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Physiological response of C₃, C₄ and CAM plants in changeable climate

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Abstract
Climate Change is a serious global problem due to increase the global average surface temperature. The global average surface temperature increased by 1.5-4.5°C over the next 100 years. It is primarily caused by the building up of Green House Gases (GHG) in the atmosphere. Global Warming is a specific example of the broader term "Climate Change". C_3 photosynthesis is an excellent compromise of photosynthetic efficiency due to photorespiration. C_4 photosynthesis is suited to maintained photosynthesis and productivity for plants that have evolved in drier and warmer environments. CAM plants acclimated days and night photosynthetic process differentially to temperature. Moreover, within C_3 species, evergreen woody plants and perennial herbaceous plants showed greater temperature homeostasis of photosynthesis (*i.e.*, the photosynthetic rate at high growth temperature divided by that at low-growth temperature was close to 1.0 μmol CO2 m-2 s-1) than deciduous woody plants and annual herbaceous plants. It is considered that these differences in the inherent stability of temperature acclimation of photosynthesis would be reflected by differences in the limiting steps of photosynthetic rate. The largest negative yield impacts are projected for wheat crop (1°C rise in temperature reduces 4-5 million tonnes of wheat yield). Overall, millet and sorghum yields are projected to be slightly higher under climate change. The changes in climate parameters are being felt globally in the form of changes in temperature and rainfall pattern. The global atmospheric concentration of carbon dioxide is largely responsible for global warming, which will reach up to 770 ppm in end of 2100. The total average impact may be positive or negative depending on the climatic scenarios. But most scenarios show that climate change will have an overall negative impact but not on Indian's agriculture until 2050. By the year 2080 when temperature increase is very largely then Indian agriculture will suffer.

Keywords: temperature adaptation, temperature acclimation, C₃, C₄ and CAM photosynthesis

Introduction
Climate change is resulting in increases in the daily, seasonal, and annual mean temperatures and precipitation which experienced by plants and animals. Moreover, climate change will increase the intensity, frequency, and duration of abnormally low and high temperatures (Tebaldi *et al*. 2006; Christensen *et al*. 2007, Kevin E. and Trenberth 2011) [57, 11, 32]. Precipitation and temperature are limits plant growth and is also a major determining factor in the distribution of plants across different environments (Rebecca Boehm *et. al*. 2016; Mittler 2006) [50, 41]. The plants cannot move from unfavorable to favorable temperature conditions, the ability to withstand and a climate to environmental temperature variation is essential for plant survival. Photosynthesis has been recognized as one of the most temperature-sensitive physiological processes in plants, that underlie the temperature response of photosynthesis and its acclimation is important to both agriculture and the environment. The photosynthesis and temperature response can be described in a parabolic curve having an optimum temperature, and the photosynthesis is inhibited at both low and high temperatures (Berry and Bjo¨rkman 1980) [18]. The most of plants show capacity to adjust their photosynthesis with increasing of temperatures. The most typical plants shift the photosynthesis with increase of temperature like seasonal temperature shifts that allows the plants to increase photosynthetic efficiency with increasing of temperature (Berry and Bjo¨rkman 1980; Yamori *et al*. 2005, 2010a) [18, 75]. The inherent ability for temperature acclimation of photosynthesis is different with different photosynthetic pathways like; C3, C4, and crassulacean acid metabolism (CAM) pathway. (Oberhuber and Edwards 1993; Kubien and Sage 2004; Osborne *et al*. 2008) [43, 33, 44] suggested that C4 plants required arid regions with high temperatures, so it have good ability for photosynthetic acclimation to high temperature than C3 plants. In C3 plants have been observed inter specific differences in temperature acclimation of photosynthesis. (Hill *et al*. 1988 Read 1990; Cunningham and Read 2002) [25, 28, 14] observed the inherent ability for

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temperature acclimation of photosynthesis appears between temperate evergreen species and tropical evergreen species, between cold sensitive species and cold tolerant species (Yamori *et al*. 2010b) [75], and even among ecotypes of the same species, depending on their original habitats (Bjorkman *et al*. 1975; Pearcy 1977; Slatyer 1977) [5, 47, 54]. However, Campbell *et al*. (2007) [10] observed no difference in the level of temperature acclimation of photosynthesis among grasses and woody plants. So there is need identify ability of plants for photosynthetic temperature relationship between groups of plants, and also clarify to predict how climate change and changing temperatures will affect on photosynthetic process of different group of plants. In this review article, we first summarize the differences in photosynthetic response of in C3, C4, and CAM plants in changeable climate and growing temperature, and also summarize typical and classic temperature acclimation and various environmental conditions response with photosynthesis pathway of C3, C4, and CAM plants, based on (Farquhar *et al*. 1980; von Caemmerer 2000) [18, 64] models for photosynthesis. Then we consider the physiological and biochemical mechanisms for temperature acclimation of photosynthesis and also the limiting step for photosynthetic rate at various temperatures level. The CAM plants showing clear differences between day and night temperature responses on photosynthesis. The diurnal temperatures variation is very high in deserts where many CAM plants are found. We discuss the CO_2 fixation rates at night and chloroplast electron transport rates in the day in two CAM species grown at two different temperature regimes. Finally, we evaluate the response of higher plants from the pool of published data in reference to photosynthetic temperature acclimation, and also describe plant types (i.e., functional types and photosynthetic types) have the better ability for photosynthetic acclimation to temperature.

Climate change

The changes in climate parameters are being felt globally in the form of changes in temperature and rainfall pattern. The global atmospheric concentration of carbon dioxide, a greenhouse gas (GHG) largely responsible for global warming, has increased from a pre-industrial value of about 280 ppm to 387 ppm in 2010. Similarly, the global atmospheric concentration of methane and nitrous oxides, other important GHGs, has also increased considerably resulting in the warming of the climate system by 0.74°C between 1906 and 2005 (*IPCC, 2013*) [30]. Of the last 12 years (1995–2006), 11 years have been recorded as the warmest in the instrumental record of global surface temperature (since 1850). The global average sea level rose at an average rate of 1.8 mm per year over 1961 to 2003. This rate was faster over 1993 to 2003, about 3.1 mm per year (*IPCC, 2007 a*) [29]. There is also a global trend of an increased frequency of droughts as well as heavy precipitation events over many regions. Cold days, cold nights and frost events have become less frequent, while hot days, hot nights and heat waves have become more frequent. It is also likely that future tropical cyclones will become more intense with larger peak wind speeds and heavier precipitation. The IPCC (2007) [29] projected that temperature increase by the end of this century is expected to be in the range 1.8 to 4.0°C. For the Indian region (South Asia), the IPCC projected 0.5 to 1.2°C rise in temperature by 2020, 0.88 to 3.16°C by 2050 and 1.56 to 5.44°C by 2080, depending on the future development scenario (*IPCC 2007 b*) [29]. Overall, the temperature rise is likely to be much higher during the winter (*Rabi*) rather than in the rainy season (*Kharif*). It is projected that by the end of the 21st century, rainfall over India will increase by 10-12% and the mean annual temperature by 3-5°C.

According to climate change model of forecast experiments from 16 groups (11 countries) and 23 models collected at PCMDI, the global surface temperature is going to increase averages 0.1°C per decade for the first two decades of the 21st century and the across all scenarios, the average increasing of temperature is 0.2°C per decade for that time period (IPCC 2007) [29], Fig. 2.

India is a country which has different types of climate and also all types of vegetation like C3 plants, C4 plants and CAM plants. Growth of these crop and non-crop plants depending on the particular climatic condition and its adoption. The climatic factors are directly responsible for these plants adoption and survival which is shown in fig.5.
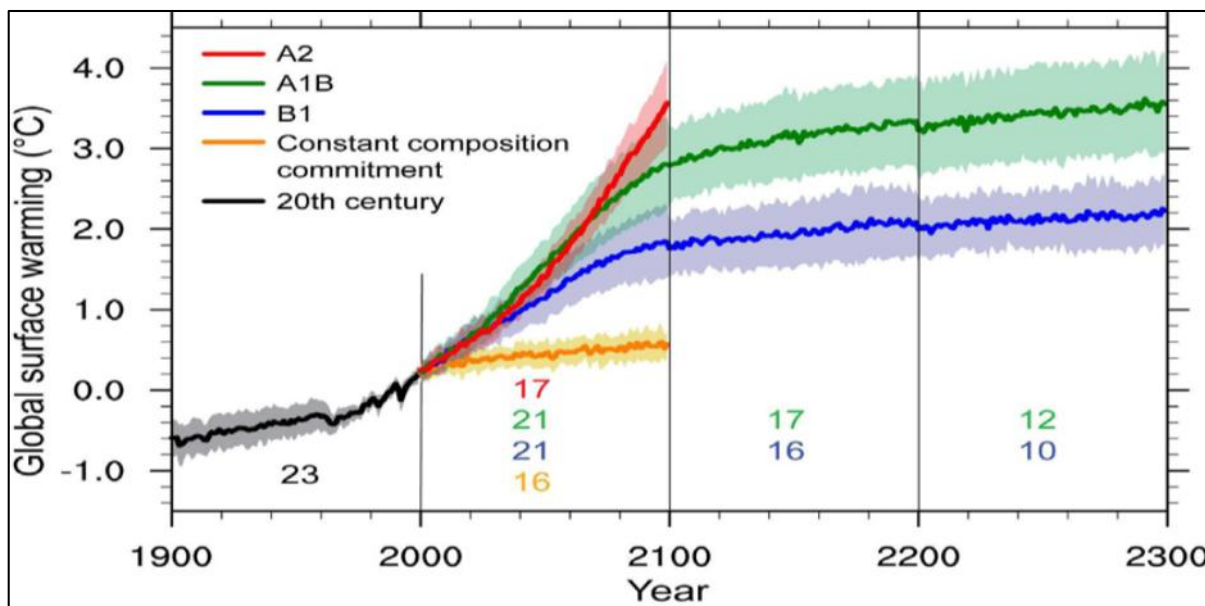

Fig 2: Global surface temperature forecast from climate change model experiments from 16 groups (11 countries) and 23 models collected at PCMDI (over 31 terabytes of model data). Source: IPCC (2007)
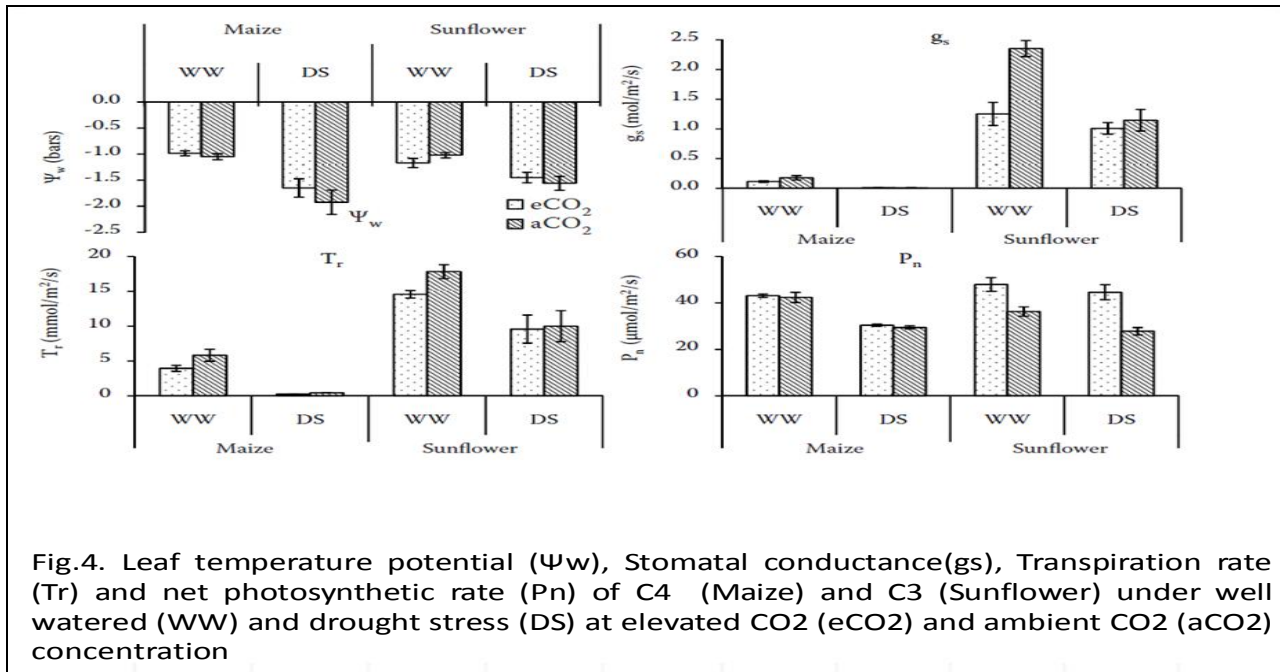
Fig.4. Leaf temperature potential (Ψw), Stomatal conductance(gs), Transpiration rate (Tr) and net photosynthetic rate (Pn) of C4 (Maize) and C3 (Sunflower) under well watered (WW) and drought stress (DS) at elevated CO2 (eCO2) and ambient CO2 (aCO2) concentration
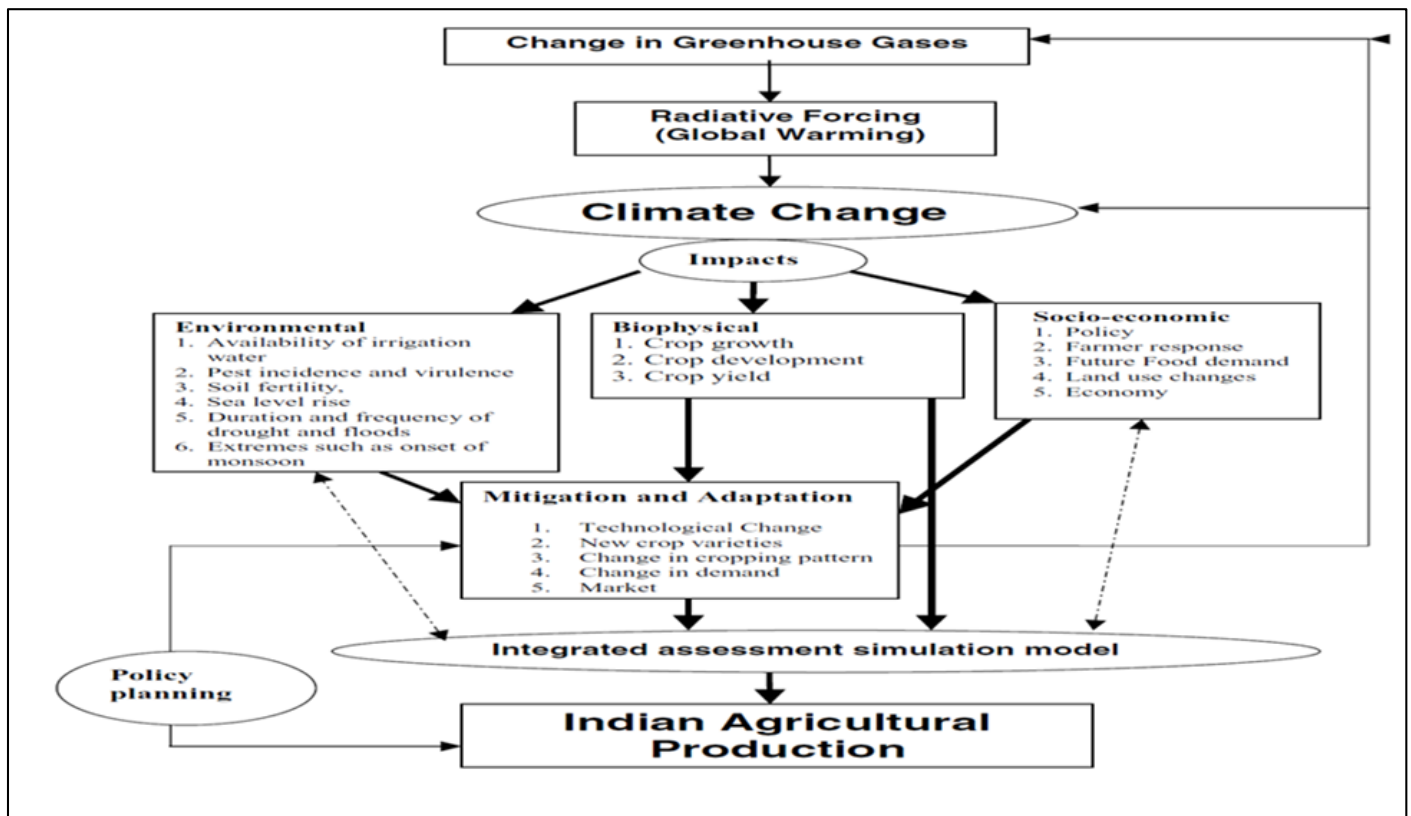

Fig 5: Driving force for assessments of vulnerability of Indian agriculture in changeable climate.

Difference in photosynthesis of C3, C4, and CAM plants
Global plant distribution based on photosynthetic pathway; C3 species represent approximately 85 % of all higher plant species, C4 species account for about 5 %, and CAM species make up the remaining 10 %. C4 plants are thought to have originated in relatively arid regions, where high temperatures occur in combination with water stress, whereas desert CAM plants are adapted to drought in arid regions, where day and night temperatures can show drastic swings (although some CAM species occur in tropical rainforests as epiphytes). Because of adaptation to their respective growth conditions over evolutionary time scales, photosynthetic characteristics greatly differ among C3, C4, and CAM plants (Fig. 1). (Furbank and Hatch 1987; Jenkins *et al*. 1989) [20, 31] say that C4 plants photosynthesis has a biochemical CO_2 concentrating mechanism that increases CO_2 concentrations by 10–100-fold at the catalytic sites of Rubisco in the bundle sheath compared to ambient air. In C4 plants, CO_2 is hydrated to HCO_3^- by carbonic anhydrase and assimilated to oxaloacetate (OAA) with substrates of phosphoenolpyruvate (PEP) by phosphoenolpyruvate carboxylase (PEPC) located in the cytosol. PEP is produced from pyruvate and ATP, catalyzed by pyruvate phosphate dikinase (PPDK) located in the chloroplast. OAA is reduced to malate, or alternatively is

transaminated to aspartate in a reaction with alanine. Whether malate, aspartate or a mixture of the two are formed, depends on the subtype of the C4 species. Among C4 plants, there are three subtypes, based on the C4 acid decarboxylation enzyme: NADP-malic enzyme (NADP-ME) type, NAD-malic enzyme (NAD-ME) type, and phosphoenolpyruvate carboxykinase (PCK) type. Malate (or aspartate) is transported to the vascular bundle sheath cells and is finally decarboxylated, producing CO2 and pyruvate. CO2 is then fixed by Rubisco in the chloroplasts of the bundle sheath cells, which have a normal Calvin cycle, as in C3 plants. CAM photosynthesis also has a biochemical CO2 concentrating mechanism, but it requires a temporal separation of the C3 and C4 components, compartmentalized within a common cellular environment. By opening stomata and incorporating CO2 at night when evapotranspiration rates are low, CAM plants can achieve high water use efficiencies than for C4 and C3 species, respectively (Nobel 1996) [42]. In C3 plants, CO2 diffuses through the stomata and the intercellular air spaces, and eventually arrives in the chloroplast. Carbonic anhydrase catalyses the reversible hydration of CO2 to HCO3 - in the aqueous phase (i.e., chloroplast, cytosol, and plasma membrane) and is thought to maintain the supply of CO2 to Rubisco by speeding up the dehydration of HCO3-, although the importance of carbonic anhydrase may not be high in C3 plants (Price *et al*. 1994). In the chloroplast, Rubisco catalyzes the carboxylation of ribulose-1, 5-bisphosphate (RuBP) by CO2 and produces 3-phosphoglyceric acid (PGA). ATP and NADPH produced by photosynthetic electron transport in the thylakoid membranes are used to produce sugars and starch, as well as the regeneration of RuBP from PGA in the Calvin–Benson cycle (Wataru Yamori *et al*. 2013) [75]. CAM is divided into four distinct phases in a day: (phase I) nocturnal uptake of CO2 via stomata, CO2 fixation mediated by PEPC, malate synthesis by NAD(P)-malate dehydrogenase (NAD(P)-MDH) in the cytosol, and accumulation of malic acid in the vacuole of the mesophyll tissue; (phase II) transition when stomata remain open for CO2 uptake at dawn; (phase III) decarboxylation of malic acid and re-fixation of the regenerated and concentrated CO2 by Rubisco behind closed stomata; and (phase IV) transition when stomata reopen again for CO2 uptake at dusk. Two subtypes of CAM plants, NAD (P)-ME type and PCK type, are known, based on the difference in the reaction of decarboxylation of malate during the day (Dittrich *et al*. 1973, 1976) [15, 16].
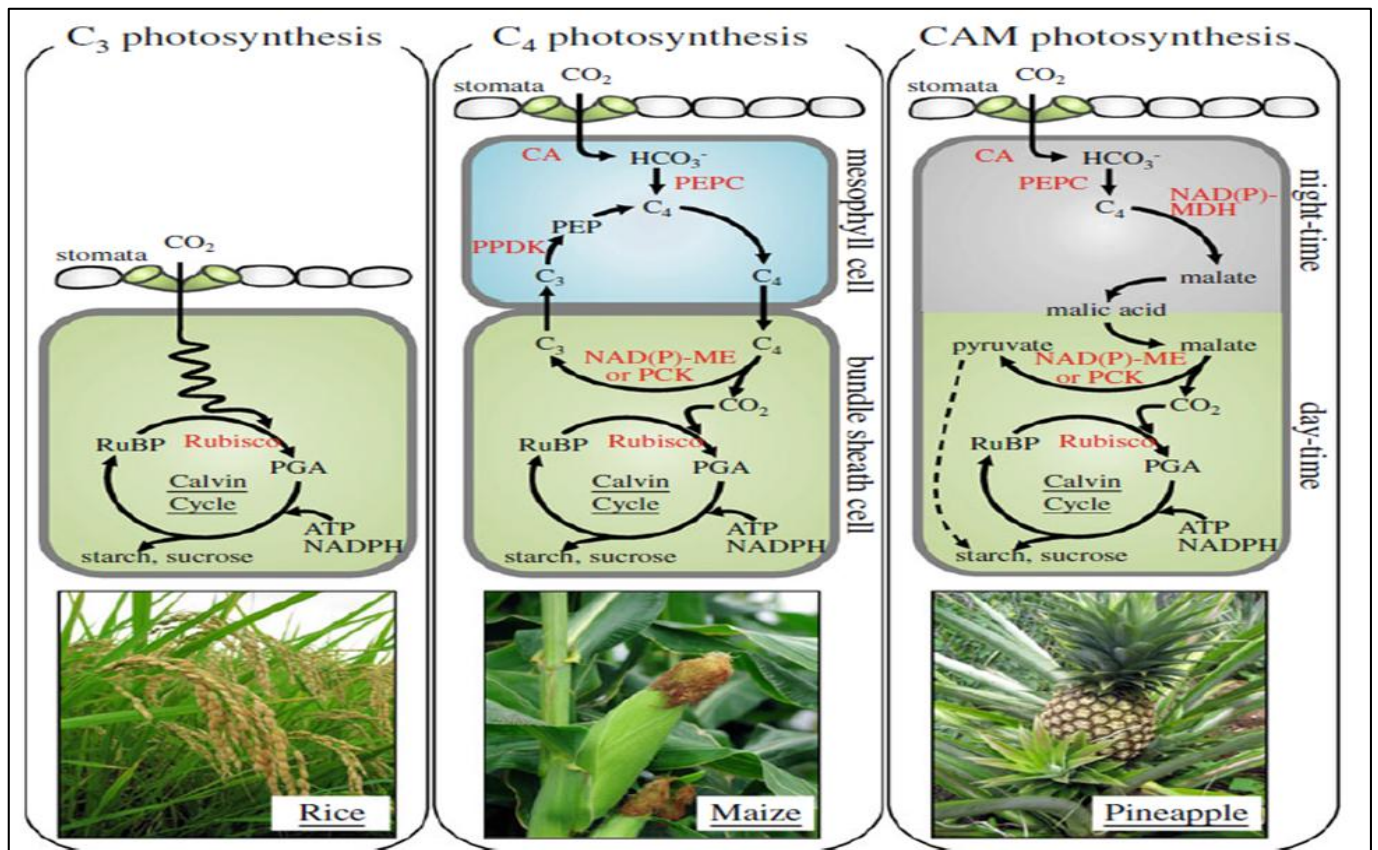

Fig 1: Pathway difference in C3, C4 and CAM plants. (Sources: Wataru Yamori 2013)

Temperature acclimation of photosynthesis for long time on plants at low and high temperature

At most of the time some plants have greater photosynthetic capacity at lower temperatures but some plants have greater capacity for photosynthesis at higher temperatures (Berry and Bjorkman 1980, see Fig.3) [18, 4]. Figure 3 is going to summarizes example of temperature acclimation of photosynthesis, along with the proposed mechanisms. Generally speaking, photosynthetic acclimation to low temperature involves an increase in the capacity of temperature-limited enzymes, whereas photosynthetic acclimation to high temperature involves increased heat stability of the photosynthetic apparatus. The photosynthesis–temperature curve is often symmetrical or bell-shaped (Yamori *et al*. 2010b) [75]; however, the curve is more shallow and broad when Rubisco limits photosynthesis and more peaked when electron transport limitations dominate (Sage and Kubien 2007) [51], and there can be a rapid fall-off of photosynthetic rate at high temperatures (Salvucci and Crafts-Brandner 2002) [52]. The plants grow at high temperature level

need greater heat tolerance of thylakoid membranes and photosynthetic enzymes, to enable greater photosynthetic rates at high temperatures. Proton leakiness of the thylakoid membrane has been frequently proposed as a problem at high temperatures, since it could lead to the impairment of the coupling of ATP synthesis to electron transport (Havaux 1996; Pastenes and Horton 1996; Bukhov et al. 1999, 2000) [23, 46, 8]. Increases in cyclic electron flow around PSI at high temperature can compensate for thylakoid leakiness, allowing ATP synthesis to continue (Havaux 1996; Bukhov et al. 1999, 2000) [23, 8]. Thus, for photosynthetic acclimation to high temperature, greater stability of membrane integrity and increases in electron transport capacity are involved. It should be noted that damage to thylakoid reactions by moderate heat stress is not caused by damage to Photosystem II (PSII) itself, since damage to PSII only occurs at high temperatures, often above 45 _C (Terzaghi et al. 1989; Gombos et al. 1994; Yamane et al. 1998) [58, 21, 71]. Low temperatures loving have higher amounts of photosynthetic enzymes, such as enzymes of the photosynthetic carbon reduction cycle, including Rubisco, sedoheptulose-1,7-bisphosphatase (SBPase), and stromal mfructose-1,6-bisphosphatase (Holaday et al. 1992; Hurry et al. 1994, 1995; Strand et al. 1997, 1999; Yamori et al. 2005, 2011b) [77, 26, 55, 27], and those of sucrose synthesis, including sucrose phosphate synthase (SPS) and cytosolic fructose-1,6-bisphosphatase (Guy et al. 1992; Holaday et al. 1992; Hurry et al. 1994, 1995; Strand et al. 1997, 1999) [26, 55, 27]. Large amounts of these enzymes would be needed to compensate for decreased activities of the enzymes at low temperatures. Compensation for decreased activities at low temperatures can also be achieved by shifting protein expression to produce isoforms with improved performance at low temperature.

In some plant species, the Rubisco activation state decreases at high temperature (Yamori et al. 2006b, 2012; Yamori and von Caemmerer 2009) [76, 77]. Mechanistically, it has been proposed that the activity of Rubisco activase is insufficient to keep pace with the faster rates of Rubisco inactivation at these high temperatures (Crafts-Brandner and Salvucci 2000;

Salvucci and Crafts-Brandner 2004a; Kurek et al. 2007, Kumar et al. 2009; Yamori et al. 2012) [78, 52, 35, 54]. In plants transferred to elevated growth temperatures, a different isoform of Rubisco activase that confers heat stability can be produced by some species, including spinach (Crafts-Brandner et al. 1997) [52], cotton (Law et al. 2001) [36] and wheat (Law and Crafts- Brandner 2001) [37], though not all species seem to have this ability. Thus, maintenance of a high-activation state of Rubisco via expression of heat stable Rubisco activase and increases in Rubisco activase contents at high temperature could be important for high-temperature acclimation.

The mitochondrial respiration and net photosynthetic rate also affected by thermal acclimation (Fig. 3). Whereas the optimum temperature of photosynthesis is generally between 20 and 30°C, the optimum temperature for respiration reduction is identified by enzymatic activity reduction that is above 45 °C. Therefore, above the thermal optimum for photosynthesis, photosynthetic rates decrease, but respiration rate continues to increase. Changes in all these factors for low- or high-temperature acclimation could result in an alteration in the temperature response of photosynthesis. Plants exhibit a set of characteristic responses to growth temperature (Yamori et al. 2009, 2010b) [75]. This set of responses has been termed a ''syndrome of temperature acclimation'' (Yamori et al. 2010b; see also Way and Yamori 2013) [75, 68, 78]. Leaves that develop at high temperatures also often a climate respiration, such that they have lower respiration rates at a common measurement temperature than do leaves grown in colder environments (Atkin and Tjoelker 2003; Atkin et al. 2005; Yamori et al. 2005) [76 1, 2], and photosynthesis shows less acclimation potential to a change in temperature than dark respiration in mitochondria (Atkin and Tjoelker 2003; Way and Sage 2008a; Ow et al. 2010; Way and Oren 2010) [2, 68]. While the temperature effects on respiration are outside the scope of this paper, we discuss the interplay between temperature responses of respiration and photosynthesis elsewhere in this issue (Way and Yamori 2013) [76].
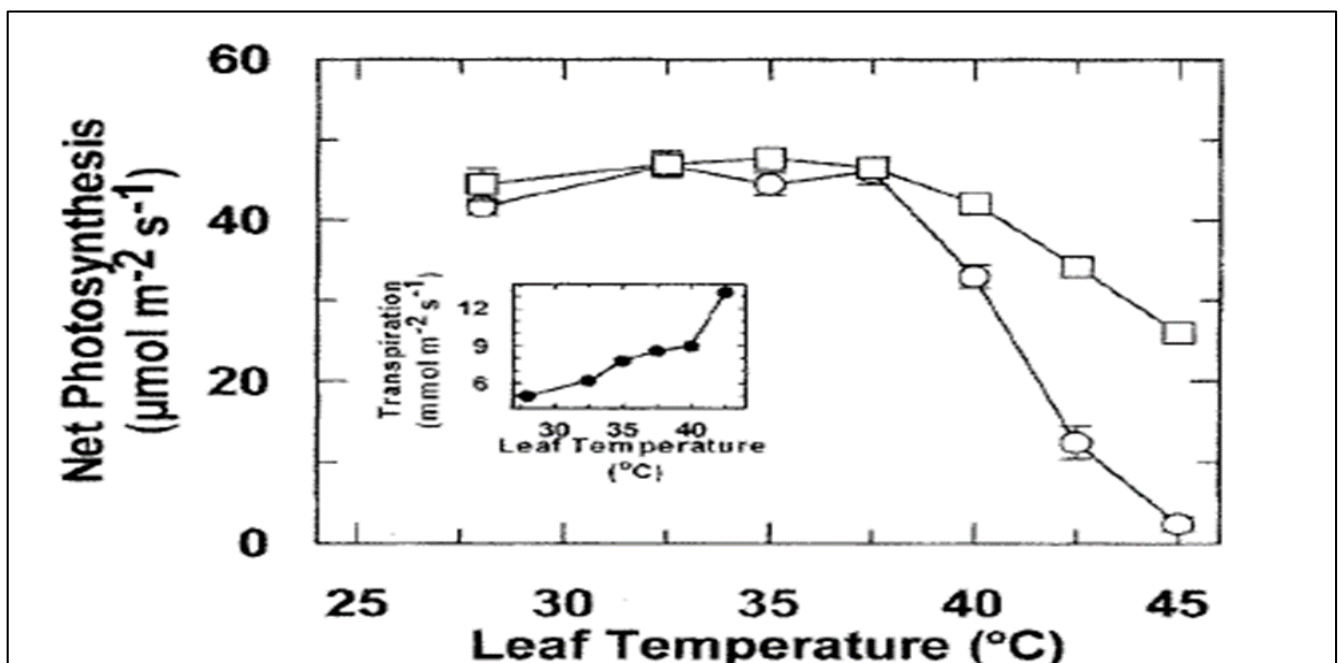

Fig 3: A classic, idealized diagram of temperature acclimation of the response of photosynthesis to temperature. The proposed mechanisms underlying the temperature acclimation of photosynthesis are summarized

Response of c3 and c4 plants in changeable climate
Response of C4 (maize) and C3 (sunflower) crop plants to drought stress and enhanced carbon dioxide concentration
C_3 crop responded significantly and positively with eCO_2 under both well-watered and drought stress treatments for root: shoot ratio while C_4 crop showed a better response only with the drought stress environment. Root volume showed a positive significant response with CO_2 concentration enhanced over ambient level and the increment in root volume was 146% and 340% in sunflower and maize crops, respectively. The leaf water potential, stomatal conductance and transpiration showed a decreasing trend in both the crops with drought stress and eCO_2 showed an ameliorative effect leading to higher Photosynthetic rates in sunflower crop under drought stress treatment. The study confirmed the beneficial effect of eCO_2 in maize and sunflower by ameliorating the adverse effects of drought stress. C_3 species would produce more biomass than C_4 species, when grown individually under enhanced CO_2 Stomatal conductance (gs) of both ambient and elevated CO_2 grown sunflower and maize plants were influenced by drought stress ($P \leq 0.01$). Stomatal conductance of well watered sunflower (46.8%) and maize (35.6%) plants was significantly reduced by growth under elevated CO_2 conditions ($P \leq 0.01$) (Vanaja et. al. 2011) [63].

The reduction of stomatal conductance is the primary impact of increased atmospheric CO_2 concentration on plants (V. Volpe et al. 2011; Madegowda Madhu and Jerry L. Hatfield. 2014) [61, 39]. Considerably lower stomatal conductance at elevated CO_2 was reported in some other crops such as sugarcane (C.J. Stokes et al. 2016) [9], barley (Attipalli R et. al. 2010) [3], rice (Uprety et al. 2002) [60] and wheat (Wall 2001) [66]. Elevated CO_2 reduced transpiration by 18% and 32% in sunflower and maize under well watered condition. It appears eCO_2 exposure tends to enhance soil moisture conservation, which can improve overall plant water relations and facilitate higher biomass production. Reduction in the rates of net photosynthesis under water stressed conditions

was less in C_4 plants as compared to C_3. The root length in sunflower and root volume in maize was significant for CO_2 levels. Highly significant response was observed for maize with the interaction of CO_2 and moisture levels. The root: shoot weight ratio response was highly significant in maize with moisture levels. (Vanaja et. al. 2011 and Vanaja et. al. 2015) [62, 63].

Elevated CO_2 helped in amelioration of adverse effects to a larger extent in both the crops. Leaf, stem, root dry weights of maize decreased due to moisture stress by 58%, 50% and 78% under aCO_2; however, eCO_2 helped the plants to ameliorate the adverse affects by improving them to the extent of 26%, 47% and 19%, respectively over aCO_2. The decrease in these parameters due to moisture stress in sunflower was 53%, 48% and 48% under aCO_2; however, eCO_2 improved leaf, stem, root dry weights to the extent of 30%, 21% and 17%, respectively (Table.1 Given by Vanajaet. et. al. 2011) [63]. The improvement in root length was 400% in maize and 104% in sunflower under the ED over AD. The root volume decreased by 70% in maize and 59% in sunflower under AD, which was ameliorated to the extent of 83% and 58%, respectively, by eCO_2. Drought stress led to a decrease in leaf area by 71% and 64% in maize and sunflower respectively. Elevated CO_2 might enhance the drought tolerance of plant by lowering osmotic potential (Tyree and Alexander 1993). Beneficial affects eCO_2 in both maize (C_4) and sunflower (C_3) crops more so under drought stress conditions. The root: shoot ratio in sunflower improved under EW and ED conditions by 28% and 16%, respectively over AW and AD Thomas, Prasad, Boote and Allen, 2009; studying the combined effects of temperature (28/18°C and 34/ 24°C; day/night) and [CO2] (350 and 700 ppm) on the composition of red kidney beans seeds, also found that seed composition was unaffected by elevated [CO_2], but seeds produced at 34/24°C showed decreased glucose concentration (44%) and significantly increased concentrations of sucrose (33%) and raffinose (116%) compared to the 28/18 °C treatment.

Table 1: Different plants biometrics of C4 (Maize) and C3 (Sunflower) under elevated CO2 (eCO2) and ambient CO2 (aCO2) concentration (Vanajaet. Al. 2011) [63]

Particulars	Maize		Sunflower	
	aCO2	eCO2	aCO2	eCO2
Root characters				
Root length	13.1	−39.3 (400)	30.5	−1.16 (104)
Root volume	69.7	12.0 (83)	58.6	24.7 (58)
Root dry weight	78.2	63.2 (19)	47.8	39.5 (17)
Shoot characters				
Shoot length	31.5	28.4 (10)	39.2	23.8 (39)
Stem dry weight	50.4	26.5 (47)	48.4	38.1 (21)
Leaf area	71.1	49.8 (30)	63.6	44.0 (31)
Leaf dry weight	58.3	43.4 (26)	53.4	37.4 (30)
Root and shoot characters				
Total dry weight	64.3	45.9 (29)	50.7	38.1 (25)
Root shoot ratio	39.9	39.6 (1)	−6.6	3.1 (147)

Response of CAM plants on photosynthesis at changeable climate in day and night
The responses of photosynthetic reactions at difference in temperature during the day and night have not been seen on CAM species. We may expect differential temperature responses of the different phases of CAM photosynthesis in desert CAM plants, since these species often experience a drastic alteration in day and night temperatures during a 24-h period. Thus, we analyzed the temperature responses of

nocturnal CO2 fixation rates and also chloroplast electron transport rates in the day.
The response of temperature on CO2 fixation rates at night differed depending on the growth temperature. CO2 fixation rates at low temperatures were greater in 20°C grown plants than in 30°C grown plants, whereas CO2 fixation rates at high temperatures were greater in 30°C grown plants than in 20°C grown plants. The average optimum temperature for nocturnal CO2 fixation rates were increased by elevated growth

temperatures. The 30°C grown plants showed higher optimum temperatures for electron transport rate in the day than 20°C grown plants. So it's clear that the optimum temperature for daytime electron transport rate could not be obtained. Thus, both CO_2 fixation rates at nighttime and electron transport rates in the daytime acclimated to shifts in growth temperatures (Wataru Yamori *et. al.* 2013) [75].

Leaf mass per unit area (LMA) and leaf nitrogen content were greater in CAM plants grown at 20°C compared with those from 30°C (Fig.3 of Wataru Yamori *et. al.* 2013) [75]. Temperature acclimation for photosynthesis is related to leaf nitrogen economy, since more than half of leaf nitrogen is in the photosynthetic apparatus, and thus, photosynthetic capacity is strongly related to leaf nitrogen content (Evans 1989; Makino *et al.* 2003; Hikosaka 2004; Yamori *et al.* 2010b) [75, 40, 17]. Increase in leaf nitrogen content by low-growth temperatures are considered to be a compensatory response to low temperature, which decreases enzyme activity.

The CO_2 fixation rate at night is mainly determined by the rate of CO_2 uptake by PEPC and malate formation by NAD(P)-MDH, whereas in the light, it is determined by the decarboxylation rate by NAD(P)-ME, CO_2 assimilation rate by Rubisco, and photosynthetic electron transport in the thylakoid membranes. During the daytime, the optimum temperature for the three determining processes would be expected to be adapted to higher daytime temperatures, whereas at night, PEPC and NAD (P)-MDH would be adapted to low temperatures, representative of the cooler nights where they operate.

There is lake of deep studies on broad temperature response on CAM plants. An efficient and stable transformation in K. fedtschenko has been developed a model for CAM system for manipulate photosynthetic reactions by antisense suppression and over expression of particular genes (Borland *et al.* 2009; Wataru Yamori *et al.* 2013) [6, 75]. So, we need to analyze the limiting process of CAM photosynthesis like C3 and C4 photosynthesis.

Conclusions and future perspective

Climate Change is a serious global environmental concern to increase the global average surface temperature by 1.5-4.5 C over the next 100 years. It is primarily caused by the building up of Green House Gases (GHG) in the atmosphere. Global Warming is a specific example of the broader term "Climate Change". C_3 photosynthesis is an excellent compromise of photosynthetic efficiency with some photorespiration in temperate conditions. C_4 photosynthesis is suited to maintained photosynthesis and productivity for plants that have evolved in drier and warmer environments. On an average increasing of 1.0°C temperature reduced 17 % crop yields in most of the crops (Lobell and Asner 2003) [38]. Cereal production growth for a range of crops in SSA is projected to decline by a net 3.2 percent in 2050 as a result of climate change. The largest negative yield impacts are projected for wheat (C3 plant) followed by sweet potatoes. Overall, millet and sorghum (C4 plants) yields are projected to be slightly higher under climate change. The changes in climate parameters are being felt globally in the form of changes in temperature and rainfall pattern. 1°C rise in temperature can possibly result in 4-5 million tonnes of loss in wheat production in India. It is estimated that by 2020, food grain requirement would be almost 30-50% more than the current demand. There is need to start a new "green revolution" in world agriculture to increase crop yields for future food demands (Fischer and Edmeades 2010) [19]. For achieving this goal, we must to know about climatic limiting factors for photosynthesis and also know about behavior of photosynthesis in changes of temperature at different plants species like C3 plants, C4 plants and CAM plants. We found clear differences in the ability to acclimate photosynthesis to increases in growth temperature between species from differing photosynthetic pathways. C3 plant species tended to maintain the same photosynthetic rate at their growth condition across a range of growth temperatures (it have better homeostasis) than C4 plant species. In this article we also clarified that, within C3 plant species, evergreen woody plants and perennial herbaceous plants showed greater temperature homeostasis of photosynthesis than deciduous woody plants and annual herbaceous plants. C4 plant species have higher optimum temperatures of photosynthesis, but a reduced ability to acclimate the temperature optimum of photosynthesis to growth temperature, than C3 plant species. In CAM plants, the temperature response for CO_2 fixation at night was much different from that of chloroplast electron transport in the day, and that both CO_2 fixation rates and electron transport rates acclimated to shifts in growth temperatures. This response is considered to be an adaptive response of CAM plants for dry environmental conditions. The new technology of transformation make it possible by manipulate over expressing particular genes which is responsible for photosynthesis. It's also increase by penetration of bimolecular for enhancing leaf photosynthesis. There is no single bimolecular for the limiting of photosynthesis differs depending on plants species, and it also differs depending on growth and measuring temperatures over a single plant species (Yamori et al. 2010b) [75]. So climate change is the main task by which prediction we can full fill the feature requirement of foods of the world population. There is more attention paid to analyze differences in the photosynthetic limitations on different species of plants and also enzymatic response of plants at different temperature level in reference to photosynthesis and also the impact on control of carbon dioxide fixation in different plant species (C3 plants, C4 plants and CAM Plants) at different climatic condition.

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