

Physiological Adaptations of Vegetables to Climate Stress

ABSTRACT

Vegetables, being rich in vitamins, carbohydrates, minerals, proteins and antioxidants are essential for overcoming micronutrient deficiencies, offering higher incomes and more employment opportunities per hectare to smallholder farmers compared to staple crops. Major challenges faced by vegetable growers are increased terminal heat stress, rainfall variability leading to flooding, drought, irrigation water availability, salinity, incidence of pests and diseases, extreme weather events. These gets further worsened in the future due to climate change. Vegetables exhibit various physiological adaptations to cope with changing environmental conditions such as enhanced photosynthetic efficiency, improved water-use efficiency, and altered phenological development. Higher temperatures accelerate the life cycle of vegetables cause increased respiration, leading to earlier maturation and potentially lower yields. Increased frequency of heatwaves can cause heat stress, affecting growth and development. Moreover elevated temperatures increase the incidence of pests and diseases, leading to higher crop losses. Changes in precipitation patterns alter water availability, impacting growth and productivity. Nevertheless drought conditions cause stomatal closure limiting water loss besides reducing CO₂ uptake. Excessive rainfall can lead to waterlogging, disrupting root function and nutrient uptake. Variability in climate conditions lead to inconsistent yields, making it challenging for farmers and necessitating adaptive strategies to ensure crop resilience and productivity. Genetic improvement through breeding for heat and drought tolerance helps to develop resilient vegetables. Additionally, agronomic practices like mulching, organic farming, and resource conservation technologies help mitigate the adverse effects of climate change. Understanding these physiological responses could streamline sustainable vegetable production in the face of a changing climate.

Keywords: Climate change, crop physiology, temperature rise, elevated CO₂, salinity, precipitation

Abbreviations: Elevated CO₂ (eCO₂), Free-Air CO₂ Enrichment (FACE), Net photosynthetic rate (P_n), stomatal conductance (g_s)

Introduction

Climate change is one of the significant challenges that plant scientists are currently facing. It has resulted in erratic rainfall, rising temperatures, fluctuations in atmospheric carbon dioxide, ozone levels, variation in sea level and change in weeds, pests, microbes. The changing climate impacts the agricultural production system directly and indirectly affecting food security. Direct effects include the effect on production systems brought by a change in temperature levels and rainfall distribution. When changes are made to other species, such as pollinators, pests, disease vectors and invading species, it has an indirect effect on production. Thus crop production and climate change are intrinsically linked affecting the global food production.

According to the Global Monitoring Lab's annual report, the average amount of carbon dioxide in the atmosphere reached 417.06 ppm in 2022 and the mean rise in atmospheric carbon dioxide between 2021 and 2022 was 2.13 ppm, marking the 11th year in a row where the increase was greater than 2 ppm (NOAA, 2023). The consequences of elevated atmospheric carbon dioxide, changes in temperature and precipitation patterns were anticipated to have significant impacts on distribution, relationships and ecophysiology of plants (IPCC, 2014). Prolonged exposure to elevated carbon dioxide resulted in photosynthetic adaptation due to increased soluble sugars which lead to imbalance in C:N ratio, faster leaf senescence and/or limited growth rate affecting crop yield and quality. It is believed that crop quality is a multifaceted and a complex process that involves growth, assimilation, partitioning, storage, pre- and post-harvest as well as nutritional, technological and environmental components (Hay & Porter, 2006).

Extreme weather events and variations in seasonal climate impacted rainfed agriculture and home garden food production systems in rural areas, leaving people more vulnerable to food and nutrition insecurity (IPCC, 2014). The land and ocean combined global surface temperature data (1880–2019) from the National Oceanic and Atmospheric Administration (NOAA) demonstrated a change of 1.2°C compared to the 1901–2000 average. As

temperatures continues to warm, global average precipitation will also increase by the end of the century. This increase is not, however, expected to be distributed evenly around the globe or throughout the seasons. In many regions around the world, extreme rainfall events may become more frequent and intense, while in other areas dry conditions could worsen and persist for longer period. It is important to note that many areas, particularly in low- and mid-latitude regions, are expected to experience more frequent and severe droughts (IPCC, 2021).

Vegetables are rich source of vitamins, carbohydrates, minerals and proteins. They are the best means of overcoming micronutrient deficiencies, provide much higher incomes and more jobs per hectare to small holder farmers than staple crops. After China, India is the second-largest producer of vegetables worldwide (www.fao.org). According to the National Horticulture Database's (3rd Advance Estimates) report, India produced 204.84 million metric tonnes of vegetables from an area of 11.35 million hectares during 2022-23 (www.apeda.gov.in). Vegetables can be classified as fruit-vegetables such as tomato, cucumber, water melon, peas; roots and tuber vegetables such as carrot, potato, sweet potato, raddish, elephant foot yam; green leafy vegetables like amaranth, celery, cabbage, curry leaves and bulb vegetables like onion and garlic (Abewoy, 2018). Unfortunately these crops are highly vulnerable to unpredictable weather conditions and have high perishability. Vegetable cultivation becomes unprofitable due to crop failures, low yields, poor quality and an increase in pests and diseases caused by changing climatic conditions (Lal *et al.*, 2014). They are sensitive to environmental extremes *viz.*, high temperatures and limited soil moisture. These extremes affect many physiological and biochemical processes like reduced photosynthetic activity, altered metabolism and enzyme activity, tissue heat damage, reduced pollination, and fruit production, etc., which will be exacerbated by climate change (Abewoy, 2018). Climate change presents significant challenges for vegetable farmers, including crop failures, reduced yields, lower quality produce and a rise in pests and diseases. In addition to these issues, other key factors limiting vegetable production are reduced water availability for irrigation, flooding and soil salinity. Therefore, crop physiologists must more effectively address the needs of breeders and processors by evaluating, characterizing, and simulating variations in food quality among different crop varieties and species in the context of climate change (Hay & Porter, 2006).

Effect of CO₂ enrichment in C3 and C4 vegetables

Carbon dioxide is one of the greenhouse gases which has significant direct effects on plant development, physiology and chemistry (Ziska *et al.*, 2008). Elevated carbon dioxide will affect the growth and yield of both C3 and C4 plants by enhancing the net photosynthetic rate (Kimball *et al.*, 2002; Reddy *et al.*, 2010) and improving water use efficiency (Long *et al.*, 2004). Around 96% of plant's dry matter is made up of carbon, hydrogen and oxygen absorbed into organic molecules during photosynthesis (Marschner, 1995). Hence, photosynthesis is at the core of plant's nutritional metabolism and increasing the amount of carbon dioxide available for photosynthesis can have a significant impact on plant growth. According to Ainsworth & Rogers (2007) the development of plants under increased carbon dioxide concentrations of 475–600 ppm results in an average 40% increase in leaf photosynthetic rates. The opening of stomata through which plants exchange gases with the environment are regulated by carbon dioxide concentrations. The stomatal pores close when carbon dioxide concentrations are higher than ambient and they open when carbon dioxide concentrations are lower. Water may flow out of leaves through open stomata which also allow carbon dioxide to permeate into leaves for photosynthesis. As a result, plants can maintain a high photosynthetic rates with lower stomatal conductance at elevated carbon dioxide concentrations (Bunce, 2006). Since photosynthesis and stomatal behaviour are central to plant metabolism, growing plants under elevated carbon dioxide has various secondary effects on plant physiology (Ainsworth & Long, 2005). The increased photosynthesis allows most plants to grow faster and produce dry matter under higher carbon dioxide levels (Zhu *et al.*, 2016). Elevated carbon dioxide (eCO₂) has been widely employed as a gas fertilizer in the cultivation of greenhouse vegetables, especially in recent years (Bisbis *et al.*, 2018). But the positive direct impact of elevated carbon dioxide may be countered by other climate change effects like increased temperature, higher tropospheric ozone concentrations and altered precipitation patterns.

Greenhouse vegetables respond very positively to carbon dioxide enrichment by showing increased dry mass, plant height, and production of leaves and lateral branches (Mortensen, 1987). Long *et al.* (2004) found that, due to increased photosynthetic activity, leaf nonstructural carbohydrates (sugars and starches) per unit leaf area increased by an average of 30–40% under Free-Air Carbon Dioxide Enrichment (FACE) conditions. Carbon dioxide enrichment often improves plant quality, growth habit and the number of flowers by reducing the oxygen inhibition of photosynthesis and increasing net photosynthesis in plants. This enhancement in

photosynthesis forms the basis for the increased growth observed with elevated carbon dioxide concentrations (Mortensen, 1987). As a result, the excess assimilates can either be used directly to promote leaf development in leafy vegetables like lettuce (Hicklenton, 1988) or stored as reserves to support fruit development in areas with high sink potential, such as in tomatoes (Slack, 1986). According to Hamim (2005) a rise in photosynthesis caused by higher carbon dioxide particularly at the onset of a drought, may enhance the solute accumulation of organic acids and sugars necessary for osmotic adjustments. Peet and Willits (1987) reported that increasing the time of carbon dioxide enrichment significantly increased cucumber yield. According to Mortensen (1994), increasing carbon dioxide levels resulted in yield increases of 18%, 19% and 17% for lettuce, carrots, and parsley respectively. The yield of tomato and bell pepper increased by 15% and 11% respectively with elevated carbon dioxide and more light (Fierro *et al.*, 1994). Since elevated carbon dioxide causes the plants to transpire less and assimilate more carbon dioxide, it has been hypothesized that this will improve the water use efficiency (WUE) of C3 species. Drake *et al.* (1997) found that the photosynthetic rate of C3 species increased by approximately 58% as a result of increased carbon dioxide, suggesting that their response to elevated carbon dioxide may be more advantageous compared to that of C4 species.

In C4 species, photosynthesis seems to be saturated at current atmospheric carbon dioxide concentration (Von Caemmerer *et al.*, 1997). This is attributed to the fact that in C4 species, carbon dioxide concentrating mechanisms (CCM) help plants maintain their rate of carbon dioxide absorption even when water supply is limited and stomatal conductance is decreased (Knapp & Medina, 1999). According to Amthor and Loomis (1996) the ability of C4 species to respond to carbon dioxide enrichment is limited by the carbon dioxide concentrating mechanism they adopt. The effect of elevated carbon dioxide fertilization on C4 species is not well understood, although evidence suggests that carbon dioxide enrichment increased leaf net carbon dioxide assimilation rate (P_n) (Ziska *et al.*, 1999). Additionally a reduced transpiration rate may enhance P_n in C4 species by increasing leaf temperature (Ghannoum *et al.*, 2000). Therefore C4 species may show a more pronounced benefit from elevated carbon dioxide on photosynthesis under drought conditions (Seneweera *et al.*, 1998).

Effect of high temperature stress on vegetable production

Long-term global mean temperature estimates indicate a rise of 1.1 to 4.8 °C over the past 50 years, depending on future greenhouse gas emissions (Walsh *et al.*, 2014). These temperature changes are expected to increase the frequency of heat waves, reduce the number of freezing days, decrease overall rainfall while intensifying precipitation events and lead to more frequent droughts and other weather extremes worldwide. These effects would negatively impact agricultural production (Dempewolf *et al.*, 2014). Extreme events such as heavy precipitation, can lead to flooding, which has detrimental effects on vegetable production due to disturbed physiological functioning (Gibbs and Greenway, 2003). Flooded tomato plants accumulate endogenous ethylene, which causes damage and accelerates wilting and death, particularly following a brief period of flooding at high temperatures (Mohorović *et al.*, 2023). Similarly, onions are sensitive to flooding during bulb development, which can result in yield losses of up to 30-40% (Kumar, 2017). Vegetable crops are extremely vulnerable to climate change such as rapid temperature at any stage of crop growth (Afroza *et al.*, 2010). Environmental fluctuations have a substantial impact on various developmental phases, including vegetative growth, flowering and fruiting. Physiological damage caused by high temperatures, such as leaf abscission, leaf burning, senescence and restricted root and shoot development significantly affects crops and ultimately reduces production. High temperatures can also lead to lower seed germination rates, poor plant emergence, weak seedling vigor, abnormal seedlings and reduced radicle and plumule development (Bitá and Gerats, 2013). Additionally, high temperatures may disrupt several metabolic processes in guard cells; stomatal responses are typically regulated by transpiration rate, photosynthetic rate, plant water status and vapor pressure deficit (Urban *et al.*, 2017). Elevated temperatures increase the rate of evapotranspiration throughout the vegetative and reproductive stages, restricting the amount of water that plants can absorb. This leads to dehydration, which inhibits the growth of both individual plant organs and the entire plant (Fahad *et al.*, 2017). The reproductive stage is the most sensitive time in a crop's life cycle and this sensitivity causes a considerable reduction in seed set and crop output (Hein *et al.*, 2021). It is found to have a negative impact on various aspects of reproductive development in a variety of species including meiosis in both male and female gametes, pollen germination and pollen tube growth, pollen/pistil interactions, ovule viability, pollen grain number, formation of endosperm and embryo development, fertilization and post-fertilization processes. Pollen viability is lost as a result of high-temperature stress due to changes in membrane integrity, protein, carbohydrate

and lipid mechanisms and phospholipid profiles (Djanaguiramana *et al.*, 2018). High temperature stress negatively impacts agricultural productivity and the quality of agricultural produce. It disrupts enzyme functions in leaves and alters developmental stages that are directly related to crop yield (Zhu *et al.*, 2018). The optimal temperature for growing most crops is approximately 15-30°C. However, temperature elevations predominantly affect the plant's physiological processes, particularly photosynthesis, respiration, transpiration, and yield. Extreme temperatures significantly impact photosynthesis in leaves and the mechanisms involved in photosynthetic metabolism (Asthir, 2015) such as lower Rubisco activation and drop in stomatal conductance (gs) will decrease the net photosynthetic rate.

High temperature influence photosynthetic membranes, ion leakage, the activities of carbon metabolic enzymes, starch accumulation, sucrose synthesis through down-regulating certain genes involved in carbohydrate metabolism. Moreover, high temperature also has a significant impact on chloroplast throughout the photosynthesis process, including grana stack enlargement and aberrant stacking (Wahid and Shabbir, 2005). The chlorophyll production in plastids plays a significant role in light harvesting. Under temperature stress condition, chlorophyll pigments in plastids are harmed and degraded and 5-aminolevulinate dehydratase (ALAD), the initial enzyme of pyrrole biosynthesis, showed reduced enzymatic activity (Ashraf and Harris, 2013). It was also observed that the key phytohormones such as abscisic acid, ethylene, and salicylic acid are increased by high temperatures, whereas gibberellic acid, cytokinin and auxins were reduced. High temperatures affect the development of red colour in ripe chilli fruits and also cause flower drop, ovule abortion, poor fruit set and fruit drop in chilli plants (Kurtar, 2010). Reactive oxygen species (ROS) are also produced as a result of high temperatures (Bita and Gerats, 2013) and increased generation of ROS, including lipid peroxidation, superoxide free radicals and hydrogen peroxide (H₂O₂) induce cell membrane damage (Narayanan *et al.*, 2016) results in oxidative stress (Potters, 2007). High temperatures also reduce the net assimilation rate, induce protein denaturation, and trigger programmed cell death in some cells or tissues. This results in decreased ion flux, electrolyte leakage, changes in relative water content, production of toxic compounds, and disruption of homeostasis, ultimately reducing cell viability. Plant tissue protein concentration is closely related to plant nitrogen status. In FACE experiments, protein concentrations in wheat, rice, barley grains, and potato tubers have been found to decrease by 5–

14% with increasing carbon dioxide (Taub *et al.*, 2008). The nitrogen content of leaves often declines as carbon dioxide levels rise, with an average reduction of 13% less nitrogen per unit leaf mass reported (Ainsworth & Long, 2005). This decrease in tissue nitrogen may be due to several factors, including nitrogen dilution caused by increased carbohydrate concentration, reduced mineral uptake from the soil due to decreased stomatal conductivity and reduced water absorption by plants (Taub & Wang, 2008), and a reduced rate of nitrate assimilation into organic compounds (Bloom and Burger, 2010). A meta-analysis conducted by Dong *et al.* (2018) demonstrated that elevated CO₂ (eCO₂) decreased the protein concentration in vegetables by 9.5%. Specifically, fruit vegetables such as cucumber, hot pepper, strawberry, sweet pepper, and tomato experienced an average reduction of approximately 10.5%, while stem vegetables like ginger, onion, and potato saw a 12.6% reduction. Root vegetables, including carrot, radish, sugar beet, and turnip, had 20.5% reduction. The study also reported that elevated CO₂ decreased nitrate concentration in fruit and leafy vegetables by 26.2% and 18.8%, respectively. This suggests that elevated CO₂ promotes nitrate assimilation to a greater extent than it does nitrate uptake.

Impact of increased CO₂ on nutrient availability

Increased carbon dioxide (CO₂) levels may result in lower concentrations of essential nutrients in plants, including calcium, magnesium, and phosphorus (Loladze, 2002). Specifically, iron content decreased the most in leafy vegetables (31.0%), followed by fruit vegetables (19.2%), and root vegetables (8.2%). Zinc concentration reduced by 18.1% in both fruit and root vegetables, and by 10.7% in stem vegetables (Dong *et al.*, 2018). Myers *et al.* (2014) found a 5.2% drop in iron content in rice, while Loladze (2014) reported a 10% loss in C3 plants. Increased CO₂ levels in the future climates have been shown to reduce the availability of nutrients in vegetables, leading to potential negative impacts on human health, particularly in growing children (Myers *et al.*, 2014). Various studies have suggested that elevated CO₂ reduces mineral concentrations either through a dilution effect (Fangmeier *et al.*, 2002; Högy and Fangmeier, 2009; Loladze, 2014) or by restricting transpiration (McDonald *et al.*, 2002).

Increased carbon dioxide stimulates the accumulation of soluble sugars in the edible parts of the plants. Elevated CO₂ enhances triose phosphate production in leaves, which, in turn, can be converted into additional carbohydrates like glucose, fructose, and sucrose (Long *et al.*,

2004). Meta-analysis indicates that elevated CO₂ raises glucose concentrations by 13.2%, fructose by 14.2%, sucrose by 3.7%, and total soluble sugars by 17.5% across all vegetables. However, total soluble sugar increases less in fruits and roots at 8.5% and 16.3% respectively, compared to leafy vegetables. This suggests that carbohydrates produced in leaves are not fully transferred to fruits or roots, though species-specific differences are observed. Elevated CO₂ also reduces the concentration of total antioxidant capacity in fruit vegetables, ascorbic acid in root vegetables, and pigments like chlorophyll a and carotenoids by 14.4%, 14.8%, 14.1%, and 8.1% respectively. Nonetheless, it has little effect on the accumulation of other pigments such as total chlorophyll, carotenoids, lycopene, and anthocyanins (Dong *et al.*, 2018). Therefore, the anticipated increase in CO₂ levels, along with rising temperatures and associated climate changes over the next century, is likely to affect both agricultural productivity and food quality.

Salinity stress and its impact on vegetable production

It was estimated that about 20% (45 million ha) of irrigated land, producing one third of the world's food, is salt-affected (Shrivastava and Kumar 2015). Vegetable crops are more prone to climate change compared to other horticultural crops (Giordano *et al.*, 2021). Salinity stress is one of the most important environmental constraints that limits the economic productivity of vegetable crops (Hong *et al.*, 2021). Salinity in soil is influenced by a regular fluctuation in climatic conditions, irrigation of crops with low quality water, excessive use of ground water, and massive introduction of irrigation associated intensive farming (Tiwari *et al.*, 2010). Salinity-induced oxidative stress in vegetables can impact both their quality and quantity by causing a range of biochemical and physiological changes in the plants (Kashyap *et al.*, 2020).

Salinity presents a significant challenge in vegetable production by creating water stress for plants. Salt stress leads to reduced growth and decreased stomatal conductivity. Plants affected by salinity often show lower transpiration rates and reduced cell water potential. Onions are particularly vulnerable to saline soils, whereas cucumber, brinjal, pepper, and tomato exhibit moderate sensitivity to salinity (De la Peña and Hughes, 2007). In cabbage, salinity notably decreases germination percentage and rate, as well as the length and fresh weight of roots and shoots (Jamil and Rha, 2004).

Impact of pests and diseases in vegetables

The ecology and biology of insect pests are affected by climate change. Being cold-blooded, insects are extremely sensitive to temperature. Rising temperatures will result in longer breeding seasons and higher reproduction rates. Climate change has direct effects on the reproduction, growth, survival, and dissemination of pests, while it has indirect effects on the interactions between pests, their surroundings, and other insect species, including natural enemies, rivals, vectors, and mutualists (Prakash *et al.*, 2014). Temperature is the most significant environmental element influencing the insect behavior, dispersal, development, and reproduction (Kocmánková, 2010). Because of the new biological niches brought about by climate change, insect pests have the chance to establish themselves, spread, and move between different geographic areas (FAO, 2020). Studies showed that increased temperatures will hasten the growth of the Colorado potato beetle, European corn borer, onion maggot (Newton *et al.*, 2011). Studies on aphids and moths have demonstrated that rising temperatures can enable insects to achieve their minimum flight temperature earlier, enhancing their ability to disperse (Zhou *et al.*, 2014). Some insects with short life cycles, including aphids and diamondback moths reproduce more often and finish their life cycles early under increased temperature therefore create more generations every year (FAO, 2009). Elevated air temperatures boost insect growth and oviposition rates, leading to increased insect outbreaks and the potential introduction of invasive species. However, these higher temperatures also diminish fungi's effectiveness in biocontrol, undermine the reliability of economic threshold levels, reduce insect diversity within ecosystems, and lower parasitism rates (Das *et al.*, 2011).

Changes in temperature and precipitation patterns may have an impact on the host plant's physiology and resistance as well as the growth stage, development and pathogenicity of infectious pathogens (Mboup *et al.*, 2012). Parameters of climate change can affect both the pathogen and the host. For instance, some temperatures can increase the host's tolerance to pathogenic infections, while other temperatures can encourage the growth of the pathogen. Wheat and oats are two examples that illustrate these phenomena; when temperatures rise, they become more vulnerable to rust infections, but certain forage species become more resilient (Coakley, 1999). Airborne infections experience accelerated disease cycles at higher temperatures, which also enhances their survivability due to reduced frost (Boonekamp, 2012). Certain

mycotoxins such as fusarium mycotoxins (produced by *Fusarium* spp.) have increased concentrations at harvest due to high humidity and temperature. Humid conditions also increase proliferation of weeds, and weed biomass increases with increasing temperatures

(Abdou, 2020). According to Harvell *et al.* (2002) it is anticipated that the effects of plant infections will increase with climate change because the low temperatures and extended winters in northern latitudes, which now restrict the survival, generations per year, reproduction rate and activity of majority of diseases attacking crops during the growing season.

Adaptation strategies for climate resilience

In the event of climate change the production depends on how well the crops adapt to environmental stresses. Emphasis should be laid to select technologies based on agroecological unit wise and season bound to improve the resilience the production of horticultural crops to climate change *viz.*, resistant root stocks and varieties to various stresses (Malhotra, 2015 and Malhotra 2012). To adapt to increased temperature and water stress, planting dates can be adjusted. Adopting various agronomic practices like irrigating during critical stages, water and soil conservation measures helps to thrive in climate change. Moreover perennial horticultural crops are a boon to climate resilience by way of carbon sequestration.

Conclusion

The impact of climate change is a long-term concern, but it demands immediate action because greenhouse gases are accumulating in the atmosphere and there is the possibility of global temperatures rising by more than 2°C. It has been noted that the development of plants under increased carbon dioxide concentrations of 475–600 ppm results in an average 40% increase in leaf photosynthetic rates. Increased CO₂ stimulates the accumulation of soluble sugar in plants' edible portions. Vegetables are highly susceptible to unpredictable weather conditions and are highly perishable. They are sensitive to environmental extremes *viz.*, high temperatures and limited soil moisture. Major challenges faced by vegetable farmers are crop failures, low yield, decreased quality, and increase in pest and disease incidence. High

temperature reduces the net assimilation rate, induce denaturation of proteins and programmed cell death in some cells or tissues. It causes decreased ion flux, leakage of electrolytes, changes in relative water content, the production of toxic compound and disruption of homeostasis, ultimately reduce cell viability. So any changes in long-term mean annual temperature and extreme temperature events will probably have a tremendous effect on physiological responses of crops and ultimately affect the quality of food produced. Germination, vegetative stage, reproductive stage and the yield are impacted by high temperature stress and it is critically necessary to find innovative ways to adapt crops to these changes. High temperature induced by climatic fluctuations are an important threat for plant growth, development and quality of agricultural produces. Adaptability to environmental changes generally derive from a large set of genetic traits affecting physio-morphological, biochemical and agronomic parameters. Therefore to mitigate the adverse impact of climate change on productivity and quality of vegetable crops identification of genotypes with higher yield and good quality parameters at high temperatures is becoming increasingly necessary for future breeding programs.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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