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Review Article

Alleviating the adverse effects of plant pathogens, drought and salinity stress factors using plant growth promoting bacteria

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Abstract

Climate change is one of the most important threats to agricultural production, therefore, more attention must be paid to study the environmental stresses that affect plant production. Pathogen stress is one of the most important stresses that negatively affect growth and yield, also drought and salinity are very dangerous abiotic factors. Pathogens, drought and salinity stresses led to decrease morphological characters and yield production of plant. However, the application of plant growth promoting bacteria (PGPB) positively affect morphological, physiological, and yield characters such as number of leaves, stem height, chlorophyll concentration, relative water content, antioxidant enzymes and crop yield. PGPB can play a pivotal role in facilitating nutrient uptake, bioactive compounds and scavenging reactive oxygen species (ROS) to control various pathogens and increase plant tolerance to drought and salinity stresses. Finally, the latest studies of these beneficial bacteria have been presented comprehensively under stress conditions to highlight the recent trends with the aim to maximize the crop production.

Keywords: chlorophyll; drought; enzymes; hydrogen peroxide; pathogens; PGPB; superoxide

Introduction

Plant growth promoting bacteria (PGPB) are the most numerous living beings on earth, they are plant–microbes association, which play an important role in biological system and improve growth characters as well as crop production (Pindi *et al*., 2013; Yadav *et al*., 2017). It is well known that some genera of PGPB were studied such as *Bacillus, Azotobacter, Paenibacillus, Azospirillum, Rhizobium,* and *Pseudomonas*. These genera have the ability to fix nitrogen, produce amino acids and phytohormones (Tank and Saraf, 2010) such as indole-3-acetic acid and siderophores (Jahanian *et al*., 2012), 1-aminocyclopropane-1-carboxylate (ACC) deaminase (Glick, 2012), phosphate solubilization, lytic, antibiotics and volatile compounds (Rijavec and Lapanje, 2016) as well as improve plant growth in several plants (AL Kahtani *et al*., 2020a and b). Some of these genera are symbiotic (Bradyrhizobium, Rhizobium, Mesorhizobium) and the others are non-symbiotic (*Bacillus, Klebsiella, Pseudomonas, Azotobacter* and *Azospirillum*). The biological strategies for improving plant

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production have a strong rank among researchers to explore a wide range of PGPB which can deal with drought (Raheem *et al*., 2018; EL Sabagh *et al*., 2019; Mokrani, 2020), heavy metal stress (Ma *et al*., 2011), salinity (Rijavec and Lapanje, 2016; AlKahtani *et al*., 2021a) and biological control of pathogens and pests such as fungi (Ahemad *et al*., 2012; Hafez *et al*., 2017; Hafez *et al*., 2020a; Hafez *et al*., 2022a) and insecticides (Ahemad and Khan, 2011). Furthermore, previous studies proved that, PGPB can use in the biofertilization process resulting in increased nutrients uptake (Kour *et al*., 2020) such as phosphorus and nitrogen (Çakmakçi *et al*., 2006) and enhanced plant growth characters consequently, increased yield production in maize (Sandhya *et al*., 2010), sugar beet (Abou-Attia and Abdelaal, 2007), lettuce (AlKahtani *et al*., 2021a), black pepper (Dastager *et al*., 2011) and pea plants (Arafa *et al*., 2021).

Application of PGPBs led to increase stress tolerance under several environmental factors especially phytopathogens (Table 1) by induced systemic resistance (Gonzalez *et al*., 2015; Abdelaal *et al*., 2021a). Moreover, application of *Pseudomonas fluorescens* and *Azospirillum brasilense* gave the best results of shoot biomass of brachiarias plants (Hungria *et al*., 2021). Also, root yield and sugar yield were increased in sugar beet treated with PGPB (Abdelaal, 2015a), in sorghum, Abdelaal *et al*. (2015) observed an increase in sorghum yield according to the treatment with PGPB. Additionally, application of PGPB gave the best results in controlling viral (Murphy *et al*., 2000) and bacterial diseases (Indiragandhi *et al*., 2008) via production of important compounds such as siderophores and antibiotics. Heinrichs *et al*. (2020) found that, application of *A. brasilense* positively affect shoot dry weight of rangeland, the dry weight was increased with 13 and 6% in both seasons, respectively. Under normal or stress conditions, PGPB led to significant increases in morphological characters in sugar beet (Abou-Attia and Abdelaal, 2007; Abdelaal, 2015a), sugarcane (Gonzalez *et al*., 2015), lettuce (AlKahtani *et al*., 2021a) and faba bean (El-Flaah *et al*., 2021). Additionally, physiological characters such as RWC, chlorophyll a and b concentrations, proline content, activities of catalase, peroxidase and superoxide dismutase were positively affected in various plants such as pepper (ALKahtani *et al*., 2020a) and sugar beet (Abdelaal, 2015a). Therefore, in this review we try to clarify the concept of PGPB and their underlying mechanisms in plant growth improvement and stress tolerance under various stress conditions mainly plant pathogens, drought and salinity as well as save the ecosystem and human health with the application of PGPB.

Effect of plant growth promoting bacteria (PGPB) on morphological characters

Effect of PGPB on morphological characters under pathogens stress

Application of growth promoting bacteria in pathogens control is an alternative method to chemical control and called biological control, the effect of these bacteria was noted on morphological characters (Table 1). These bacteria can decrease the negative effects of various pathogens on many plants and save human as well as environment, several studies strongly preferred application of biological agents to control various pathogens (Hafez *et al*., 2017; El-Tarabily *et al*., 2010; Gupta *et al*., 2021). Biological activities of PGBP in the ecosystem make it strong for sustainable agricultural production. PGBP can improve morphological growth by nitrogen fixation (Aasfar *et al*., 2021), phosphorus solubilization (Kusale *et al*., 2021), production of siderophores (Gouda *et al*., 2018), phytohormones and antibiotics (Migunova and Sasanelli, 2021). PGPB can stimulate a defence mechanism having a hypersensitive reaction (Compant *et al*., 2005), and improve plant growth through morphological and internal several changes in plants (Kloepper *et al*., 2004). PGPB can play an important role in biological control by producing secondary metabolites including volatile compounds, antibiotics, siderophores, HCN, and other compounds (Showkat, 2012). Application of *Bacillus subtills* led to control *Salmonella enterica* and Enterohaemorrhagic *Escherichia coli* and in mung bean (Shen *et al*., 2017), also, *B. cereus* can produce two antibiotics (Zwittermicin and Kanosamine) which act as biocontrol agent against damping-off in the alfalfa seedlings (Lozano *et al*., 2016) and improve morphological characters in alfalfa. These bacteria can improve plant growth by increasing mineral and water uptake, producing growth-stimulating compounds, and suppressing growth of pathogens. Huang *et al*. (2017) reported that *B. subtills* led to control *Rhizoctonia solani* and improve fresh and dry weight of pepper. Also, Mokrani *et al*. (2019) found that *Pseudomonas cepatia* P7 was effective on seed germination, root growth characters and may play a significant role in biocontrol of bean common blight as alternative to chemicals. Application of isolates *P. cepatia* P7 and P25 led to decrease the number of common blight tasks on leaves of bean compared to control plants.

Azotobacter, Paenibacillus polymyxa, Bacillus spp. promote plant growth and control microbial diseases in a wide range of plants via nitrogen fixation and production of volatile substances (Vessey, 2003). Furthermore, the useful effects of *Pseudomonas* spp. on plant yield and biocontrol of some plant diseases such as Fusarium wilt have been stated. Murphy *et al*. (2000) reported that treated tomato with *B. subtilis* 937b led to increase fruits yield under infection with Tomato mottle virus (ToMoV). Kloepper *et al*. (1980) reported that P. fluorescens BI0 led to control *F. oxysporum* f. sp. *Lini* in wheat and improve growth characters of wheat (Table 1). Additionally, application of *P. putida* WCS358 as seed treatment give a good control for fungal rhizosphere microflora in wheat in the both seasons (Glandorf *et al*., 2001). Thomas and Sekhar (2016) showed antagonistic effect of the endophytic bacteria *P. aeruginosa* (strain GNS.13.2) on *Fusarium oxysporum* f. sp. *cubense* in banana, the infection with Fusarium decreased by more than 99%.

Table 1. Effect of PGPBs as biocontrol agents to pathogens on morphological characters in host plants

PGPB	Host plant	Pathogen or disease	References
Bacillus subtilis 937b *Methylobacterium oryzae*	Tomato Tomato	Tomato mottle virus (ToMoV) *Pseudomonas syringae*	(Murphy *et al*., 2000) (Indiragandhi *et al*., 2008)
Pseudomonas fluorescens	Wheat	*Fusarium oxysporum*	(Shen *et al*., 2017)
B. subtilis	Mung bean	*Salmonella enterica*	(Huang *et al*., 2017)
B. subtilis *Pseudomonas spp.*	Pepper Common bean	*Rhizoctonia solani* common bean blight	(Mokrani *et al*., 2019) (Vessey, 2003)
P. fluorescens BI0	Wheat	*Fusarium oxysporum*	(Glandorf *et al*., 2001)
Pseudomonas putida *P. aeruginosa* *Pseudomonas spp.*	Wheat Banana Maize	fungal rhizosphere microflora *Fusarium oxysporum* *Verticillum* sp.	(Thomas and Sekhar, 2016) (Lawongsa *et al*., 2008)
B. subtilis	Wheat	Yellow rust of wheat	(Reiss and Jørgensen, 2017) (Ordentlich *et al*., 1988)
Serratia marcescens	Fungi	*Sclerotium rolfsii*	(Phi *et al*., 2010)
P. polymyxa	Pepper	*Xanthomonas axonopodis*	(Ahmad *et al*., 2008)
Mesorhizobium sp.	Some plants	Fusarium and Rhizoctonia	
Pseudomonas sp.	Rice	*Verticillum* sp.	(Lawongsa *et al*., 2008)

Effect of PGPB on morphological characters under drought stress

PGPB can alleviate the adverse effects of drought on morphological parameters of plants. These negative effects were recorded in several crops such as soybean (Khaffagy *et al*., 2022), barley (Abdelaal *et al*., 2018; Abdelaal *et al*., 2020a; Abdelaal *et al*., 2022a), wheat (Abdelaal *et al*., 2021b) and flax (Rashwan *et al*., 2020). In this context Arafa *et al*. (2021) stated that drought caused significant decreases in leaves number, plant height, number of pods and dry weight of 100 seeds in stressed pea plants. However, seed priming with *B. thuringiensis* boost adaptation in pea under drought and led to increase plant height, number of flowers per plant, number of pods and dry weight of 100 seeds in stressed pea plants during two seasons. Under drought, Ahmed and

Nadira (2015) found cellular dehydration, decrease water uptake, reduction in cell growth, hampered cell wall synthesis, and salt accumulation around stomata causing their malfunction. PGPB also increase the availability of nutrients via production of siderophores and availability of phytohormones such as gibberellins and auxins (Pathania and Rajta, 2020). Furthermore, these bacteria can improve the morphological characters, increase water availability and produce secondary metabolites to protect the plants against stress (Juan *et al*., 2012). Inoculation with *Pseudomonas* spp. and *Arthrobacter* spp. led to remarkable increase in fresh weight and water availability as well as improve plant growth characters in rice plants under drought (Yuwono *et al*., 2005). *B. cereus* AR156 was used for enhancement the drought tolerance in tomato plants and led to improve morphological characters of tomato plants (Casanovas *et al*., 2002). The mechanism of PGPB may be due to the production of IAA which may increase root–shoot biomass under drought, also, some PGPB genera can produce aminocyclopropane1-carboxylate deaminase which can resist root drying. In tomato and pepper, *Achromobacter piechaudii* exhibits ACCD activity, leading to an improvement in biomass under drought. Khanghahi *et al*. (2021) reported that, application of *Azospirillum* causes increase in growth characters in maize under drought. Previous studies have found that application of PGPBs and plant growth regulators led to increase plant tolerance to drought (Abdelaal *et al*., 2021c; Vanhaverbeke *et al*., 2003). Morphological characters were significantly improved by application of PGPB via increasing micronutrients and the availability of growth-promoting chemicals such as exopolysaccharides (ESP).

Effect of PGPB on morphological characters under salinity stress

One of the important effects of PGPB genera is improvement the growth characters under salinity stress, it is very important role to mitigate the negative effects of salt stress in many crops. Salinity stress cause harmful effects such as decrease plant height, leaves number, fresh and dry weight in several plants; rice (Mohamed *et al*., 2022; Elhity *et al*., 2021a; Elhity *et al*., 2021b; Hafez *et al*., 2020b), pea (Abdelaal *et al*., 2022b), soybean (Abdelaal *et al*., 2021d), wheat (Alnusairi *et al*., 2021), faba bean (El-Flaah *et al*., 2021; El Nahhas *et al*., 2021) and pepper (Abdelaal *et al*., 2020b). The negative effects of salinity on morphological parameters can be improved with PGPB application according to Qurashi and Sabri (2012), they stated that, the inoculation of Halomonas variabilis HT1 and *Planococcus rifietoensis* RT4 led to improve chickpea growth under salinity. Additionally, inoculation with *Bacillus* in wheat cause increase in nutritional content and growth characters (Upadhyay and Singh, 2015). Furthermore, the production of osmoprotectants such as proline, trehalose, glycine and flavonoids are very important compounds from PGPB to cope with instable osmotic conditions and improve growth characters (Bano and Fatima, 2009). According to El-Flaah *et al*. (2021) salinity led to a significant decrease in root length, fresh weight of shoot and root system in the stressed rice, however, there was an increase in root length and fresh weight of shoot and root in the treated plants with *Rhizobium* compared to control. Also, Egamberdieva (2009) reported that, the effect of salinity on wheat plant can be mitigated with application of *P. aureantiaca* TSAU22, *P. extremorientalis* TSAU6 and *P. extremorientalis* TSAU20 which increased root growth up to 52% at 100 mM NaCl, compared with control because of the production of phytohormones like IAA.

Effect of plant growth promoting bacteria (PGPB) on physiological characters

Effect of PGPB on physiological characters under pathogens stress

PGPB can enhance physiological characters through direct or indirect mechanisms, which enhance plant status and provide tolerance to different pathogens through various methods (Zakry *et al*., 2012), these methods include neutralizing biotic and abiotic stress, producing volatile compounds and antibiotic to control disease. Application of PGPB can improve the physiological status of plants under pathogens stress via increasing antioxidants such as CAT, POX, SOD, GR and alpha tocopherol which protect the cell from the oxidative stress (Gruau *et al*., 2015). In this context, application of *P. fluorescens* PTA-CT2 led to upsurge local and systemic resistance against *Botrytis cinerea* (Backman and Sikora, 2008). According to Gupta *et al*. (2021), PGPB can increase plant growth and physiological characters under pathogens stress via induced systemic resistance, antibiosis and resisting the plants against biotic agents and protect the plants from the pathogens. The tolerance mechanism to pathogens stress includes the increase in enzymes activity (Schouten *et al*., 2004), antibiotic production (Miethke and Marahiel, 2007), production of siderophores (Kloepper *et al*., 2004) induction of systemic resistance (Van Loon *et al*., 2006). The inoculation with PGPB under pathogens stress was associated with production of some enzymes such as protease, chitinase, and lipase, which can lysis the cell wall of fungal pathogens (Trivedi *et al*., 2008), and the production of various metabolites such as hydrocyanic acid, siderophores, antibiotics such as fengycins, and surfactins in the infected plants (Omara *et al*., 2019; Esmail *et al*., 2019). The important physiological characters which negatively affect under pathogens stress are chlorophyll, RWC and enzymes activity, these changes were associated with the over production of ROS and lipid peroxidation. The increase in ROS was recorded as a result of oxidative damage under fungal pathogens in wheat (Omara and Abdelaal, 2017; Omara and Abdelaal, 2018; Abdelaal *et al*., 2020c; El-Nashaar *et al*., 2020) and barley under various stresses (Hafez *et al*., 2020c; Hafez *et al*., 2016; Abdelaal *et al*., 2022a). Also, *Bacillus* spp. was highly effective in control plant diseases in pepper and strawberry plants and improve the physiological characters of the infected treated plants. Akram *et al*. (2016) reported that application of *B. fortis* IAGS162 led to improve physiological characters of tomato under infection with Fusarium wilt. Many genera of bacteria were recorded as biocontrol agents such as *P. fluorescens* PICF7 was effective against *Verticillium* wilt, *P. fluorescens* SS101 was effective in control of *P. infestans* which cause late blight in tomato (de Souza *et al*., 2003; Tran *et al*., 2007; Hesse *et al*., 2018).

Effect of PGPB on physiological characters under drought stress

Drought-tolerant PGPB regulates plants' key physiological developments such as ion transport, water and nutrients uptake as well as photosynthesis (Danish and Zafar-ul-Hye, 2019). These bacteria can associate with roots and produce metabolites and organic compounds to protect the plants under normal and stress conditions (Tahir *et al*., 2017). The physiological characters may negatively affect under drought; chlorophyll and RWC were significantly reduced under drought in faba bean (Abdelaal, 2015b), rice (Omar *et al*., 2020) and maize (Abdelaal *et al*., 2017). Rashid *et al*. (2022) reported that *B. megaterium* (MU2) and *B. licheniformis* (MU8) isolated from semi-arid region induces drought tolerance of wheat and increased plant biomass, RWC, and osmolytes. They also showed that *B. megaterium* led to improve physiological characters of wheat; RWC (59%) and chlorophyll concentration (70%) as well as ROS. Under drought conditions, plants can reduce the oxidative damages by the upregulation of several enzymes like ascorbate reductase, SOD, CAT, POX and GR which can scavenge the ROS (Zhang *et al*., 2020). Moreover, PGPB led to increase plant tolerance to drought and improve physiological parameters such as net photosynthesis and water use efficiency in stressed plants (Rolli *et al*., 2015). Furthermore, application of *Azospirillum* in wheat led to improve lateral root formation and improve physiological characters due to the production of IAA under drought (Barnawal *et al*., 2017). These positive effects of PGPB may be due to the availability of water and upregulation of enzymes as well the accumulation of ABA under drought. It has been also stated that, application of *A. brasilense* cause an increase in RWC and increase drought tolerance in the stressed plants, also, the valuable effect of PGPB is mediated by proline accumulation and several osmolytes formation as well as increase antioxidant activity (Furlan *et al*., 2017).

Effect of PGPB on physiological characters under salinity stress

Salinity stress is one of the most harmful factors that negatively affect the physiological growth characters in many plants such as strawberry (El-Banna and Abdelaal, 2018) and mung bean (Hasan *et al*., 2017). Salt stress can harm the all-plant stages and processes like germination and productive stages; physiological processes such as chlorophyll formation, photosynthesis, RWC, and enzymes activity were negatively affected under salinity conditions. The adverse effect of salinity on chlorophyll content and photosynthesis process could be attributed to the photooxidation for chlorophyll in chloroplast (Sukweenadhi *et al.*, 2018) and the inhibition of carbon fixation as well as the overproduction of hydrogen peroxide and superoxide as well as lipid peroxidation (Abdelaal *et al.*, 2021b; Ghanem *et al.*, 2021). Under high salinity levels the efficiency of root plants to absorb water and nutrients was decreased consequently, decreased physiological characters (Kumar *et al.*, 2020). Additionally, salinity led to decrease leaf area, photosynthetic pigments and photosynthetic efficiency (Ashraf *et al.*, 2013), also, cause oxidative damage to organelles due to the accumulation of ROS, which induces DNA fragmentation and induce accumulation of lipid peroxidation in the stressed plants (Abdel Latef *et al.*, 2020). These adverse effects of salinity can be mitigated with the application of PGPB, these bacteria produce some osmoprotectants such as proline, trehalose, and flavonoids which are very important to cope with salinity stress conditions. Additionally, it was indicated that PGPB such as *B. megaterium* MPP7, *P. putida* MPP18 and *A. bereziniae* IG2 led to increase TSS, proline concentration and decrease EL, ROS and oxidative damage in the stressed plants (Zhu *et al.*, 2020; Haroon *et al.*, 2021). Application of *Rhizobium* on the salt-stressed plants caused an increase in RWC, this increase might be due to the pivotal role of *Rhizobium* in the production of vitamins and hormones such as IAA which induce physiological characters such as chlorophyll content and proline, consequently, increase salinity tolerance in the stressed faba bean and soy bean plants (El-Flaah *et al.*, 2021; Sapre *et al.*, 2021).

Table 2. Effect of plant growth promoting bacteria on yield production under pathogens, drought and salinity

PGPB	The mechanism of yield improvement	Plant	Stress type	References
Bacillus thuringiensis	Improve water uptake, head weight and total yield	Lettuce	Salinity	(AlKahtani *et al.*, 2021)
B. subtilis	Increase tolerance to powdery mildew, improve enzymes activity and fruits yield	Cucumber	Powdery mildew	(Hafez *et al.*, 2020a)
B. subtilis	Increase tolerance, improve growth of mung bean	Mung bean	*E. coli*	(Shen *et al.*, 2017)
B. subtilis	Improve growth and yield characters	Papper	*R. solani*	(Mokrani *et al.*, 2019)
Rhizobium sp.	Improv physiological characters and seed yield	Faba bean	Salinity	(El-Flaah *et al.*, 2021)
Rhizobium sp. and *Pseudomonas sp.*	Improved water potential, plant growth and yield	Maize	Salinity	(Bano and Fatima 2009)
Azotobacter sp.	Improv RWC and chlorophyll	Maize	Salinity	(Haroon *et al.*, 2021)
Pseudomonas sp.	Increase compatible solutes and antioxidant status	Maize	Drought	(Sandhya *et al.*, 2010)
P. fluorescens	Increase tolerance and improve growth wheat	Wheat	*F. oxysporum*	(Showkat, 2012)
P. fluorescens	Increase tolerance and improve growth tomato	Tomato	*P. infestans*	(Tran *et al.* 2007)
Bacillus cereus	Improve tomato growth and yield	Tomato	Drought	(Juan *et al.*, 2012)
Klebsiella variicola	Improve metabolites and antioxidants	Wheat	Salinity	(Kusale *et al.*, 2021)

Enterobacter ludwigii	Improve antioxidants and decrease ROS	Pea	Salinity	(Sapre *et al.*, 2021)

Effect of plant growth promoting bacteria (PGPB) on yield characters

Yield production is a very important and complex process which affected by many environmental stress factors such as pathogens, salinity and drought (Table 2). Pathogens and insects are very harmful biotic stress that cause negative effects on many plants such as fungal diseases (Shahin *et al.*, 2021; Hafez *et al.*, 2022b and c) and insects (Morsy *et al.*, 2021; Abdelaal *et al.*, 2021e; Essawy *et al.*, 2020). Also, abiotic stress factors are very dangerous on yield crop production such as salinity and heat stress (El-Flaah *et al.*, 2021; Abdelaal *et al.*, 2020d; Abdelaal *et al.*, 2021f) and drought (AlKahtani *et al.*, 2021b; Abdelaal *et al.*, 2021d; Mohamed *et al.*, 2022; Asseri *et al.*, 2021). Previous studies showed that the environmental stress factors negatively affected yield components in the economic plants like wheat, barley, rice, faba bean, sugar beet, lettuce and soy bean. On the other hand, application of PGPB led to increase the yield production under normal conditions in sugar beet (Abdelaal and Tawfik, 2015), under salinity stress in bean and lettuce (AlKahtani *et al.*, 2021a; El-Flaah *et al.*, 2021) and under drought in tomato and wheat plants (Juan *et al.*, 2012; Barnawal *et al.*, 2017). Overall, application of PGPB can alleviate the negative effects of pathogens, drought and salinity via improving morphological, physiological and yield characters in several plants.

Conclusions

Plant growth promoting bacteria have many beneficial effects that can be focused to maximize the agricultural production, especially under different environmental stresses such as pathogens, drought and salinity. PGPB led to improve morphological such as plant height, number of leaves, leaf area, number of flowers and number of branches, also physio-biochemical and yield characters such as chlorophyll content, relative water content, enzymes activity and grain yield of many plants under stressful conditions. This positive role of PGPB could be due to the useful compounds such as antibiotics, vitamins and phytohormone that aid stressed plants to overcome the adverse conditions and grow well under these abnormal conditions.

Authors' Contributions

Conceptualization (A.O., M.R., A.Al.); Data curation (A.O., M.R.); Formal analysis (A.O., M.R., A.Al.); Funding acquisition (A.O., M.R., A.Al.); Methodology (A.O., M.R.); Project administration (A.O., M.R., A.Al.); Resources (A.O., M.R., A.Al.); Software (A.O., M.R.); Supervision (A.O., M.R., A.Al.); Writing - original draft (A.O., M.R.); Writing - review and editing (A.O., M.R., A.Al.). All authors read and approved the final manuscript.

Ethical approval (for researches involving animals or humans)

Not applicable.

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Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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