UNIVERSITÄT BAYREUTH

EFFECTS OF INCREASING TEMPERATURE ON AGRICULTURAL PRODUCTION

By: Adeleke Emmanuel.D.

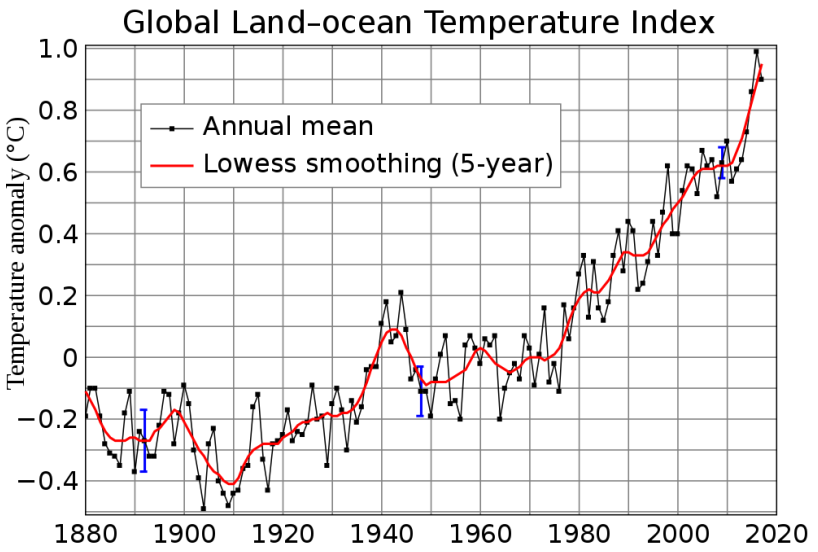
Seminar: Global Change and Agroecosystems(A5)

Structure

- Observed temperature increase
- Contributions of agriculture to GHG emissions
- Effects of increasing temperature on plants
- Plants response to temperature rise
  - C3: Wheat
  - C4: Maize and Sorghum
- IPCC projections
- Conclusions

Temperature increase

- a long-time rise in the GMST since 1880
- due to human-caused observed warming since pre-industrial times
- the emission of greenhouse gases, e.g. CO_2, CH_4 and N_2O
- Total CO_2 emissions from agricultural lands represents 20 - 25% of total amount released due to human activity



Source: Goddard Institute for Space Studies

How does agriculture contribute to GHG emissions?

- Tillage and harvest operations contributes largely to CO_2 emissions, through the burning of fossil fuels
- Agricultural soil management activities, e.g fertilizer application and cropping practises are the largest source of N_2O emissions
- Livestock manure application contribute to CH_4 emissions.
- Nitrification/Denitrification process within manure storage/application releases N_2O
- Global rice paddies (rice fields) also contributes to CH_4 emissions.

Effects of increasing temperature on plants

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Ahad & Reshi (2015)

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- changes the rate and timing of physiological processes, such as organ development rate, respiration, and senescence.

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- Extreme temperatures damage plant cells.
- reduce plant biomass; affect crop reproductive efforts
- increased incidence of plant diseases

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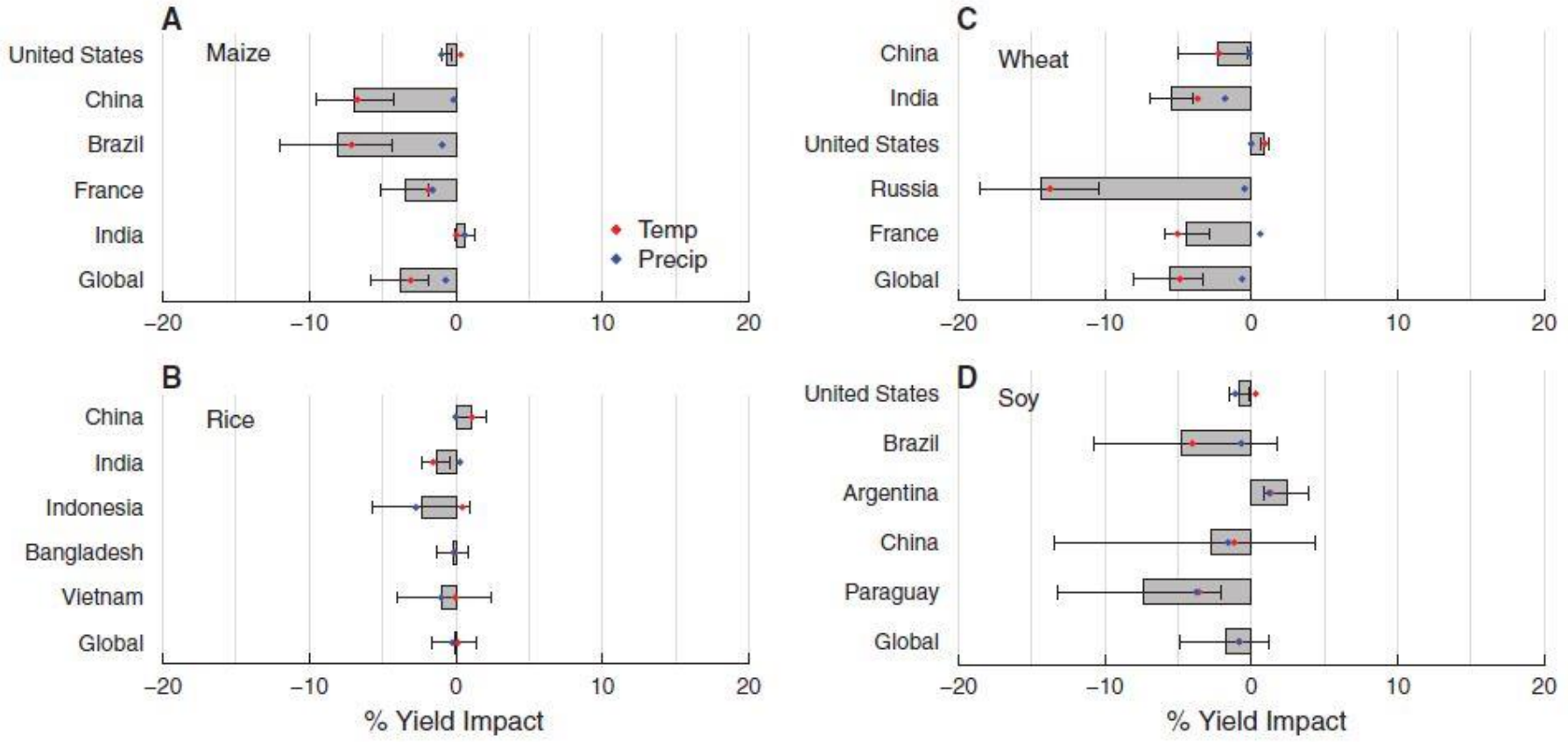
How do plants respond to increasing temperature?

- a robust root system
- smaller leaves
- Leaf dropping; leaf rolling and vertical orientation; transient wilting
- Stomatal closure

➢ Reduces photosynthesis rate and increase heat-related impacts

Ahad & Reshi (2015)

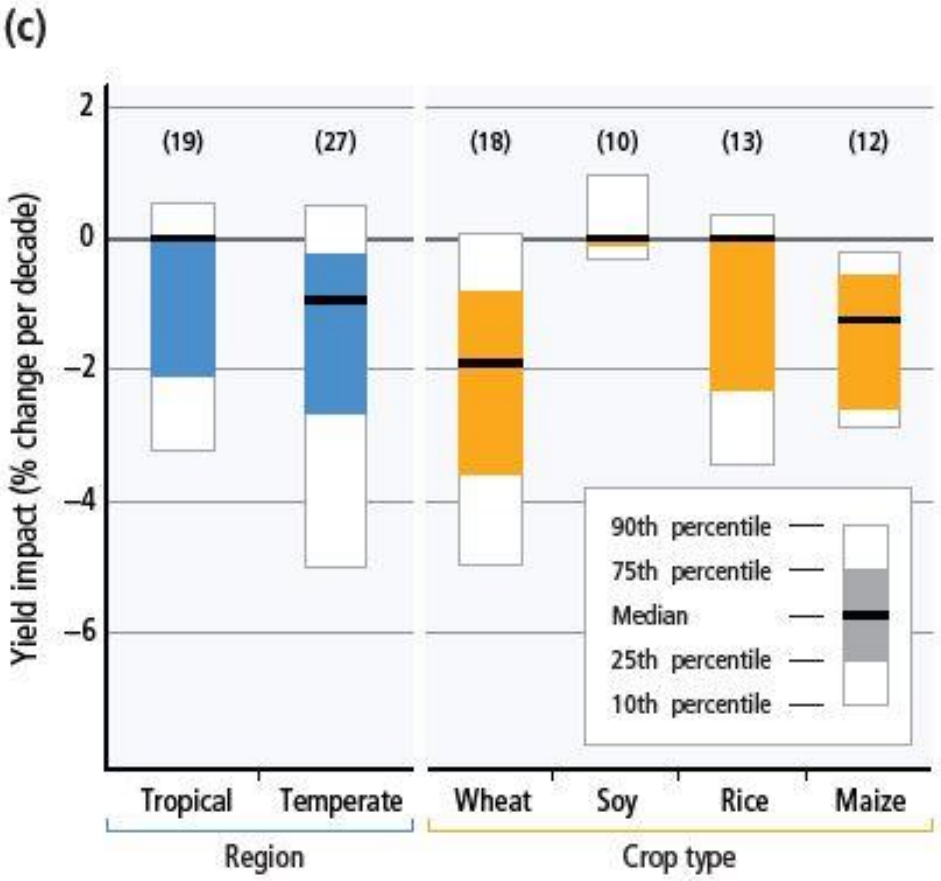


Estimated net impact of climate trends for 1980–2008 on crop yields for major producers and for global production. Values are expressed as percent of average yield.

Lobell et al. 2011

According to the IPCC AR5

- Climate Change has negatively affected wheat and maize yields for many regions. Smaller effects on rice and soybean yields.
- Several periods of rapid price increases following climate extremes in recent times



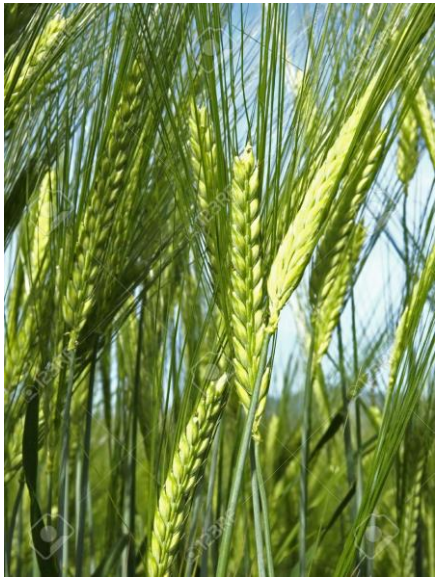
Crop Ecosystem Responses to increasing temperature: Wheat

- no impact on growth during the vegetative growth phase
- impact during the reproductive phase

➢ decreased seedling or leaf mass or pollen sterility.

➢ reduction in biomass, rate of grain filling, and yield

- $<5^0C$ and $>30^0C$ at anthesis damages pollen formation
- Increased photosynthesis and reduced photorespiration; decreased stomatal conductance



Young et al. 2003

Effects of temperature rise on the biomass and grain yield of wheat

- Shortens the duration of all developmental stages

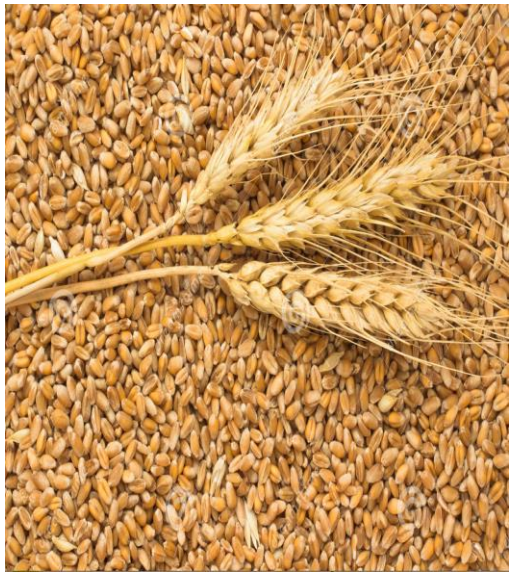
➢there is less time for capture of light, water & nutrients.

➢Biomass production decreases

- Duration of grainfill determines grain yield

➢1^0C increase during grainfill shortens it and reduces the harvest index and grain yield proportionately.

- Partial sterility at anthesis also reduces yield



Young et al. 2003

Crop Ecosystem Responses to increasing temperature: Maize and Sorghum

- SOT are higher for maize and sorghum than in cereal crops, with sorghum showing significantly higher values than maize.
- In temperate areas (suboptimal) – rising temperature will result in increased rates of germination, emergence, and viability
- In tropical areas (supraoptimal) – rising temperature results into reduced germination, emergence and viability, esp. maize.

Young et al. 2003

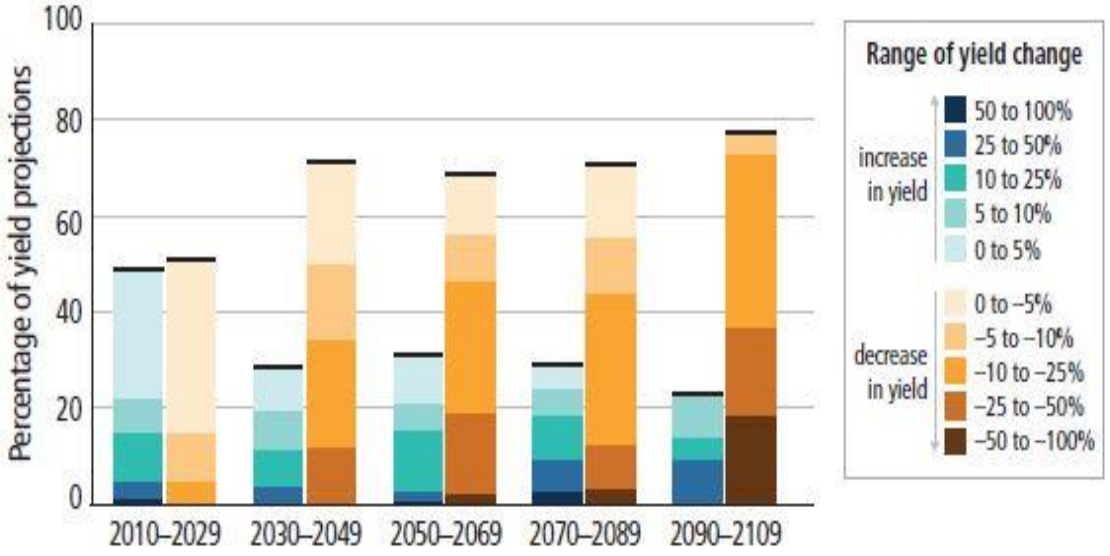
Effects of temperature rise on photosynthesis and respiration in Maize and Sorghum

- C4 photosynthesis is more tolerant of high temperatures than C3
- Due to absence of photorespiration
- C4 photosynthetic efficiency declines with temperature above 35^0C with some inactivation at 40^0C and above

Young et al. 2003

Projections according to the IPCC AR5

- Local and Global temperature increase of 20C & 40C or more above late 20th century levels, respectively.
- Impacts on wheat, rice and maize production in tropical & temperate regions.
- Large risk to food security and agricultural yields in the coming years.



Conclusions

- The most direct and threatening impact on crop production is temperature extremes.
- a consistent yield loss in major crops like maize, sorghum, wheats, and rice in the future
- C4 plants are more tolerant to temperature stress than C3 plants
- More decline in agricultural productivity of tropical areas

Thanks for listening!

Questions?