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Crops Production and Factors Limiting the Yield

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Abstract

Crop production supplies food for humans, animal fodder and fabric for clothing. Crop production concepts include the production of food crops, fodder crops, fiber crops, sugar, oil seeds and other crops. Improving food security requires a thorough grasp of the dynamics involved in food production. Crop production is a difficult task. It has been proven that increasing crop yields reduces poverty dramatically. Several factors influence yield or the amount of harvested crop product in a given area. These factors are divided into three categories: Technological (agricultural methods, managerial decisions), biological (diseases, insects, pests and weeds) and environmental (diseases, insects, pests and weeds) (climatic condition, soil fertility, topography, water quality, etc). These variables account for yield disparities between regions around the world. The current review will go over each of these three main factors and offer some suggestions for dealing with them. It will also emphasize the relevance of climate smart agriculture in increasing agricultural yields while also facilitating crop production in a safe environment. This aligns with the United Nations' 2030 agenda for sustainable development's second aim of ending hunger, achieving food security, improving nutrition and promoting sustainable agriculture in transforming our planet. Many beneficial characteristics have been included and hybrids generated by breeders and biotechnologists.

Keywords: Yield; Food security; Production; Agriculture

Introduction

Plant morphological (structural) and plant physiological (functional) responses to a soil and atmospheric environment are used in agricultural production to produce a high yield per unit area of land. Agriculture is a vital human activity since it provides basic human needs including food, clothing and shelter [1]. Population growth is predicted to reach 9.7 billion people by 2050, necessitating a 70% increase in food production to meet demand. Agricultural productivity is growing more and more dependent on more severe weather events. Water availability, air pollution and temperature all have a substantial impact on agriculture. Rain fed agriculture is predicted to account for one-third or more of global food output growth over the next few decades [2].

Agricultural production and the risks associated with farming are influenced by a number of factors. When these factors are not properly monitored and regulated, they pose a significant risk to farms, resulting in decreased yield. These components fall into three categories: Technological, biological and environmental. Pressure to boost crop production has led to the extension of agricultural area and the development of farmland management practices such as irrigation, the use of enormous amounts of artificial fertilizers and synthetic insect and weed control chemicals in many nations. Soil properties and water quality have worsened as a result of these practices, soil erosion has accelerated, groundwater has been contaminated and food quality has degraded. This has sparked efforts to increase yields on existing area while also lowering agriculture's environmental impact [3-5]. Organic farming is one of the pollution reduction measures promoted by alternative agriculture. As a result, some countries have switched to organic farming to replace chemical based farming methods. In order to conserve and regenerate soil properties, Soil Organic Matter (SOM) preservation has received a lot of attention [6]. Because of geographical differences in soils, temperature and agricultural techniques, the link between SOM and yield has been challenged. The relationship between these components should be examined and proper soil management practices employed to enhance sustainable crop production.

Our agricultural systems are undeniably impacted by climate change. Drought followed by severe rain, for example, could increase the risk of flooding, promoting fungal infestations of leaves, roots and tuber crops. Furthermore, due to global climate change, the loss of bees has led in the extinction of several plant species locally. Producing enough food to fulfil population growth while preserving the environment, especially in light of climate change, is a big challenge. The components that influence agricultural yields will be examined in this study, as well as some approaches for overcoming yield loss while maintaining the environment [7].

Literature Review

Environmental factors affecting crop yield

Environmental factors that affect agricultural production include abiotic and biotic constraints. Global warming, which causes climate change, amplifies these effects significantly. Plant development and production are harmed by abiotic stresses, which also cause

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morphological, physiological, biochemical and molecular changes. Abiotic constraints include soil factors (components, pH, physicochemical and biological aspects), as well as climatic pressures (drought, cold, flood, heat stress, etc.). Biological forces include beneficial organisms (pollinators, decomposers and natural enemies), pests (arthropods, illnesses, weeds, vertebrate pests) and anthropogenic evolution [5].

Abiotic constraints

Effects of climatic conditions on crops: Climate change is thought to be to blame for nearly half of the harvest. Annual rainfall changes, average temperatures, global CO_2 increases and sea level fluctuations are all signs of climate change, all of which have a negative impact on agricultural output [4]. Temperature and rainfall variations are expected to have a significant negative impact on a wide range of agricultural activities during the next few decades. As the climate changes, agriculture is being increasingly influenced by extreme weather events, resulting in considerable crop yield losses [5]. Because crop plants were developed for high yield rather than stress tolerance, they are often vulnerable to shocks. Climate change is caused by global warming. It has severe effects on plant growth and yield, lowering crop yields by up to 70% directly, indirectly and socioeconomically (Figure 1).

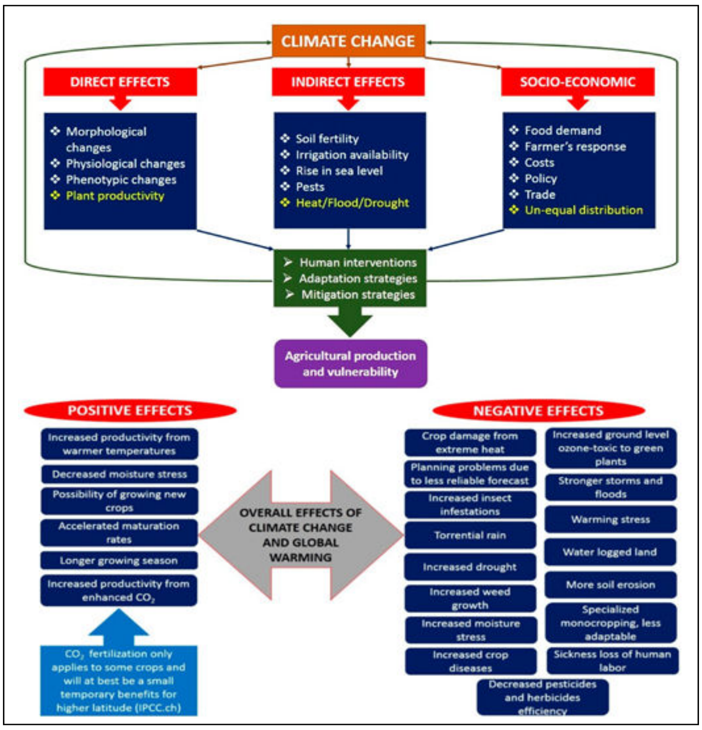

Figure 1: General effects of climate change in agricultural production (a), the positive and negative impacts in the environment.

Drought: When the amount of available water from rainfall and/or irrigation is insufficient to meet the crop's evapotranspiration requirements, drought occurs. Climate change is influenced by changes in water availability (volumes and seasonal distribution), as well as water demand for agriculture and other competing industries. Approaching climate change problems are known to affect abiotic pressures such as shifting temperature regimes and their associated impacts on water availability, resulting in drought, increased disease and pest incidence and extreme weather events on a local to regional scale [3]. In field crops, moisture or drought stress reduces productivity by 30-70% during the crop growth cycle. Drought stress can create an accumulation of Abscisic acid in guard cells, causing stomatal closure. Drought affects plants differently depending on their stage of development, with flowering being the most vulnerable [4].

Heat stress: Temperature is used to determine the intensity of heat energy. A temperature range of 15 to 40 degrees Celsius is ideal for most agricultural plants [3]. When temperatures rise above a specific threshold for an extended period of time, heat stress occurs, causing permanent damage to plant growth and development.

Seed germination percentages, photosynthetic efficiency, agricultural phenology, reproductive biology, flowering times, pollen viability and pollinator populations are all negatively affected by climate change. During the reproductive growth stage, the increase in temperature prevents pollen grains from expanding, resulting in insufficient pollen discharge from the anther at dehiscence. Plant development stages including reproductive organ production and function, are harmed by heat stress. Variable temperature regimes may also result in unexpected disease outbreaks in various places of the world [8]. Heat stress reduced overall wheat yields by 40% for every increase in temperature above 30°C and maize yields by 1.0-1.7% per day for every increase in temperature above 30°C.

Cold stress: Plants subjected to cold or chilling stress between 0 and 15°C lose a large amount of their harvest. Poor germination, stunted seedlings, chlorosis (growth retardation), limited leaf development, wilting and necrosis are all indications of non-freezing low temperatures, which affect or kill a range of tropical and subtropical crops. Plants' gene expression and protein synthesis patterns change when they are exposed to low temperatures [8]. In comparison to tropical and subtropical crops, temperate region plants are generally believed to be chilling tolerant to varied degrees and can improve their freezing tolerance through cold acclimation [9].

Soil properties: Land plants are completely reliant on the soil they thrive in. Crop growth is influenced by soil moisture, air, temperature, soil mineral matter, organic matter, soil organisms and soil reactions. Soils are the earth's top layer, formed mostly by rock weathering, humus production and material transfer. They differ in terms of origin, appearance, characteristics and manufacturing capability. The ability of a soil to give nutrients essential for a crop's optimal growth is referred to as soil fertility. It's one of the most important parts of crop cultivation. A variety of physical, chemical and biological properties influence its ability to support agricultural production. Soil fertility is an important aspect of soil productivity since it is a vital source of micronutrients needed for plant growth. Plant deficiencies are caused by a lack of specific minerals in the soil, whereas their excess causes toxicities, which lower crop yields.

A multitude of factors can be used to determine the fertility of a soil. The soil fertility index was found to be the most useful indicator for producing cost-effective agricultural yields and promoting sustainable land use management. Human caused soil deterioration has resulted in low yield production per unit area of agricultural harvest on some croplands around the world. Around 40% of agricultural areas are affected by human-caused land degradation [9]. Intensive agricultural production characterized by misuse of fertilizers and pesticides without attention to agricultural sustainability results in soil deterioration, land degradation and major environmental problems.

Soil salinity and acidity stress: Salinity stress affects agricultural yield in around 30% of irrigated crops and 7% of dry land agriculture around the world. Salt damage affects around 20% of cultivated land and 33% of irrigated land worldwide, making it one of the most important challenges influencing crop yield. Salt causes osmotic stress and ionic toxicity in crop plants. The higher osmotic pressure in plant cells permits water and essential nutrients to be absorbed into root cells from a soil solution under normal conditions. Under salt stress, however, the high concentration of salts in the soil solution prevents the absorption of water and critical minerals.

Floods: Depending on the depth and duration of the flood, plants are subjected to a variety of stressful scenarios. Soil water logging harms most crops, with the exception of rice, which, like other wetland species, thrives when not completely submerged. Flooding has become more regular in many lowlands and cultivated areas each year, inflicting substantial damage to humans, including crop losses and food shortages. Heavy rain, poor soil drainage and insufficient irrigation are all common causes. Soil water logging has a negative impact on agricultural output, especially for dryland species like crops. Extra water induces complex changes in plant physiology in non-adapted crops. The rapid shortage of oxygen required to sustain aerobic respiration of submerged tissues is the primary limitation for plant growth under flooding conditions. The reduction-oxidation potential (redox potential) of the soil decreases as the length of flooding increases (Figure 2).

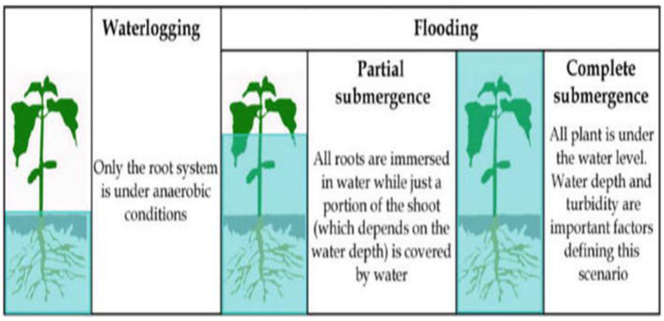

Figure 2: Different levels of excess of water in crop environment.

Discussion

Biotic factors affecting crop yields

Diseases and pests: Plant diseases are caused by microbes such as viruses, bacteria and fungi. A number of soil borne and above ground insect pests also have an impact on crop yield. Climate change frequently increases pathogen growth while lowering plant productivity and soil fertility. It depletes plant resources, causing them to produce insufficient biomass, seeds and eventually, yield. Climate driven migration allows pathogens and pests to migrate from one location to another. Resistance to pathogen secondary infections can be caused by plant microbe interactions or microbe associated molecular patterns. As a result of climate fluctuation and change, new illnesses and pests may originate or the virulence of existing diseases and pests may increase.

Technological factors affecting crop yield

A wide range of technological innovations in agriculture have been achieved through research programs to understand their implications in enhancing crop productivity, including genetic improvement of varieties, fertilizer technology, adaptive microbial technology, pesticides, farm machinery and agronomic and management practices. A number of factors have a negative impact on agricultural operations. Late planting, wrong plant spacing, inaccurate planting method, insufficient sowing depth, delayed weeding, ineffective pest and disease control, inappropriate fertilizer use, late harvesting and the use of low producing cultivars all diminish crop yields significantly [8].

Strategies for overcoming agricultural yield loss

Climate Smart Agriculture (CSA) is now widely acknowledged as the most effective technique for addressing the impacts of climate change on agriculture. Sustainable agriculture is defined as agriculture that increases output, resilience (adaptation), reduces/removes greenhouse emissions (mitigation) and promotes national food security and development goals [7]. CSA supports and encourages the reform of agricultural systems and policies to enhance food production, improve food security and ensure that food is affordable (low input cost) all while ensuring sustainable natural resource management and climate resilience [10].

Environmental management: All aspects of agricultural output, including crop acreage and crop intensity, are affected by the weather [11. Weather forecasting and crop yield prediction or simulations can help farmers plan for the upcoming season. Farmers can alter crop planting dates, employ appropriate genotypes and manage fertilization and irrigation cycles to achieve adequate yields, lowering the chance of unplanned events. Reduced use of fertilizers and pesticides, as well as increased agricultural input efficiency, will reduce greenhouse gas emissions while also safeguarding the environment. Even if the total planted area remains constant, climate events have an impact on planting method selection and as a result, yield; therefore knowing the proper planting methods is critical. Agriculture that is sustainable can improve production while lowering environmental effect [12-14].

Agricultural input management: To ensure water availability for both agricultural productivity and competing human and environmental needs, irrigation efficiency and water management must be enhanced. To improve crop productivity and sustainability, it is critical to assess the effects of human activities on soil fertility through the use of appropriate agricultural systems such as tillage [15], fertilizer application at recommended rates and types, incorporation of farmyard manure and/or crop residues into the soil (increase supply of N, P, K and other nutrients) and avoid sewage sludge irrigation. Over time, these inputs improve the physical properties of soil or soil organic matter, assuring the long-term viability of agriculture.

The most effective technique for mitigating the negative effects of climate change on crop adaptation is climate smart agriculture. The type of inputs employed during cultivation, as well as suitable high yielding genotypes, will impact the quality and quantity of harvest products obtained. Cover crops also aid in weed and disease control, soil erosion prevention and nitrogen, phosphorus and carbon loss reduction. Disease control and phosphate availability were provided by plant beneficial bacteria. Many countries' policymakers should adopt rules on sustainable fertilizer and pesticide management in crop production, utilizing a variety of application strategies to reduce chemical misuse while safeguarding the environment [14].

Development of new adapted crop genotypes: Breeding is commonly done to boost levels of permanent resistance to specific pests, diseases and abiotic stresses using classic crop improvement methods. Modern biotechnology techniques such as marker-assisted selection and transgenic approaches that involve genetic modification and high-throughput sequencing of both plants and pathogenic microbes are becoming more widely used. Transgenic technology has also been used to change functional genes in plants in order to create natural tolerance mechanisms [15]. Sustainable technologies such as traditional breeding procedures and integrated farming concepts are being investigated to develop crop adaption and/or strengthen adaptive mechanisms.

In response to stressful environmental conditions, crop plants have evolved a complex of perception and signal processes that include regulation, transcription, gene expression, protein translation, modification, degradation and metabolic control [16]. Membrane protection, photosynthesis, respiration and transpiration regulation are all physiological responses to drought and heat stress in plants. Dresselhaus and Hückelhoven for example, designed crop genotypes with improved water use efficiency as a response to drought stress [17,18].

A combination of genomics approaches like as Marker Assisted Selection (MAS) and Genome Wide Associated Studies (GWAS) can be used effectively to develop biotic and abiotic stress resistant cultivars [19]. Future bio-computational integration of multiple omics and meta-omics with cutting-edge research tools (reference genomes, proteomes and metabolomes with comprehensive annotations and structure function relationships) will improve understanding of plant stress physiology, leading to the development of high yielding and best adapted crop cultivars.

In order to promote the development of climate smart agriculture, which reduces agricultural emissions and increases agricultural production, research activities in water quality and efficiency, nutrient and soil conservation technologies and techniques, climate resistant crops and livestock, as well as agricultural productivity, must be improved in accordance with each country's national development policy.

Food security and climate smart agriculture

The most difficult and important responsibility is to ensure that the earth is preserved from degradation through sustainable consumption and production, sustainable natural resource management and urgent national, regional and global climate change action. One of the most serious risks to food security is climate change, which affects food availability, accessibility, use and system stability. Climate Smart Agriculture (CSM) is a strategy of reorganizing and reorienting agricultural systems to provide food security in the face of changing climate conditions. It encourages farmers, researchers, businesses, civil society and governments to collaborate across disciplines to develop climate resilient solutions [20].

Conclusion

Climate smart agriculture enhanced crop yields while easing the achievement of crop production adaptation and mitigation targets. The propagation of innovative cultural methods, the deployment of diverse cropping schemes and the integration of multiple conventional and non-conventional ways will be required for the creation of new climate resilient crops that are tolerant and adaptive to biotic and abiotic challenges. The development of integrated soil crop system management and integrated disease and pest control with existing crop varieties, as well as the expansion of new improved and adapted high yielding varieties in water and nutrient constrained environments, should be the new goal for future generations. The introduction and/or overexpression of specified genes into genetically altered crop plants appears to be a viable strategy for hastening the breeding of improved suited and high yielding crop genotypes. To identify meaningful answers for all of the environmental concerns affecting crop yields while preserving food security, transdisciplinary and multidisciplinary research is required.

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