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Review Article

Review on: Response of Cereal Crops to Climate Change

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Abstract: Climate change has verified moveable effect in different part of the world, its effect is severe in the developing countries. The adaptation and production of the crops highly affected due to climate change i.e. the ambient weather factors are becoming beyond the suitability ranges. Here, it focuses on the effects of rising atmospheric CO_2 concentrations, rising temperature, and changes in precipitation and their interaction on plant growth, development and yield. Therefore, this paper is aimed at reviewing the response of cereal crops to the changing of climate. The existing knowledge sources demonstrated climate change has negative impacts on cereal crops production and productivity. While in some cases these responses are variable within and between species and are dependent on developmental stage. Variability also exists between C3 and C4 species in response to elevated CO_2, especially in terms of growth and seed yield stimulation. C3 plants will benefit more than C4 plants at elevated CO_2. However, if global warming will take place, an increase in temperature may offset the benefits of increasing CO_2 on crop yield. The difference in responses of different crops to elevated CO_2 might be due to difference in water, soil, nutrient availability and temperature variation. It concludes that there is a need for further research regarding the weather and climate variability and change together within a specific region.

Keywords: Climate Change, Cereal Crops, Adaptation, Elevated [CO_2], Crop Yield

1. Introduction

Climate change refers to long-term changes in the state of the climate. These changes are identifiable, i.e. the mean or the variability of climate change components such as the increase of temperature, changes in precipitation and elevated atmospheric CO_2 levels can be assessed by the application of appropriate analytical and statistical methods [28]. The release of greenhouse gases (carbon dioxide, methane, nitrous oxide) due to various anthropogenic activities is very likely to be one of the major causes of recent climatic change [21]. Plausible climate change scenarios include higher atmospheric CO_2 concentrations, higher temperatures, and changes in precipitation [51].

The Intergovernmental Panel on Climate Change (IPCC) fourth assessment report (AR4), states that global temperatures are on the rise. Instrumental records of temperature over the period of 100 years ending 2005 clearly show an average global increase of 0.74°C with the 2nd half of the century being twice as warm as the entire period [26]. Continental average temperatures over the same period also rose similarly. Notably, global and continental temperature rise is clearly attributable to human activity. The annual carbon dioxide (CO_2) emissions rise to 80% since 1970 [26]. This and longer term greenhouse gases (GHGs) emission rise is reportedly a result of fossil fuel burning and land use changes among other human activities.

As climate change have contrasting effect in different part of the world, it mainly affects the developing world, causing variability in precipitation, solar radiation, temperature, CO_2, humidity etc., it leads to increased infestation of disease, insect, pest and dispersal of weed, which may affect food production and productivity. When the ambient factors affecting growth will become beyond the tolerance of the plant species, it will have a negative effect on their reproduction, life cycle and eventually extinct of the species from natural ecosystem. Climate change will alter plant development in ways that will have significant impacts on the function of crop plants and plants in natural ecosystems. Future growing conditions will bring increased temperature, increased frequency of extreme events including heat waves and drought events, and changes in the composition of the atmosphere [29].

Global food security threatened by climate change is one of the most important challenges in the 21st century to supply sufficient food for the increasing population while sustaining the already stressed environment. The whole world especially African countries has affected by Climate change which causes a significant influence on water resources, food security, hydropower and human health. climate change has been considered as an inevitable danger to the whole agriculture production system, the effects of which are highly unpredictable and needs a complete assessment as to what are the sources and inferences of these threats on our crop plants with special emphasis on cereal plants [7]. Recent studies suggest the world will need to produce 60 to 100% more food when the global population will reach 9 billion people by 2050 [17]. As FAO schemes food production increase in 70 percent between 2005/2007 to 2050. The yield potential and yield quality of cereal crops have been greatly improved due to intensive research and breeding efforts over the last 20 years. Currently, yield safety has gained more importance because of the forecasted climatic changes [58].

It is widely held that developing countries in Africa will be particularly susceptible to climate change, in part, because of the extraordinary growth of its human population, fragility of national and regional economies, food and water insecurity, and rapid loss of natural resources [25, 27]. Furthermore, the majority of subsistence food produced in Africa comes from rain-fed agricultural systems that are dominated by small-scale subsistence farming; practices have changed little over the last few centuries. The scarcity of water and lack of irrigation systems throughout most of Africa substantially increases the dependency people have on climate for food production. Fluctuating climatic cycles (e.g. El Nino) have led to extensive drought, famine, and loss of life throughout sub-Saharan Africa and altered rainfall patterns and the subsequent loss in agricultural productivity can have direct influences on national economies [60].

Ethiopia is one of the African countries which arguably the most at risk from climate change impacts on agricultural productivity and food security. With a population exceeding 85 million people, nearly 40% of Ethiopia's population is considered food insecure. Approximately 85% of Ethiopians live in rural areas and rely heavily on subsistence farming for survival. Family households usually cultivate areas less than 1 ha and collectively account for approximately 95% of the country's agricultural production [16]. Yet the Ethiopian economy is largely based on agriculture, which accounts for 41% of its Gross Domestic Product, 75–80% of exports, and 80% of the job market [56]. As a general, Agriculture, the main economic sector of many developing countries, is the most affected sector by climate change. On the other hand, agriculture is expected to feed a population that will number 9.1 billion in 2050, while providing income, employment and environmental services [34].

The change and variability of climate components such as precipitation, solar radiation, CO_2, temperature, humidity, air pressure, wind, methane, nitrogen oxides etc. have effects on growth, development and yield of cereal crops. Among those increasing temperature, changing precipitation regimes and increasing atmospheric CO_2 concentration are the primary factors that have affected and will continue to affect cereal crops production in the coming decades. Hence, study about climate and cereal crops in relation to response of cereal crops to climate change is a paramount importance to enhance production and productivity in the near future. Therefore, the objective of this paper is to review the literature about the response of cereal crops to climate change.

2. Methodology

The paper is based on review and use of secondary data published in journals, research centers, annual reports, technical and consultant reports available in the studies conducted by various researchers, institutions and organizations. The review focused primarily on literature search and restricted to articles and report papers published between 1997 and 2019. A literature searches for this review focused primarily on studies conducted in Ethiopia, African countries and cereal crop producing countries in the world. Published articles were searched and identified from different electronic databases such as Web of Science, AGRIS (agris.fao.org), Research Gate (https://www.researchgate.net), Science Direct, Taylor and Francis, Springer, different African and Ethiopian Journals, and libraries of the Ethiopian research institutes. The secondary data available at the Food and Agriculture Organization (FAO) Corporate Statistical Database (FAOSTAT), United States Department of Agriculture (USDA) and Intergovernmental panel of climate change (IPCC) relevant to the review were used. Following a critical review, data and literatures were compiled on existing and detailed cereal production and productivity, their importance and contribution in agricultural system, their practicality in agricultural production and overall contribution to livelihoods. Research and technical gaps on the overall production aspects of cereal crop were identified and recommendations are forwarded for the future endeavor of enhancement in agricultural production system.

3. Result and Discussion

3.1. Cereal Crops Production in the World

Cereals belong to the monocotyledon family Poaceae. The most cereals in the world are maize, wheat, rice, barley, sorghum, millet, oats, rye, triticale etc. Those are group of grass crops that produces edible grain seeds, and are made up of endosperm composed of the carbohydrate molecules, germ (embryo) that contains the genetic contents and seed coat made contains the proteins and other essential vitamins. Thus cereals and cereal-based foods are rich sources of energy, protein, vitamins, and minerals for wide world population [10]. Cereals are the major human food resource together with its privileged service as a source of animal feed and raw materials for agro-industries [60]. Wheat, rice, maize, pearl millet, and sorghum provides over half of the world's food calories [36]. Wheat is produced from 217 million hectares of land about 620 million metric tons, and utilizes about 30% of the land area under cereal cultivation and account for about 27% of the world cereal yield [15]. By increasing need to exploit existing genetic variability and develop cultivars with superior genetic yield potential and stress adaptation which could uphold global food security within the challenge of climate change.

3.2. Effects of Elevated CO_2 on Cereal Crops

Plant biomass and yield tend to increase significantly as CO_2 concentrations increase above current levels as reported by hundreds of studies over the last 30 years. Such results are found to be robust across a variety of experimental settings, such as controlled environment closed chambers, greenhouses, open and closed field top chambers, and free-air carbon dioxide enrichment experiments. Elevated atmospheric CO_2 concentrations, which tend to increase plant growth and yield, and may improve water use efficiency, particularly in so-called C3 carbon fixation plants such as wheat, rice, soybean etc... The impact on so-called C4 carbon fixation plants, such as maize, sorghum, sugarcane, and many tropical pasture grasses, is not as pronounced due to different photosynthetic pathways [59].

3.2.1. Effects of Elevated CO_2 on Crop Physiological Characteristics

Increasing levels of atmospheric CO_2 due to various anthropogenic activities will directly influence photosynthesis, transpiration, and respiration, the main processes by which elevated CO_2 can be sensed directly by the plants and ecosystems [13]. Elevated CO_2 concentrations stimulate photosynthesis, leading to increased plant productivity and modified water and nutrient cycles [31, and 40]. Producing larger number of mesophyll cell, chloroplasts, longer stems and extended length, diameter and number of large roots, forming good lateral root production with different branching patterns; in some agricultural food crops, resulting in increasing root to shoot ratios due to elevated CO_2 [46].

C3 and C4 plant types exhibit different responses to CO_2 enrichment. The current amount of CO_2 in the atmosphere is inadequate to saturate the ribulose-1, 5-bi-phosphate carboxylase oxygenase (RuBisCO) enzyme that drives photosynthesis in C3 plants [62]. Experiments under optimal conditions show that doubling the atmospheric CO_2 concentration increases leaf photosynthesis by 30% –50% in C3 plant species and 10% – 25% in C4 species, despite some down-regulation of leaf photosynthesis by elevated atmospheric CO_2 concentrations [1].

Photosynthetic response is higher than crop yield increase [33]. The crop yields increase at 550 ppm CO_2 in the range of 10–20% for C3 crops and 0–10% for C4 crops on average across several species and under unstressed conditions as compared to current atmospheric CO_2 concentrations of approximately 380 ppm. The rates of photosynthesis increased in most plants growing in atmospheric CO_2 higher than ambient. High CO_2 also reduces the stomata openings of some crop plants that reduce transpiration of water per unit leaf area while enhancing photosynthesis. Thus it may lead to improve water-use efficiency. As a result of these interactions, elevated CO_2 alone tends to increase growth and yield of most agricultural plants. Most of the studies on the experimental effects of CO_2 on crops have been conducted either under controlled environmental conditions (chambers), or under optimal field conditions [31]. In all circumstances potential CO_2 effects on plant biomass depend on the nutrient and water levels [12]. Most agricultural models used in climate change impact studies have been modified to simulate the direct effects of CO_2 on crops [52].

Therefore, future increases in CO_2 concentrations up to 57% by 2050, or even at higher levels (600–800 ppm) [20], will most probably favor C3 plant types. In contrast, C4 type plants are likely to respond less to elevated CO_2 levels as they possess an innate concentrating mechanism that increases CO_2 level at the site of RuBisCO to 2000 ppm. Hence, predicted increases in atmospheric CO_2 concentrations, from a current ambient level of about 370 ppm, are less relevant to the photosynthetic capacity of C4 plants which, most probably, will respond only marginally [44]. The association of photosynthesis rate and intercellular CO_2 concentration was compared in soybean (C3) and maize (C4). Photosynthesis in soybean was stimulated by 39% under elevated CO_2 concentration but not in maize [51].

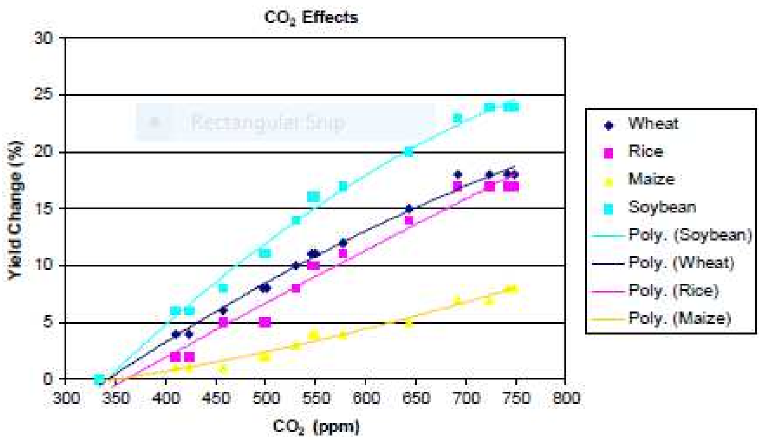


Figure 1. *Potential increase in yield exhibited by wheat, rice, maize, and soybean under elevated levels of CO_2.*

3.2.2. Effects of Elevated CO_2 on Crop Yields

Carbon dioxide is fundamental for plant production, and increases of atmospheric CO_2 concentrations have the potential to enhance the productivity of agro-ecosystems. Elevated CO_2 is expected to increase plant yield through root mass and leaf area increases and to alter plant chemical composition, hence the rate of nutrient cycling in soil [40]. Elevated CO_2 also has the benefit of reducing stomata conductance, thereby increasing water-use efficiency in both C3 and C4 crops [1]. Increases in marketable yield of cereals, particularly those that exhibit C3 photosynthetic pathway, range between 8 and 70%. The quality of agricultural products may be altered also by elevated CO_2. Nitrogen content, for example, in some non-nitrogen fixing plants grown at elevated CO_2, was found reduced [1; 14]. Elevated CO_2 increases seed yield in numerous agricultural species, but the nutritional quality of the grain is generally reduced, due to altered ion profiles, notably reduced iron and zinc content. Elevated CO_2 also reduces nitrogen and protein content of seeds of non-legume crops [39].

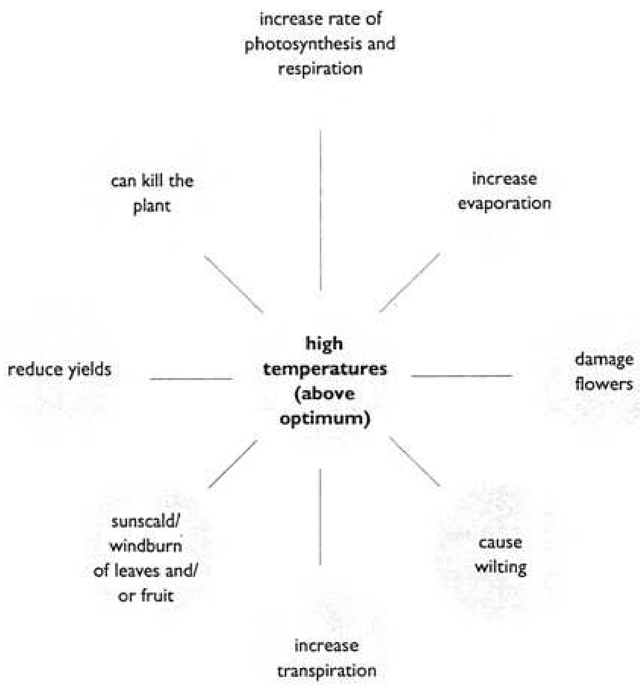


Figure 2. *Temperature effect on plants.*

3.3. Impact of Increase Temperature on Cereal Crops

Changes in the global climate, notably in regional spatial and temporal temperature patterns, are predicted to have important consequences for crop production. Both plant growth and development is affected by temperature. The most significant factors for heat stress related yield loss in cereals include the high-temperature induced shortening of developmental phases, reduced light perception over the shortened life cycle and perturbation of the processes associated with carbon assimilation (transpiration, photosynthesis and respiration) [48]. Losses in cereal yields can be attributed to heat stress induced metabolic changes, to a decrease in the duration of the developmental phases of plants and the consequent reduction in light perception over the shortened life cycle, and to the perturbation of processes related to carbon assimilation (transpiration, photosynthesis and respiration), all of which may lead to fewer and/or malformed and/or smaller organs [48]. High growing temperature reduces the duration of all developmental stages in wheat thereby squeezing its phenology, in such conditions, plant growth promoting rhizobacteria (PGPR) plays a greater role in ameliorating the heat stress [37].

3.3.1. Effects of Temperature Increases on Crop Physiological Characteristics

Temperature increases result in altered phenology of leaf development, flowering, harvest and fruit production, decreased vernalization period, and in asynchrony between flowering and pollinators [4]. In addition, increased temperatures result in higher respiration rates, shorter seed formation periods, and lesser biomass production, hence lower yields. Key stages of crop development, seasonal temperature incidents, day-night temperature fluctuations, and geographical scale are the major parameters that should be taken under consideration when the effects of temperature on crop yields are evaluated. Only few days of extreme temperatures at the flowering stage can drastically reduce yield in many crops [61]. Pre and post anthesis heat incidents at 35°C led to significant yield loss of barley, wheat, and triticale [45 & 54]. Each crop species exhibits an optimal temperature for vegetative growth with growth decreasing as temperatures diverge from this optimum. Similarly, there is a range of temperatures within which a plant will set seeds and outside of which the plant will not be able to reproduce.

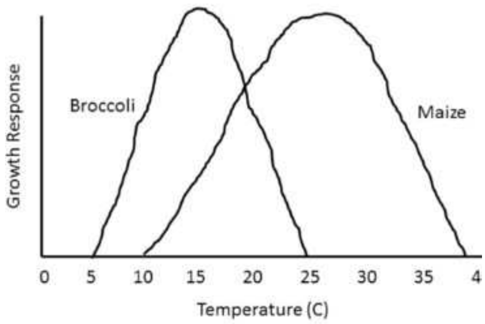
High temperature stress (>30°C) from early meiosis to pollen maturity also has a damaging effect on the viability of pollen grains in wheat, resulting in a failure of fertilization, and thus in a reduction in seed set. The reduction in seed set occurs at temperatures higher than 38°C mainly because of a reduction in pollen germination ability and pollen tube elongation and reduction of the kernel number per ear due to lateral ear heating by 4.5°C above the air temperature in the heated zone prior to silk emergence [48]. Increased temperature over the mid-anthesis period decreased the grain number per ear at maturity in spring wheat [17] indicating the heat sensitivity of fertilization and grain setting. High-temperature stress at flowering reduces spikelet fertility in rice (*Oryza sativa* L.). Sterility is caused by poor anther dehiscence (caused by the tight closure of the locules) and low pollen production, and hence low number of germinating pollen grains on the stigma [35, 47].

High temperatures (above 35°C) in combination with high humidity and low wind speed caused at 4°C increase in rice panicle temperatures, resulting in floret sterility [49]. A review on the effect of temperature extremes, frost and heat, in wheat (*Triticum aestivum* L.) revealed that frost caused sterility and abortion of formed grains while excessive heat caused reduction a grain number and reduced duration of the grain-filling period [5].

3.3.2. Effects of Temperature Increases on Crop Yield

Temperature affects yields through five main pathways. First, higher temperature causes faster crop development and thus shorter crop duration, which in most cases is associated with lower yields [48]. Second, temperature impacts the rates of photosynthesis, respiration, and grain filling. Crops with a C4 photosynthetic pathway (e.g. maize) have higher optimum for photosynthesis than C3 crops (e.g. rice and wheat), but even C4 crops see declines in photosynthesis at high Temperature [11]. Warming during the day can increase or decrease net photosynthesis (photosynthesis-respiration), depending on the current temperature relative to optimum, whereas warming at night raises respiration costs without any potential benefit for photosynthesis. Third, warming leads to an exponential increase in the saturation vapor pressure of air. Fourth, temperature extremes can directly damage plant cells. Finally, rising temperature, along with higher atmospheric CO_2, may favor the growth and survival of many pests and diseases specific to agricultural crops [62].

Crop yields particularly those of temperature sensitive crops such as maize, soybean and wheat will be decreased with temperature increases at the regional and local scales [32]. Night temperature increases resulted in rice and wheat grain yield losses [32, 47, 38]. Thus, even a C3 crop like rice which is expected to yield better under increased CO_2 will suffer serious yield losses under high temperature. Since the majority of global rice is grown in tropical and semitropical regions, it is likely that higher temperatures would negatively affect its production in these areas due to an increase in floret sterility that would subsequently decrease yields [47]. The detrimental effect of high temperature on rice yield will be exacerbated by increased CO_2 in the atmosphere.



Source: [43]

Figure 3. Temperature response for maize and broccoli plants showing the lower, upper and optimum temperature limits for the vegetative growth phase.

Table 1. Total vegetative biomass and grain yield for hybrid RX730 grown under normal and warm temperatures for two experimental replicates using Ames, Iowa and normal conditions [43].

Replicate	Parameter	Normal temperature	Warm temperature
1	Total vegetable biomass (g m^{-2})	920.3	1188.0
1	Grain yield (g m^{-2})	1870.0	213.8
2	Total vegetable biomass (g m^{-2})	1007.0	1122.1
2	Grain yield (g m^{-2})	471.2	59.9

3.4. Alter Precipitation Regimes on Cereal Crops

Changes in precipitation patterns, especially when considering likely changes in the frequency of extremes, with both droughts and flooding events projected to increase in coming decades, leading to possible negative consequences for land-production systems. At the same time, a critical factor affecting plant productivity will be linked to simultaneous temperature and precipitation changes that influence soil water status and the ratio of evaporative demands to precipitation.

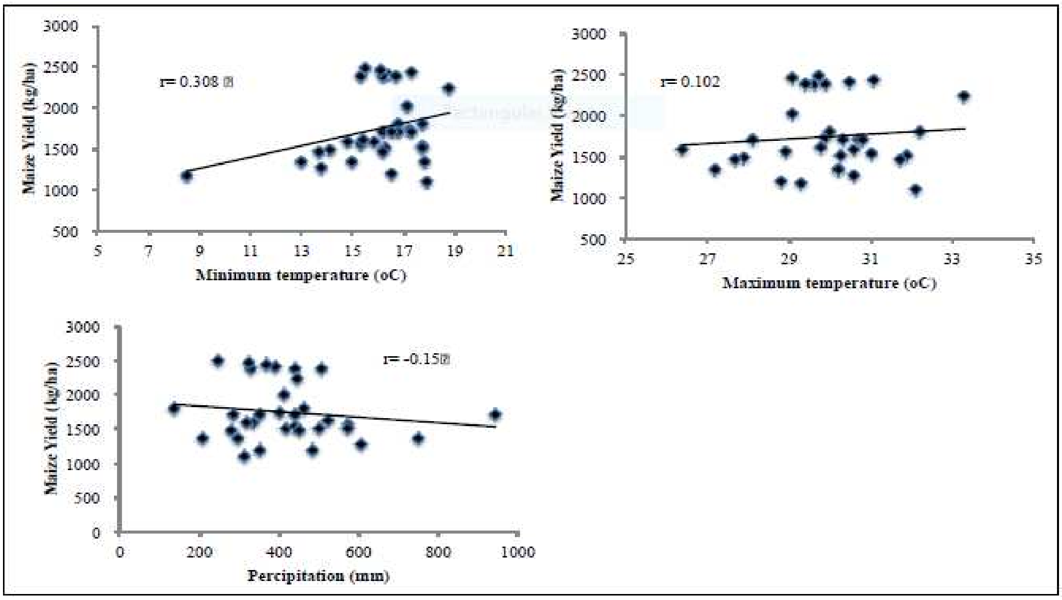
3.4.1. Effects of Water Stress on Crop Physiological Characteristics

Physiological responses of plants to drought stress are complex and vary with plant species and the degree or time of the exposure to drought [9]. Under drought conditions, photosynthesis inhibition occurs because of stomata closure and reductions in the CO_2/O_2 ratio in leaves [23]. Drought stress has severe effects on the growth of three important stages. These steps are: Occurrence and formation of flower, Pollination and fertilization, and Seed formation. Photosynthesis process are reducing due to drought stress reducing leaf area, pore blockage, reducing protoplasm activities and stabilization of carbon dioxide, reducing protein synthesis and chlorophyll. The conditions of severe respiratory stress, absorption of carbon, assimilate translocation, and transmission of raw materials in a wooden vessel, is rapidly decrease to a very low level, and while hydrolytic activity of the enzyme increases, reduction of assimilates saturates the levels from these substances and finally lead to the photosynthesis reduction and hunger. Drought reduces inoculation of flowers and this has a significant effect on the number of produced seeds [57]. Water stress at flowering is most serious and devastating to yield because it has diverse effect of pollination and causes flower abortion, grain abscission and increasing of percentage of unfilled grain. It indicated the high sensitivity of rice to water stress with any intensity (mild or sever) during the reproductive stage (booting, flowering and panicle initiation). This effect might be due to decrease in translocation of assimilates towards reproductive organs [47].

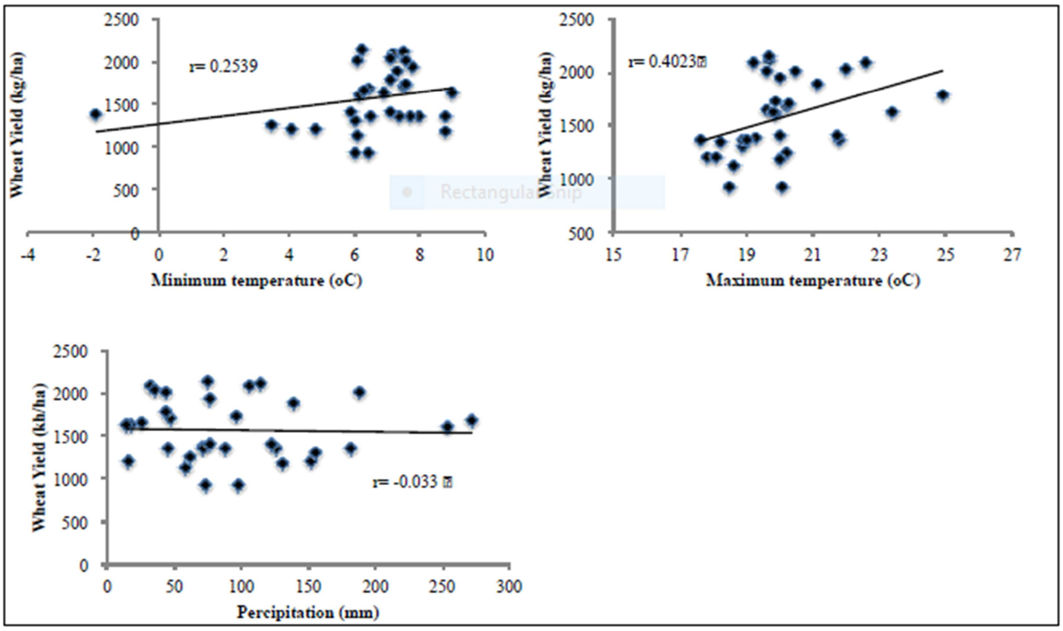
3.4.2. Effects of Water Stress on Crop Yield

The reduction in plant growth resulting from the imposition of drought is in part related to changes in whole plant carbon status, which in turn depends on changes in the partitioning of assimilate between different organs and also the balance between photosynthesis and respiration [18]. Seed number, which is a major component of yield potential, is mainly determined at flowering and slightly afterwards. While the number of ovules greatly exceeds the number of seeds that are finally produced in most species, exposure to water deficits decreases the seed/ovule ratio even more because of flower abortion [6].

Significant crop yield reductions occur under drought stress through dry weight accumulation reductions in all plant organs and shorter plant life cycles [8]. Recorded significantly fewer nodes, lower dry weights of stems, and reduction in height and leaf area between water stressed and well-watered cotton plants [42]. In addition, water deficit at flowering may limit the viability of pollen, the receptivity of its stigma, and seed development [8]. Reduced yields, especially in rain fed cropping systems, is the norm under drought conditions, and the severity of which may increase due to changing world climatic trends. One possible scenario is that the irrigated wetland rice (13 Mha of cultivated land) in Asia may experience physical water scarcity by 2025, while the irrigated dry season rice (22 Mha of cultivated land) may suffer economic water scarcity (human, institutional, and financial capital limit access to water even though water in nature is available locally to meet human demands) [53]. Deleterious effects of water deficit on crops such as soybean [24], maize [30], and many others are well known.



(a)



(b)

Figure 4. *Correlation of wheat and maize, with maximum temperature, minimum temperature and corresponding seasonal accumulated precipitation. Source: www.mdpi.com/journal/climate, 2016.*

3.5. Interactions of Elevated CO_2 with Temperature and Precipitation

Climate changes projected for future decades will modify, and may often limit the direct CO_2 effects on cereal crops. Factors contributing to the loss of yield stimulation in drought coupled with elevated CO_2 include increased canopy size and canopy temperature in elevated CO_2 [22]. For instance, high temperature during the critical flowering period of a crop may lower otherwise positive CO_2 effects on yield by reducing grain number, size, and quality [50]. Increased temperatures during the growing period may also reduce CO_2 effects indirectly, by increasing water demand. For example, yield of rain-fed wheat grown at 450 ppm CO_2 was found to increase up to 0.8°C warming, then declined beyond 1.5°C warming; additional irrigation was needed to counterbalance these negative effects. Future CO_2 levels may favor C3 plants over C4; yet the opposite is expected under associated temperature increases; the net effects remain uncertain. Because of the key role of water in plant growth, climate impacts on crops significantly depend on the precipitation scenario considered. In general, changes in precipitation, and more specifically in evapotranspiration to precipitation ratios, modify ecosystem productivity and function, particularly in marginal areas; higher water use efficiency caused by stomata closure and greater root densities under elevated CO_2 may in some cases alleviate or even counterbalance drought pressures. Although the latter dynamics are fairly well understood at the single plant level, large scale implications for whole ecosystems are not well understood [19].

3.6. Responses of C3 and C4 Crops to Climate Change

C4 species have evolved in a high CO_2 environment because of this both their nitrogen and water use efficiency increases as compared to C3 species. Improved leaf and plant water use efficiency in C4 plants is due to both higher photosynthetic rates per unit leaf area and lower stomatal conductance, with the greater CO_2 assimilation contributing to a major extent [20].

Elevated CO_2 have a positive effect on some annual C3 field crops, such as wheat and rice cultivars, etc. Growth and development accelerated throughout the vegetative phase, and before flowering stage started seven days earlier, which contributed to the higher grain yield and change in the chemical composition of the rice grain [55]. Some studies also show that a yield reduction in maize (C4 species) occurred under elevated CO_2 condition due to shortened growing period, and a yield reduction also recorded in some experiment on winter wheat (C3 species) due to an effect on vernalization period [3].

Generally, effects of elevated CO_2 on photosynthetic heat tolerance were investigated in C3 and C4 species are summarized as follows: (i) in C3 species, elevated CO_2 typically increases heat tolerance of photosynthesis, except for plants grown at supra-optimal growing temperature, then elevated CO_2 may provide no benefit or even decrease photosynthesis; (ii) in C4 species, elevated CO_2 frequently decreases photosynthetic thermo-tolerance, at near-optimal growing temperature as well as supra-optimal growing temperature [55].

3.7. Interactive Effects of Climate Change Components on the Physiology and Yields of Cereal Crops

The effects of climate change components on crop plants were examined individually although environmental changes occur concurrently [2] with management practices (52]. For instance, crop yield response to elevated CO_2 levels is relatively greater in rain-fed than in irrigated crops, due to a combination of increased water use efficiency (WUE) and root water uptake capacity [52]. In addition, the projected increases in atmospheric CO_2 concentration will increase crop growth and consequently nitrogen uptake by the crop, thus potentially will increase the need for fertilizer applications if production is to be maximized [41]. Elevated CO_2 resulted in a sustained larger N pool in aboveground biomass of grasses during a 5-year study on long-term enhancement of N availability under CO_2 concentration increases, suggesting that more N was taken up each year from the soil under elevated CO_2 [44]. Also, increased soil moisture under elevated CO_2 supported higher rates of N mineralization, thereby reducing N constraints on plant growth. Therefore, it is possible that C3 species exhibit a higher plant N acquisition and utilization under elevated CO_2 concentrations. C4 photosynthesis response to water stress in interaction with CO_2 concentration and reported that elevated CO_2 concentration lessens the deleterious effect of drought on plant productivity [20]. This is due to reduced stomata conductance, CO_2 assimilation rate, and intercellular CO_2 levels; therefore, saturating CO_2 concentration keeps the photosynthetic capacity unchanged and limits reductions in plant productivity.

4. Conclusion and Recommendation

4.1. Conclusion

As climate change have contrasting effect in different part of the world, it mainly affects the developing world, causing in altering precipitation, rising temperature, increasing atmospheric CO_2 concentration etc… It leads to increased infestation of diseases, insects, pests and dispersal of weeds, which may affect food production and productivity. Climate change directly and/or indirectly affects cereal crops growth, development, yield and yield quality.

Higher temperature can make an obstacle on crop growth, the rise in temperature shorten the growth period due to early flowering and fruit-bearing, and seeds might not fully develop because of decrease in nourishment sent to the seed due to increased respiration. Elevated CO_2 besides affecting the crop also affects the environment, which in turn may have either beneficial or damaging effect on agricultural production. The difference in responses in different ecosystems to elevated

CO_2 might be due to difference in water, soil, nutrient availability and temperature variation.

When the climate change affecting growth and development will become beyond the tolerance of the plant species, it will have a negative effect on their reproduction, life cycle, yield, and eventually extinct of the species from natural ecosystem. This indicates that only a moderate range of climate will increase cereal grain yields even with an extensive choice of adaptation measures.

4.2. Recommendation

Globally natural resources are depleting, while the ever increasing human population are constant in need of food, water, energy and shelter. In the future, it is crucial to use different effective conservation strategies to maintain species, genetic diversities, and ecosystem services, and to proceed with research on different cereal crop species to investigate their response to climate change and variability, and to identify which species will be most restricted in range and which will be most endangered and how they can be protected from extinction.

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