

BIOLOGICAL CONTROL OF MICROBIAL CONTAMINATION ASSOCIATED WITH PLANT TISSUE CULTURE OF DATE PALM (*PHOENIX DACTYLIFERA*)

AHMED ABD BURGAL^{1*}, EMAN ABOOBMUKHAIFI¹, KHUDHAIR M. ALKANANY² AND
WIJDAN HUSSEIN AL-TAMIMI¹

¹Department of Biology, College of Science, University of Basrah, Iraq

²Basra Tissue Culture Lab, Date Palm Department, College of Agriculture, University of Basrah, Iraq

(Received 28 April, 2021; accepted 21 June, 2021)

ABSTRACT

Biotechnology in the agriculture field provides tremendous potential for producing crops with lower costs and increased productivity. This is a very essential choice for introducing the best tools of biotechnology to overcome the challenges in this field. In this study eight bacteria isolate from the contaminated tissue culture of date palm, all isolates were genetically identified based on the 16S rRNA gene. The bacterial strains were *Enterococcus faecium* strain MK748256 (IW21), *Bacillus cereus* strain B26 (IW22), *Bacillus* sp. strain PK-7 (IW24), *Bacillus cereus* strain JS22 (IW25), *Lysinibacillus* sp. Strain IADCASC12 (IW28), *Lysinibacillus* sp. strain IADCASC11 (IW29), *Bacillus thuringiensis* strain Sol 1 (IW31) and *Bacillus cereus* strain Q1 (IW32). In the current study, the genus *Lysinibacillus* was isolated for the first time from a culture of plant tissues contaminated with microbes. The isolated bacteria were tested with four different types of antibiotics. The results showed all bacterial isolates were sensitive to Amikacin, the highest inhibition zone was 21mm against IW31 *Bacillus thuringiensis* while the lowest was 12 mm against IW22 *Bacillus cereus* strain B26, also all isolates were resistant to Ampicillin. Antibacterial assay of extracts amber was found the alcoholic extract of orange amber and the DMSO extract of yellow amber best antimicrobial activity against *Enterococcus faecium* strain MK748256, *Bacillus cereus* strain B26 and *Bacillus* sp. strain PK-7. The yellow amber extract showed wide effectiveness against seven out of eight strains, the highest inhibition value was 20 mm and the lowest was 8 mm, while the orange amber extract was less effective against four strains, the highest inhibition was 15 mm and the lowest was 10 mm. Sterilization of the excised plant parts and the control of microbes is an important stage in the success of plant tissue culture. This study demonstrated the possibility of using natural extracts to reduce bacterial contamination without harming cultured plant tissues.

KEY WORDS : Microbial contamination, Micropropagation, Date palm, Tissue culture sterilizing agents

INTRODUCTION

The date palm (*Phoenix dactylifera* L.) is a fruit tree that predominates in hot arid regions of the Middle East and North Africa and is resilient to adverse climatic conditions (Al-Khayri and Naik, 2017). This species of the Arecaceae family is propagated by seed, which is known as sexual reproduction in addition to many other methods of reproduction. Propagation by seed is one of the oldest methods;

the fruits produced are of poor quality and have high contrast. The second method of reproduction is vegetative or asexual reproduction by branches known as offshoots. The resulting palm tree is identical to the original parent species, but this method has some disadvantages, such as the limitation of offshoots that are produced between the first ten and fifteen years after planting (Jain, 2012). As a date producer, Iraq is among the top ten of the world's major date producing zones. Several

commercial and government institutions are working on the propagation of date palm cultivars for tissue culture (Abass and Awad, 2019). The date palm is one of the palm family's most significant economic species, grown primarily for its fruits (dates). The market for date palm fruits around the world is growing nowadays. To satisfy this demand, many methods of propagation have been used, including micropropagation that has been used for large-scale date palm multiplication in Iraq and many other nations to multiplication of Date palm in large-scale (Abass, 2013). In recent years, the technology of micropropagation has expanded in date palm cultivated, due to not controlled to seasonal influences and produces healthy varieties free from diseases and identical to the mother plant in genetic characteristics, as well as producing large numbers of offshoots in a short time (Kriaa *et al.*, 2011). The early stages of the initiation of culture are the most important and face challenges in micropropagation. The risk of this stage is microbial contamination (Daud *et al.*, 2012; Vujovic *et al.*, 2012). Infection or microbial contamination, both endogenous and exogenous, is one of the most common risks that reduce the chances of success of *in vitro* date palm micropropagation techniques (Emoghene *et al.*, 2020; El-Dawayati Maiada *et al.*, 2020). Microbial contamination causes a lot of harmful effects on the tissues of cultivated date palms, including the consumption of foodstuffs by microbes and the competition of plants for them, the internal and external enzymes and toxins resulting from the effectiveness of microbes into the medium, whether bacteria or fungi, lead to damage to the affected tissue and change in color. Resulting from these economic losses and wasted time and effort (Hameed and Abass, 2006; Omamor *et al.*, 2007). Contamination of date palm tissues with fungi, bacteria, yeast and viruses is one of the most difficult that impedes the reproduction process, which can infect cultures at every micropropagation stage (Odutayo *et al.*, 2007; Abass, 2013). Plant tissue cultures may be infected by significant bacterial diversity which leads to contamination, which can decrease shoot and root growth rate, multiplication factor, and sometimes cause plant death. (Kidus and Teku, 2020). The bacterial contamination of date palms may result from plant materials, laboratory environment, tools used, or inefficient sterilization stages, all of this leads to increased mortality and decreased success rates, especially when the infection or contamination is severe with internal

bacteria (Mbah and Wakil, 2012). Several species of bacteria were isolated from a culture of contaminated date palm tissue and identified by biochemical tests or by genetic identification depended on 16S rRNA. The most commonly explored endogenous Gram-positive and Gram-negative bacterial species in date palm tissues are the genus *Bacillus*. It is a predominant group that includes *B. subtilis*, *B. safensis*, *B. cereus* and *B. sonorensis*, other species belonging to the Enterobacteriaceae family, some isolates of *Achromobacter*, *Acinetobacter*, *Serratia* and *Pseudomonas*. (Al-Hadethy *et al.*, 2007; Al-Mussawi 2010; Al-Dosary *et al.*, 2011). The basic procedures in plant tissue culture are sterilization for controlling microbial contamination by using physical, chemical, and filtration methods (Singh *et al.*, 2015). The culture media should be sterilized for 15-20 minutes at 121 °C by an autoclave, tools are washed with sodium hypochlorite 5% for 15 minutes (Ikenganyia *et al.*, 2017). Disinfecting of glassware in the oven at 180 °C for 2 hours, as well as using flame and methyl alcohol 99% in addition to sterilization of lamina flow table and hands with 70% alcohol (Leelavathy and Sankar, 2016). Many compounds are used to control microbial contamination associated with tissue culture, including antibiotics, chemicals such as hydrogen peroxide, and plant extracts. The aim of this study was the isolation and identification of bacterial contaminants of *in vitro* date palm in *in vitro* cultures and to evaluate the efficacy of antibacterial and amber extract agents identified bacteria.

MATERIALS AND METHODS

Isolation of bacteria

Contamination of palm tissue culture in Palm Research Center at Basrah university is shown in Figure 1. The contaminating bacteria were isolated on a nutrient agar medium by placing a small amount of sample on the side of the agar plate with inoculum from an inoculating loop. A sterile loop is then used to spread the bacteria out in one direction from the initial site of inoculation. This is done by moving the loop from side to side, passing through the initial site. The loop is then sterilized (by flaming) again and the first streaks are then spread out themselves, this is repeated 2-3 times (Collins and Lyne, 1984). In this method single bacterial cells get isolated by the streaking method. After incubation at 35°C±2 for 24 hours, colonies were



Fig. 1. The appearance of an advanced stage of bacterial contamination associated with the cultivation of date palm tissue, the different color represents the aggravation of bacterial growth.

observed and pure cultures of these bacteria were obtained by picking up the colonies and streaking them onto the fresh medium. Bacterial isolates were characterized morphologically after staining with Gram stain to distinguish Gram-positive, Gram-negative bacteria and spores forming cells.

DNA extraction and PCR amplification

Genomic DNA was extracted from 12 isolates using Promega, USA extraction kit according to the manufacturer's protocol. Extracted DNA was detected by 1% agarose gel electrophoresis. The bacterial 16S rDNA was amplified using the universal bacteria-specific primers, 27 F (5'-AGAGTTTGATCCTGGCTCAG-3') and 1492R (5'-CGGCTACCTGTTACGACTT-3') (Lane, 1991). The PCR reacting system consists of green mastermix 25 μ l mixed with 2 μ l of each forward and reverse primers (10 pmol/ μ l), 5 μ l of template DNA and equal volume to 50 μ l by added nuclease-free water. The thermal cycling conditions were as follows: initial denaturation for 2 min at 94 $^{\circ}$ C, 35 cycles of 40 sec. of denaturation at 94 $^{\circ}$ C, 30 sec. of annealing at 55 $^{\circ}$ C, and 1 min of elongation at 72 $^{\circ}$ C. Cycling was completed by a final elongation step at 72 $^{\circ}$ C for 10 min. Amplified fragments were approximately 1,500 bp (Liu *et al.*, 2007). Gene products (16S rRNA) about 1500 bp were detected by electrophoresis 1.5% agarose with TBE buffer in conjunction with DNA ladder (100 base pair) from Thermo Fisher Scientific Company, USA.

A sequence of PCR products

The 16S rDNA genes products from Amplified DNA

were sequenced at Macrogen company laboratories /Korea. 16S rDNA of each isolate was purified and sequencing then aligned with known 16S rDNA sequences Gen bank using the Basic Local Alignment Search Tool (BLAST) at the National Center for Biotechnology Information (<http://www.ncbi.nlm.nih.gov/BLAST>) (Kato *et al.*, 2002).

Preparation of DMSO and alcohol extraction of amber

Three types of amber were used in the present study. The necklaces of orange, brown and yellow Baltic amber were obtained from the local market. after Amber crushed by using a ceramic mortar, dissolved in Quantity information of Dimethyl Sulfoxide (DMSO) to obtain the required concentrations of 250 mg/ml. five grams of orange amber powder was dissolved in 100 ml of ethanol to prepare alcohol extract, the mixture left for 24 hr. with continuous stirring on the magnetic stirrer, then the solution filtered and dried in a Petri dish at room temperature. The dry orange amber was collected as a powder, a certain weight dissolves with DMSO to obtain the required concentrations of 250 mg/ml.

Determination of antibiotic-resistant and amber activity

Susceptibility of 12 isolates to 5 types of antibiotics was achieved by the disc diffusion method (Van Dijk *et al.*, 2014). Commercially available antibiotics disc (Bioanalysis company, Turkey) were used containing Nitro furantoin 300 μ g, Chloramphenicol 30 μ g, Ampicillin 10 μ g, Norfloxacin 10 μ g and Amikacin 10 μ g. 0.1 ml inoculum of bacteria was added to 100 ml of nutrient broth and then incubated at 30 $^{\circ}$ C for 24h and then dilution of bacterial solution with physiological normal saline compared with the standard test tube McFarland for 10^8 cells/ml of stuck bacterial and inoculated into nutrient agar, using L-shape to spread bacteria on Muller Hinton Agar media, put the antibiotic disc and incubated dishes in the incubator 37 $^{\circ}$ C for 24 h. Inhibition zone diameters were measured inclusive of the diameter of the discs. The Results were expressed as sensitive, S (\geq 21 mm); intermediate, I (16-20 mm) and resistant, R (\leq 15 mm), respectively according to that described by Vlkov *et al.*, (2006). Alcohol and DMSO extracts of amber efficacy were tested for antimicrobial activity against isolates were achieved on Mueller Hinton agar medium by using the diffusion method (Gandhimathi *et al.*, 2008). The plates were incubated at 37 $^{\circ}$ C for 24 h. the



Fig. 2. Colony grown of some bacterial isolates on nutrient agar medium after 24 hr. of incubation at 3.5 °C ± 2.

diameters of the inhibition zones were measured.

RESULTS

Isolation and genetic identification

The results of bacterial isolation from tissue culture of (*Phoenix dactylifera*) date palm on nutrient agar during isolation technique were showed that most isolates were detected as Gram positive, while only one isolates was Gram negative Figure 2.

The genetic identification of bacterial isolates was showed that 8 strains identified according to the partial sequence obtained from their 16S rRNA gene, after compared the sequences with those described

in databases the partial sequence of 16S rRNA genes. The results showed that 5 strains belong to *Bacillus* genus, 2 isolates identified as *Lysinibacillus* while one strain was *Enterococcus* as described in Table 1.

Antibiotic sensitivity and amber activity

Results of the sensitivity studies of the isolates tested against 5 types of antimicrobial agents are shown in Table 2 and Figure 3. All isolates were sensitive to Amikacin, the highest inhibition zone was 21 against isolate IW31 *Bacillus thuringiensis* while the lowest was 12 of isolate IW22 *Bacillus cereus* strain B26. In addition, all isolates were also resistant to

Table 1. The BLAST results of the 16S rRNA gene sequences of the bacteria contaminated plant tissue cultures

| Isolates code | Identified strains | Accession number | Length pb |
|---------------|---|------------------|-----------|
| IW21 | <i>Enterococcus faecium</i> strain MK748256 | MW078406.1 | 510 |
| IW 22 | <i>Bacillus cereus</i> strain B26 | JN624919.1 | 515 |
| IW 24 | <i>Bacillus</i> sp. strain PK-7 | EU685824.1 | 536 |
| IW 25 | <i>Bacillus cereus</i> strain JS22 | MT102926.1 | 940 |
| IW 28 | <i>Lysinibacillus</i> sp. Strain IADCASC12 | MH973472.1 | 504 |
| IW 29 | <i>Lysinibacillus</i> sp. strain IADCASC11 | MH973471.1 | 515 |
| IW 31 | <i>Bacillus thuringiensis</i> strain Sol 1 | KF812554.1 | 513 |
| IW 32 | <i>Bacillus cereus</i> strain Q1 | KU977289.1 | 676 |

Table 2. Assessment of bacterial strains against 5 types of antibiotics

| Sample | Nitrofurantoin | Chloramphenicol | Ampicillin | Norfloxacin | Amikacin |
|----------------------|----------------|-----------------|------------|-------------|----------|
| | 300 µg | 30µg | 10 µg | 10 µg | 10µg(s) |
| Inhibition zone (mm) | | | | | |
| Control | ≤14 | ≥18 | ≥ 15 | ≥ 17 | e" 17 |
| IW21 | 7(R) | 0(R) | 0(R) | 0(R) | 17(S) |
| IW22 | 13(R) | 16(I) | 0(R) | 31(S) | 12(R) |
| IW24 | 0(R) | 0(R) | 0(R) | 0(R) | 17(S) |
| IW25 | 0(R) | 0(R) | 0(R) | 27(S) | 15(I) |
| IW28 | 15(I) | 0(R) | 0(R) | 0(R) | 19(S) |
| IW29 | 0(R) | 0(R) | 0(R) | 0(R) | 17(S) |
| IW31 | 19(S) | 0(R) | 0(R) | 23(S) | 21 (S) |
| IW32 | 15(I) | 25(S) | 0(R) | 0(R) | 18 (S) |

R: Resent, S:Sensitvne, I:Intermidite.



Fig. 3. Antibiotics testes for bacterial isolates from tissue culture of date palm

Ampicillin, some strains include *Bacillus cereus* strain B26, *Bacillus cereus* strain JS22 and *Bacillus thuringiensis* strain Sol 1 were highly sensitive against Norfloxacin, the inhibition zone 31, 27 and 23 respectively. other isolates showed different susceptibilities to the following antibiotics Nitrofurantoin, Chloramphenicol and Norfloxacin.

The result of antibacterial activity of extracts amber was shown in Table 3 and Figure 4. According to the data included in Table 2, it was found that the alcoholic extract of orange amber and the DMSO extract of yellow amber showed the best antimicrobial activity. The maximum value of bacterial inhibition was 20 mm from both extracts against isolate *Bacillus* sp. strain PK-7. The values varied between 8 to 12 mm for the alcoholic extract of orange amber and 10 to 16 mm for the DMSO extract of yellow amber towards most of the bacterial isolates. Whereas, the DMSO extract of

brown amber showed moderate efficacy towards four bacterial isolates, ranging from 10 to 12 mm. While the lowest efficacy showed by the DMSO extract of orange amber reached 12 and 15 mm only against *Bacillus cereus* strain B26 and *Bacillus* sp. strain PK-7, respectively.

DISCUSSION

From the results in Figure 1 the striking plating is a technique used to isolate pure isolates from a single colony of bacteria. the colonies can be grown on a new plate so that the bacteria can be identified, studied, or tested, rapid and ideally by a simple process of dilution methods. The technique is done by diluting a comparatively large concentration of bacteria to a smaller concentration. The decrease of bacteria should show that are sufficiently spread apart to affect the separation of the different types of bacteria. The genetic identification showed that different species of bacteria were isolated from tissue culture after cultivated on an agar medium. The most common species were the *Bacillus*. This genus of Gram-positive bacteria possesses the ability to withstand extreme environmental conditions by producing strong, protective endospores (Nakano and Zuber, 1998). Therefore, it is found in different environments such as soil, air, and human. *Bacillus* is one of the most common bacterial species that was isolated from a date palm culture contaminated with microbes (Al-Dosary *et al.*, 2011). While *Lysinibacillus* sp. is rare in plant tissue, they may be isolated for the first time in this study from contaminated date

Table 3. Antimicrobial activity of DMSO and alcohol extract of amber against bacterial strain

| Isolates | DMSO extract of amber | | Alcohol extract | |
|----------|-----------------------|-------|-----------------|--------------|
| | | | Yellow | Orange amber |
| | Orange | Brown | | |
| WI 21 | 0 | 11 | 16 | 12 |
| WI 22 | 12 | 10 | 15 | 10 |
| WI 24 | 15 | 12 | 20 | 20 |
| WI 25 | 0 | 0 | 15 | 0 |
| WI 28 | 0 | 0 | 0 | 0 |
| WI 29 | 0 | 10 | 0 | 8 |
| WI 31 | 0 | 0 | 10 | 0 |
| WI 32 | 0 | 0 | 15 | 8 |

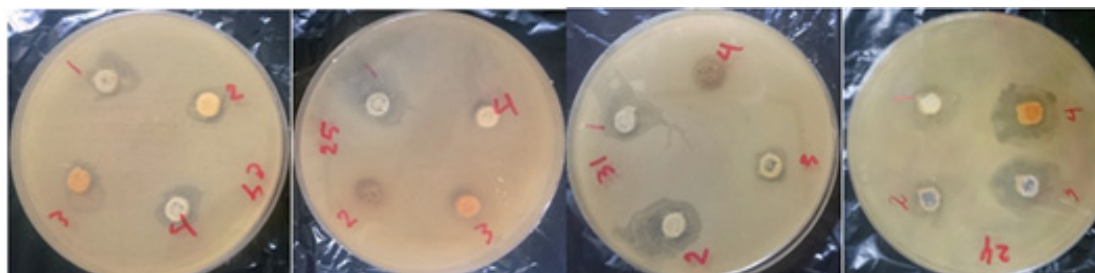


Fig. 4. Antimicrobial efficacy of different amber extract against bacterial strains

palm tissues. There is no study currently indicating the isolation of species of this genus from such environments. In a study by Ndiaye *et al.* (2019), three novel bacterial species were isolated from human skin, one of these was *Lysinibacillus timonensis*.

The majority of bacterial species that have been contaminated with date palm due to Dates are a good source of energy and rich in nutrients. Date fruits consist of 70% carbohydrates; mostly as sugars, and 15-30% water. Dates are also a source of different minerals including iron, potassium and calcium, with low levels of sodium and fat (Abass, 2013). Our antibiotic sensitivity testing revealed Amikacin as the most effective antibiotic against the contaminating bacteria Table 1 and Figure 2 inhibited the bacterial growth due to most bacteria produce a cell wall that is composed partly of a macromolecule called peptidoglycan, itself made up of amino sugars and short peptides. Amikacin prevents the final cross-linking step, or transpeptidation, in the assembly of this macromolecule and inhibits bacterial growth by stopping protein synthesis through binding to the 30S subunit of bacterial ribosome (Ramirez *et al.*, 2017). Both bacteria and humans carry out protein synthesis on structures called ribosomes. Another antibiotic such as Norfloxacin accumulated in high concentrations in the cytoplasm after crossing through membranes of bacteria. The target enzymes of these antibiotics are DNA gyrase and topoisomerase IV for inhibiting replication of DNA and other function. Norfloxacin is a broad spectrum used against both G+ve and G-ve to treat bacterial infection (Defant *et al.*, 2019).

In plant tissue culture research and applications, bacterial contamination represents a serious problem. If the presence of bacteria is ignored bacterial interference with normal plant physiology and morphology generating misleading conclusions (Moreno-Vázquez *et al.*, 2014). To eliminate bacterial contaminants serious attempts have been performed to support sterile procedures to reduce the microbial contamination of tissue culture, including controlling environmental and nutritional factors and treatment with antibiotics (Abass, 2013).

During the past decades, antibiotic-resistant bacteria have proliferated widely and at alarming rates due to a combination of different factors. There are strenuous efforts by scientists to find new materials to control intrinsic and acquired drug resistance, including natural active products. The

continued use of antibiotics in the medium or repeated treatments with a single antibiotic may lead to bacterial resistance (Kneifel and Leonhardt, 1992). Also, antibiotics have been shown to restrict rooting, general growth and multiplication in plant cultures (Leifert *et al.*, 1994). Antibiotics may be harmful to plants because of their phytotoxicity. So in our study, we used a Baltic amber extract as an antibacterial, amber has no toxicity because it's a natural product the results showed that three types of amber has activity against isolates of bacteria that contaminated plant tissue culture. Many compounds present in Baltic amber show antimicrobial properties against bacteria, fungi and viruses (Tumilowicz *et al.*, 2016).

Baltic Amber is a resin that contains several natural organic biomolecules and can be used against microbial infections, and protects the tree from disease and injury infected by insects and fungi (Langenheim, 1969). The results in the present study are compatible with the study of Carpenter *et al.* (2012) who showed that some compounds of amber such as abietic acid, α -pinene and camphene are effective antibacterial agents. Also, the results agreed with Tumilowicz *et al.* (2016) that showed Baltic amber has potent antibacterial and antifungal properties against pathogenic microorganisms that existing on human skin. Al-Tamimi *et al.* (2016) reported the potential activity of Baltic amber on clinical bacteria so it's can be used as an alternative chemotherapeutic agent. Since alcohol extract of orange amber was more effective than DMSO extract, our study recommends the use of amber alcohol extracts to control bacteria associated with plant tissue culture.

CONCLUSION

Controlling microbial contamination is one of the most important priorities for plant tissue culture. In this study, different sterilization methods are chosen in terms of efficiency and safety. Some bacterial species associated with date palm plant tissue contamination were isolated, identified and tested for sensitivity to four types of antibiotics. This study also determined the efficiency of using natural agents such as amber extracts, in controlling microbial contamination related to tissue culture.

REFERENCES

Abass, M.H. 2013. Microbial contaminants of date palm

- (*Phoenix dactylifera* L.) in Iraqi tissue culture laboratories. *Emirates Journal of Food and Agriculture*. 25 (11) : 875-882.
- Abass, M.H. and Awad, K.M. 2019. A review on date palm (*Phoenix dactylifera* L.) tissue cultured plants off-typeness in Iraqi laboratories. *Basrah Journal for Date Palm Research*. 18(2) : 1-13.
- Al-Dosary, N. H., AL-Mosauji, M.A. and Al-Taha, H.A. 2011. Isolation and Identification of Bacterial Types That Causes Contamination of Date Palm *Phoenix dactylifera* L Callus and studding Inhibitory activates of some plant extracts and Antibiotic. *Basrah Journal for Date Palm Research*. 10(1) : 68-81.
- Al-Hadethy, H.T., Al-Ataby, S.D. and Mdhi, Z.J. 2007. Isolated bacteria from contaminated date palm tissue cultures and healthy offshoots. *Basrah Journal of Agricultural*. 3(2) : 12-25.
- Al-Khayri, J.M. and Naik, P.M. 2017. Date palm micropropagation: *Advances and Applications. Ciência e Agrotecnologia*. 41(4) : 347-358.yp
- Al-Mussawi, M.A. 2010. The source of bacterial contamination of date palm *Phoenixdactylifera*L. tissue cultures. *Basra Journal for Date Palm Researches*. 9 (2) : 132-146.
- Al-Tamimi, W.H., Al-Saadi, S.A.M. and Burghal, A.A. 2020. Antibacterial activity and GC-MS analysis of baltic amber against pathogenic bacteria. *International Journal of Advanced Science and Technology*. 29 (11s) : 611-618.
- Carpenter, C.D., O'Neill, T., Picot, N., Johnson, J.A., Robichaud, G.A., Webster, D. and Gray, C.A. 2012. Anti-mycobacterial natural products from the Canadian medicinal plant *Juniperus communis*. *Journal of Ethnopharmacology*. 143(2) : 695-700.
- Collins, C.H. and Lyne, P.M. 1984. *Microbiological Methods* (5th ed.) Butterworths Co. Ltd., London. pp. 56-113.
- Daud, N. H., Jayaraman, S. and Mohamed, R. 2012. Methods paper: An improved surface sterilization technique for introducing leaf, nodal and seed explants of *Aquilariamalaccensis* from field sources into tissue culture. *Asia Pacific Journal of Molecular Biology and Biotechnology*. 2 : 55-58.
- Defant, A., Voza, A. and Mancini, I. 2019. Design, Synthesis and Antimicrobial Evaluation of New Norfloxacin-Naphthoquinone Hybrid Molecules. In: *Multidisciplinary Digital Publishing Institute Proceedings*. 41(1) : p. 9.p
- El-Dawayati Maiada, M., Zayed Zeinab, E. and Farrag Hala, M. 2020. The impact of using the *Zingiberofficinale* extract in controlling the endogenous bacterial contamination of date palm during tissue cultures. *International Journal of Environment, Agriculture and Biotechnology*. 5(4) :1038-1047 .p
- Emoghene, B. O., Idu, M., Eke, C. R. and Asemota, O. 2020. Effects of Different Sterilization Regimes & Growth Regulators on Micropropagation of Female Date Palm (*Phoenix dactylifera* L.). *Nigerian Journal of Biotechnology*. 37(1) : 159-168.p
- Gandhimathi, R., Arunkumar, M., Selvin, J., Thangavelu, T., Sivaramakrishnan, S., Seghal ýKiran, G., Shanmughapriya, S. and Natarajaseenivasan, K. 2008. Antimicrobial potential of ýsponge associated marine actinomycetes. *Journal of Medical Mycology*. 18 (1): 16-22.
- Hameed, M.A. and Abass, M.H. 2006. Study of cytological changes associated with contaminated date palm (*Phoenix dactylifera* L.) tissue cultures with fungi. *Journal of Basra Researches*. 32 : 1-27.
- Ikenganyia, E.E., Anikwe, M.A.N., Omeje, T.E. and Adinde, J.O. 2017. Plant tissue culture regeneration and aseptic techniques. *Asian Journal of Biotechnology and Bioresource Technology*. 1(3) : 1-6.
- Jain, S.M. 2012. Date palm biotechnology: current status and prospective- an overview. *Emirates Journal of Food and Agriculture*. 24 (5) : 386-399.
- Katoh, K., Misawa, K., Kuma, K. and Myata, T. 2002. MAFFT: A fast novel method for rapid multiple sequence alignment based on Fourier transform. *Nucleic Acids Research*. 30 (14) : 3059-3066.
- Kidus T., Tekla Z. and Berhe, D. 2020. Isolation, characterization and identification of contaminant bacteria from sugarcane (*Saccharum officinarum* L.) *In vitro* Culture in Tigray Biotechnology Center, Mekelle, Ethiopia. *Journal of Bacteriology and Parasitology*. 11 : 1-13.
- Kneifel, W. and Leonhardr, W. 1992. Tesring of differenr antibiotics against gram positive and gram negalive. Bacteria isolated from planrrissue cultures. *Plant Cell Tissue Organ Cull*. 29: 139-144.
- Kriaa, W. B., Sghaire-Hammami, R., Masmoudi-Allouche and Drira, N. 2011. The date palm (*Phoenix dactylifera*L.) micropropagation using completely mature female flowers. *Comptes Rendus Biologies*. 335 : 194-204.
- Lane, D.J. 1991. 16S/23S rRNA sequencing in: *Nucleic Acid Techniques in Bacterial Systematic*. (eds). Stackebrandt E., Goodfellow M. John Wiley and Sons, Ltd. *Chichester England*.
- Langenheim, J.H. 1969. Amber-abotanical inquiry. *Science*. 163 (3): 1157-1169.
- Leelavathy, S. and Sankar, P. D. 2016. Curbing the menace of contamination in plant tissue culture. *Journal of Pure and Applied Microbiology*. 10 (3) : 2145-2152.p
- Leifert, C. and Waites, W.M. 1994. Dealing with microbial contaminants in plant ýtissue and cdI culture: hazard analysis arid aíticaJ control points. In: *Physiology, ýGrowth and Development of Plants in CldI Ure*. PJ. Lumsden, J.R. Nicholar and W. J. ýDavies. eds. *Kluwa Academic Publishen*.

- Netherlands. pp. 363-378.
- Liu, J., Xie, X., Xiao, S., Wang, X., Zhao, W., and Tian, Z. 2007. Isolation of *Leptospirillum ferriphilum* by single-layered solid medium. *Journal of Central South University of Technology*. 14 (4): 467-473.
- Mbah, E.I., and Wakil, S.M. 2012. Elimination of bacteria from in vitro yam tissue cultures using antibiotics. *Journal of Plant Pathology*. 94 : 53-58.
- Moreno-Vázquez, S., Larrañaga, N., Uberhuaga, E.C., Braga, E.J.B. and Pérez-Ruiz, C. 2014. Bacterial contamination of in vitro plant cultures: confounding effects on somaclonal variation and detection of contamination in plant tissues. *Plant Cell, Tissue and Organ Culture*. 119 (3) : 533-541.
- Nakano, M.M. and Zuber, P. 1998. Anaerobic growth of a "strict aerobe" (*Bacillus subtilis*). *Annual Review of Microbiology*. 52 : 165-190.
- ýNdiaye, C., Lo, C.I., Bassene, H., Raoult, D., Lagier, J.C. and Sokhna, C. 2019. *Lysinibacillus timonensis* sp. nov., *Microbacterium timonense* sp. nov., and *Erwinia mediter raneensis* sp. nov., three new species isolated from the human skin. *New Microbes and New Infections*. 31: 100579.
- Odutayo, O.I., Amusa, N.A., Okutade, O.O. and Ogunsanwo, Y.R. 2007. Sources of microbial contamination in tissue culture laboratories in south-western Nigeria. *African Journal of Agricultural Research*. 2 (3) : 67-72.
- Omamor, I.B., Asemota, A.O., Eke, C.R. and Eziashi, E. I. 2007. Fungal contaminants of the oil palm tissue culture in Nigerian institute for oil palm research (NIFOR). *African Journal of Agricultural Research*. 2(10) : 534-537.
- Ramirez, M.S. and Tolmasky, M. E. 2017. Amikacin: uses, resistance, and prospects for inhibition. *Molecules*. 22 (12) : 2267.
- Singh, C. R. and Kathiresan, K. 2015. *In-vitro* callus induction from *Ceriops decandra*-A true mangrove viviparous. *International Journal of Advanced Multidisciplinary Research*. 2 : 01-05.
- Tumilowicz, P., Synoradzki, L., Sobiecka, A., Katarzyna, J.A., Pytkowska, K. and Safarzyński, S. 2016. Bioactivity of Baltic amber - fossil resin. *Polimery*. 61 (5) : 347-356.
- Van Dijk, K., Voets, G.M., Scharringa, J., Voskuil, S., Fluit, A.C., Rottier, W. C. and Stuart, J.C. 2014. A disc diffusion assay for detection of class A, B and OXA-48 carbapenemases in Enterobacteriaceae using phenyl boronic acid, dipicolinic acid and temocillin. *Clinical Microbiology and Infection*. 20(4) : 345-349.
- Vlková, E., Rada, V., Popeláková, P., Trojanová, I. and Killer, J. 2006. Antimicrobial susceptibility of bifidobacteria isolated from gastrointestinal tract of calves. *Livestock Science*. 105 (1-3) : 253-259.
- Vujovic, T., Ruzic, D.J. and Cerovic, R. 2012. *In vitro* shoot multiplication as influenced by repeated subculturing of shoots of contemporary fruit rootstocks. *Horticultural Science*. 39 : 101-107.
-