now be planted in heavy residues thanks to zero-till planting technology. The adoption of Turbo happy seeder technology, which is mostly used for residue control, might be hastened because of its several advantages. Another approach for dissolving rice residue faster appears to be microbial spray. The microbial spray is currently being tried in the fields, but it is still in the early stages. More research is needed to determine its influence on greenhouse gas emissions and comparative benefits to residue integration and tillage.

Conservation agriculture: High food demand may cause traditional agriculture to shift into conventional agriculture (Fig. 2). Because of the economic rewards, farmers prefer to practise conventional agriculture. The capability of land resources, on the other hand, is diminishing. Farmers began to consider how to properly manage agricultural land to ensure its economic value while avoiding environmental damage. The transition from conventional to conservation agriculture is considered as having the potential to solve several issues that cause environmental damage. Excessive reliance on chemical fertilisers makes difficult for the conservation and utilisation of organic manures (OM), which resulted in the depletion of organic carbon, microbial population retention in the soil and soil moisture. Conservation Agriculture (CA) is a set of concepts that serve as a road map for farming techniques that are both sustainable and climate-smart. Soil disturbance drives soil carbon losses through rapid decomposition and erosion, whereas no-tillage or limited agriculture frequently enhances soil carbon uptake and decreases N_2O emissions. Thanks to advancements in weed control technologies and farm automation, many crops can now be grown with minimal tillage (reduced tillage) or no-tillage (no-till). These methods are becoming increasingly popular around the world. Reusing crop wastes also improves soil carbon, but burning residues increases aerosol and GHG emissions. Reduced tillage's ability to increase the storage of more water is widely recognised. This is especially true in arid and semi-arid areas, where agricultural residue management is crucial for long-term crop productivity. Conservation agriculture saves 25%–30% irrigation water, 3% nitrogen, 50% labour, and 60% fuel expenses over regular tillage, not to mention the non-monetary benefits of timely crop sowing. The savings come from the fact that zero-tillage wheat can be planted just after rice harvest, by taking out the leftover moisture for germination and possibly avoiding pre-sowing irrigation, as well as the fact that irrigation water can easily runs faster in untilled soil than in tilled soil. When compared to CT, ZT combined with crop residue retention on the soil surface dramatically reduces erosion and improves water usage efficiency.



(Source: Adopted from Kumar *et al*. 2022)

Fig. 2. Conservation Agriculture.

Table 3: Comparison of conservation agriculture versus conventional agriculture.

Component	Conservation Agriculture	Conventional Agriculture
Tillage	Direct planting without tillage	Tillage is practiced to improve soil structure and weed control
Crop residue	The field is completely covered by crop residue or by cover crops	Farmers remove all the residues from the field

(Source: Adopted from Thiombiano and Meshack, 2009)

Soil health improvement through cover crops: Cover crops are a type of agricultural management that can raise soil carbon (C) stores and reduce CO_2 levels in the atmosphere. Cover crops improve the amount of time that roots are actively growing and protect the soil from the effects of rainfall. In comparison to bare soil, cover crops improve the amount and quality of soil organic matter. Due to the increased availability of water and oxygen, root exudates, nutrients, increasing of soil organic matter under a different cropping system encourage soil microbial activity and variety, which improves health of the soil more than conservation tillage alone (Kumar *et al.*, 2022). Cover cropping and conservation tillage when used together, can improve organic carbon, soil aggregation and biological soil health indices even more than when used alone.

Eco-friendly pest control strategy: An organic pest control is important nowadays as it gives meagre toxic to beneficial insects, environment and human. Plant volatile oils (PVO) are studied as it can act as repellent, oviposition deterrent and anti-feedant to stored insect pests by contact toxicity and fumigant toxicity (Sushmita *et al.,* 2019).

Nanofertilizers for increased nutrient use efficiency: Nanotechnology has been studied for the past two decades to improve fertilizer use efficiency and target nutrient delivery to plants. Nano scale (1–100 nm) fertilisers have a larger surface area to volume size ratio, as well as surface functionalization and delayed or plant response-based release. Zinc oxide nano fertilizer, for example, was employed to mobilize natural phosphorus ion soil as well as fertilize the zinc. Similarly, urea coated with hydroxyl apatite was tested on rice to reduce the usage of bulk nitrogen alternative fertilisers and apatite nanoparticles as phosphorus fertilisers. Nano-fertilizers (NFs) boost crop yields of high-quality fruits and grains while improving soil quality and plant growth. Macro-micronutrient management is a problematic issue globally since it relies significantly on synthetic chemical fertilisers, which are both environmentally unfriendly and expensive for farmers. By regulating fertiliser availability in the rhizosphere, NFs can improve nutrient intake and plant yield, increase stress tolerance by boosting nutritional capacity, and raise plant defence mechanisms. They could potentially be used to replace synthetic fertilisers in sustainable agriculture because they stimulate plant growth more effectively. They've been related to lowering environmental stress and increasing tolerance to adverse environmental eco-variables. Recent NF developments have emphasised the importance of appropriate agri-technology in filling in the gaps and ensuring long-term beneficial agricultural policy to safeguard global food security. As a result, nanoparticles are swiftly gaining traction as a cutting-edge agricultural tool. They do, however, make crop plants more resistant to stress.

Table 4: Advantages and disadvantages of Nanofertilizers.

Advantages	Disadvantages
Control delivery of nutrients	Showing high reactivity
Reduce loss rate of fertilizers	Environmental impact
Highly nutrient efficient crops	No cost for human health and sustainable environment

(Source: Naidu *et al.*, 2022)

Bioplastic mulch films: Bioplastic mulch films are tilled into the soil after the seasonally growing and acts as a possibly sustainable alternative to polyethylene plastic mulch. Mulch's primary purpose is to control soil moisture and weeds. More advantages may include nutrient leaching reduction, soil heating or cooling and disease management. Mulch is widely used because it helps to increase agricultural yield and profitability. Due to environmental concerns, soil health protection, and the simplicity of management of residue after the growing season, the demand for biodegradable plastic for mulching applications has skyrocketed recently. More studies are done on biodegradable plastic mulch in the last ten years which reflects the increase in demand. Because of its ease of installation, it benefits is equivalent to polyethene (PE) mulch film, in situ biodegradation, and helps to promote soil fertility and has emerged as a promising alternative material for mulching (Fig. 3).

(Source: Adopted from Barrett, 2020)

Fig. 3. Bioplast Mulch.

Urea briquette applicator in rice: In general, N fertilizer in cooperation deeper in the soil and adding it in concentrated bands instead of broadcasting uniformly is considered a good agricultural practice because it can reduce aerobic microbial processes and NH_3 (e.g., nitrification of NH_4^+ to NO_3^-), improving root zone to nutrient N and increase nitrogen use efficiency in all crop. Deep nitrogen fertiliser placement is important in regulating NO, CH_4 and N_2O fluxes (Eldridge *et al.,* 2022). For example, laboratory and field research on the influence of nitrogen deep implantation on CH_4 emissions, N_2O and NO emissions, notably N_2O from upland crop systems, report mixed (stimulatory, inhibitory, or no difference) results. The different interplay of soil N availability and site-specific variables could explain the diverse outcomes. Deep placement of N fertiliser (mostly urea) for rice growing has recently gained favour in Asian countries due to large yield gains. Briquette urea (BU) deep insertion is environmentally friendly and promotes improved nitrogen utilisation efficiency. Deep placement of fertilizer as briquettes, which is effective in reducing nutrient losses (NPK), surface runoff of N and P, and emissions of nitrous oxide and nitric oxide to the environment while also increasing rice yield, is currently available as a precision fertilizer application method for rice.

Silicon application in crops: The principal restrictions in agricultural crop production around the world are abiotic and biotic stressors. Silicon (Si) can also boost plant development and relieve these pressures, and it is not harmful to plants and does not pollute the environment even when used in large amounts. Although silicon (Si) is not a necessary element for plants, it plays an important role in a variety of plant species. Silicon could help plants grow faster and cope with a variety of challenges, including salt, drought, heat, severe temperatures, metal toxicity, nutritional imbalance, and stress caused by changes in global climate factors. Silicon can help postpone the ageing of leaves. Furthermore, even in high concentrations, Si is not toxic to plants. Plants that have silicified structures are more successful in harsh settings than those that do not. Soon, the application of Si would become a viable technique for increasing crop yield, enhancing the quality and minimizing abiotic challenges.

Speed breeding: Speed breeding is the major technologies which could revolutionise crop breeding. Increasing the time to light exposure, enhanced hand pollination and emasculation procedures, growing the crops in a chamber growth, doubling haploidy, optimal temperatures and humidity, and early seed harvest are all proven strategies for reducing the growth cycle of crops. Cereals crop like rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.) as well as legumes like peanut (*Arachis hypogaea* L.) and chickpea, speed breeding techniques have been enhanced (*Cicer arietinum* L.). These techniques could be tested with orphan crops that are closely similar, with small changes. For grain amaranths, there is already a quick production technique that was established using a mixture of controlled conditions growth and good crossing methods. The protocols for quinoa and grass pea have been devised, which may lead to new types. As a result, speed breeding appears to be quite promising and might be used straight away to improve orphan crops. With the world's population growing, there is a pressing need to quadruple global food production by 2050, and agricultural scientists should create latest varieties and technologies to accomplish so. The development of new crop is time consuming as it is dependent on the crop's generation cycle. Plant breeders are using speed breeding in another words accelerated plant breeding in order to get new cultivars in less amount of time. Plants are raised in regulated chambers growth or greenhouses with well quality and light intensity, precise day length and temperature, to increase physiological processes in plants, particularly flowering and photosynthesis and to reduce time of generation. Under typical glasshouse circumstances, generations of approximately 4-6 can be produced each year in speed breading. For important crop species including wheat, barley, and canola, speed breeding methodologies and strategy are well equipped and standardised. This method is currently being implemented, and standardised norms for additional crops, such as perennial fruit crops like apples, are being developed. Speed breeding could be used as a foundation for combining high-throughput genotyping techniques and phenotyping, gene editing and marker-assisted/genomic selections to improve agricultural attributes.

Laser land levelling: The demand for water irrigation is one of the major challenges facing now a day by the agricultural sector. For saving the water, laser land levelling is a technology which saves the water as it maximises the WUE throughout the field by uniform distribution. It also helps to conserve the available water, making the farmers to make use of the water and other resources to minimize the water logging and run-off (Kumar *et al.*, 2022). Several advantages of using laser land levelling is that, it helps to increase area of cultivation by 3-6%, saving irrigation water by 25-30%, crop establishment improvement, maximizes the water efficiency application by 50%, helps in increasing the nutrient use efficiency by 15-20%, controls the weed, uniform seed sowing depth and provides good drainage facilities. In South Asia it is adopted for approximately 1.5 million hectares. It also helps to provide appropriate levelling in a day with little levelling costs. The use of laser land levelling facilitates the resource efficiency usage in surface irrigation systems by resource conserving without hampering the environment.

CONCLUSION

Climate wise agriculture is a set of agricultural techniques aiming at increasing agricultural output, reducing greenhouse gas emissions, and mitigating the consequences of climatic extremes. Smart farming, on the other hand, stresses the use of information and communication technology for high-tech farming, such as the Internet of Things (IoT) and digital technologies that aid in data analytics, machine learning, and artificial intelligence. Exploring the possibilities of IT-enabled services and future technologies such as IoT and robotics, for example, would provide growers with real-time data on crop and soil health. Climate smart agriculture and smart farming were studied independently until recently, and digital tools, IoT, and robotics were not sufficiently explored to comprehend and remove the effects of climatic changes. One of the primary challenges is that the digital agriculture market and farmers' demands and expectations are vastly different. Smart agriculture has a lot of potential in agro-based economies like India, but it requires the integration of numerous new and existing technologies as well as crop protection techniques for long-term output. These technologies should be used with genetic engineering, such as CRISPR, to boost crop yields. CRISPR has the potential to change agriculture by allowing farmers to build cultivars and crop technologies based on genetically modified species to produce desired crop features for more resilient farming.

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