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Keywords: *traditional medicine, COVID-19, psychological health, antiviral agent.*

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Role of Plants in a Pandemic: Learning from the COVID-19 Situation

Snehangshu Das [α] & Minakshi Mahajan [σ]

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I. Introduction

Pandemics have existed since time immemorial. The humanity has seen horrific pandemics in the past and presently, it is experiencing one too. The outbreak of coronavirus illness 2019 (COVID-19) reportedly happened in a wet market at Wuhan, China, which can be accounted for a zoonotic transmission[1]. During the early days, the unexpected outbreak of the virus took more than 1800 lives and over 70,000 individuals got disease-ridden. The main warning symptoms comprises of excessively high body temperature, dry cough, and body weakness, whereas several patients have symptoms of myalgia and bowel disorders too[2]. In many cases, respiratory system failure, septic shock, and also deaths have been recorded. The World Health Organisation has declared the coronavirus disease (COVID-19) as a pandemic in March 2020, which is caused by severe acute respiratory syndrome coronavirus 2 (SARS-COV-2)[3]. As of December 14, 2020, 72.6 million confirmed cases, 50.8 million cured cases (64.74 %) and 1.6 million (2.23 %) deaths have been reported worldwide[4]. Regrettably, the total number of confirmed cases continues to upsurge due to common man's negligence. The healthcare infrastructure of world is trying its level best to cope up with the upsurge in cases. Right now, the world is hearing about vaccines for SARS-CoV-2 which are being developed through extraordinary hard work[5]. But, the concern over its long-term efficacy and post vaccine effects on the body makes it a sensitive issue of discussion. Several therapeutic methods have been proposed which includes the use of Lopinavir/Ritonavir, Hydroxychloroquine, Remdesivirto cure COVID-19. However, the medical utility of these synthetic drugs to counter COVID-19 infection is still unclear[6]. In the absence of an appropriate treatment, herbal medications are becoming an adjuvant treatment to heal the symptoms of the disease.

The early evidence related to the use of herbal preparations in tackling a disease nearly dates back to 1500 BC by Egyptians. Later, Romans and Greeks improved the combinations and were recognized in the earliest known drug books named as Pharmacopoeias[7]. From Black Death to Spanish Flu, plant-based medicines have been used extensively in the absence of drugs[7]. Even in this century, phytomedicines are the lone healing option for a large chunk of global population who are residing in the developing countries. But then, similarly in the developed nations, the practice of traditional phytodrugs is undergoing a revitalization, as it is considered as a safer and healthier option than artificially synthesised chemical drugs. Undeniably, traditional medications have existed since the inception of humanity. With a trend in increasing publication on the subject, a transformed shift of scientific interest can be seen on to plant-derived medications in the current decade[8]. The therapeutic potential of plants is solely due to the presence of secondary metabolism. Only the availability of resources to perform clinical trials of traditional medicines has limited its applications in modern world of drugs.

One role of the plants in the pandemic is in the form of medicinal values and the other role explores the importance of people-plant relationships in reference with the psychological well-being of humans. The primary measures taken to control the pandemic was completely through non-pharmacological interventions (NPIs)[9]. NPIs for preventing the disease included social distancing, isolation, quarantining the infected

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people and treating the cases[10]. From educational institutes, and work places to leisure venues, every possible place were locked up to avoid public gatherings. These recommendations were, and are still very much in place in some countries right now, which created job losses, scarcities of food and societal unrest with anxiety of the unknown at the global level[11]. Drastic changes in the daily routines led to affect the mental health among the people of all ages. They showed symptoms of trouble in concentrating, tetchiness and anxiety[12]. To a certain extent, despair, wretchedness, stress and nervousness have affected people during this period. Stress is principally associated with the existing information that does not provides a clear picture with respect to perils, extent of the pandemic, effect on the economy, and many other factors[11].Gardening and other horticultural practices as a therapy creeped in to rescue the mental health of the human beings during this time. The innate relationship between plants and people has been helping in bringing a positive change in mindset of the people. Through this review, we will explore both the roles of plants on humans during this pandemic tenure.

II. Plants as Medicines and Surface Protective Agents

The unique property of plants to produce secondary metabolites has enabled the world to make them a source of medicinal compounds. From the preliminary outbreak phase of the COVID-19, plant-based therapeutics have been implemented in China. The use of qingfeipaidumixture, gancaoganjiangmixture, sheganmahuangmixture and qingfeitouxie-fuzhengmixtureseems to be helpful in the treatment of SARS-CoV-2[13]. A total of 701 patients were healed by qingfeipaidumixture, among them 130 patients healed in just 12 days. 319 patients lost clinical symptoms and got cured in 20 days, while 252 cases showed stability in their symptoms[14]. These results show that qingfeipaidumixture has an efficacy of 90% and above in treating the COVID-19[14]. The molecular interaction analysis has shown that patchouli alcoholic mixture, ergosterol and shionone extract could be a new high-quality drug choice against SARS-CoV-2. An oral liquid known as shuanghuanglian, which comprises of three plants including *Lonicera japonica*, *Scutellariabaicalensis* and *Forsythia*[15]. Since, it's low price and no grave side-effect, it is used for healing sore throat, fever, upper throat infection and cough[15]. A recently published article showed Shuang huanglianin combination with conventional treatments (immunoglobulin injections, doses of dexamethasone, antiviral and antibiotic medications) were used against COVID-19. The outcome exhibited that this cocktail of drugs can help the body improve without any known side-effects and resolve the symptoms[16].With the help of Out of the 214 patients, traditional herbal medicines have helped 193 patients to recover completely[17]. A latest publication showed that 60107 cases were healed by Chinese herbal medicines[14]. Besides, some herbal drugs prohibited the virus from infecting healthy individuals and enhanced the health of the affected infected individuals with mild or severe symptoms in many parts of the country[17,18].The Chinese herbal drugs locally called Shu Feng Jie Du and Lianhuaqingwen have been suggested, thanks to their good efficacy against earlier known viruses such as influenza A (H1N1) or Severe Acute Respiratory Syndrome (SARS-CoV-1)[19]. Such positive results led the inclusion of Chinese herbal medicines in the plans for the treatment and stoppage of COVID-19 in the Zhongnan Hospital of Wuhan University. Additionally, to cure the virus, the authorities recommended the usage of diverse herbal combinations in accordance with the disease-stage[20].

In South Korea, Korean herbal medications are being administered to patients for free of cost, and the plant based remedies are surely helping the diseased individuals to be healthy[21]. The clinical experts from the Korean Association of Traditional Pulmonary Medicine and the Association of Korean Medicine both drafted their individual guidelines of traditional medicine on the inhibiting and curing of COVID-19[22]. The guidelines included the use of Youngyopaedoc-san along with Bojungikgi-tang, and Youngyopaedoc-san with the application of Saengmaek-san[22,23]. And, two more Korean plant-based preparations were recommended for patients who recovered from the SARS-CoV-2[23]. It included the combinations of Youngyopaedoc-san with the use of Bulhwangeumjeonggi-san and Bojungikgi-tang with Youngyopaedoc-san for eliminating post COVID-19 complications[22,23]. For patients with mild symptoms, three more herbal medications were suggested, which includes Youngyopaedoc-san along with the use of Galgunhaegui-tang for those without pneumonia but with excessive warm breath; Bulhwangeumjeonggi-san along with Sosiho-tang was suggested for people with mugginess-heat in the infected lungs[23]. The herbal recommendations for recovery stageinclude Saeng-maek-san with the use of Samchulkunbi-tang or Chungseuiki-tang with the application of Samchulkunbi-tang[23].

In India, Ayurveda, Unani, Siddha and Homeopathy system of medications has been the most sought-after prophylactic treatment for COVID-19. A set of guidelines has been released by the Indian government for each of the traditional medicine system[24]. Additionally, the Prime Minister of India in his address to country also stated that the use of such medicines can help in improving body resistance against COVID-19. Following which the demand of traditional herbal medicines increased in the country. An

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interim report on two traditional drugs combinations, Immunofree and Reginmune, has shown exceptional results when compared with conventional drug treatment[25]. On fifth day, more than 85% recovery rate has been seen only in the use of both the medicines against 60% during the use of only conventional drugs[26]. In 10 days, all the patients recovered completely[26]. Such results are very encouraging as the trials included aged patients of 70 years old with comorbidities[25]. These medicines are a combination of 15 plants which has been also recommended by the Indian government in its herbal medicine guidelines[25]. A southern Indian state, Kerala, has used traditional medicines along with synthetic drugs to treat and mitigate the spread of SARS-COV-2 in its region. And, has been successful in flattening the curve of the disease[27]. The state government has divided the population in seven groups based on the probable spread of the virus, and been recommended to use Ayurveda consequently[28].Some other Indian states have been utilising traditional medicine treatments as an anticipatory measure against the disease, which includes Gujarat is treating all asymptomatic patients with traditional medicines and is also distributing herbal immunity boosters to a large chunk of its population for free[29]. The huge community of traditional medicine practitioners makes it easy to reach the masses with low cost prophylactic treatments for the disease, and that is helping to increase the recovery rate of the nation[30].The African nations are also exploring their rich resource of traditional medicines against COVID-19. In Madagascar, a highly debatable organic drink consisting the herb *Artemisia afra* is making rounds as a viable treatment for COVID-19. It is commonly used all over Africa to improve and treat the symptoms of respiratory ailments, some of which shares similarities with COVID-19 symptoms[31,32]. Following which, the World Health Organisation has set up panel of experts totest African traditional medicine as a probable treatment for the COVID-19 infection[33]. The trials of the herbal remedy have progressed into the third phase[34]. In these similar contexts of African phytomedicines that omics machineries offer scenarios to recognizemode of action for phytodrugs and, thus, Africans are positive towards contributing to the pool of novel molecular markers for therapeutic innovation to fight against SARS-COV-2[35]. All the recommended medicinal plants have been presented in the Table 1.

There are many other secondary metabolites which are needed to be explored. Such as galactans which are antiviral in nature can be extracted from marine algae like *Ruppia maritime* and terrestrial plants such as *Stevia rebaudiana* and *Bassia rubra*[36–38]. The secondary metabolite could easily fight against herpes simplex type virus 1 & 2. A recent study also showed the efficacy of glycosides and flavonoids derived from *Allium sativum*, *Senna,* and *Salvia officinal is* yields different phytochemicals which have the capability tomutilate the gyrase produced by SARS-COV-2[39]. Even, the Persian traditional medicine recommendations include the use of both *Allium sativum* and *Allium cepa* against COVID-19[40]. Such recommendations are tedious to find if they are not available on one platform. A recent Github project has emerged which is helping the common people to store different government recommendations for herbal medicines on one platform[41]. The use of technology is helping the database to reach the masses. The probable list of plants which can be explored for their medicinal purposes has been listed in Table 2.

The current situation has taught us that a formidable vision towards developing future antiviral materials must be developed to tackle future pandemics. Marine algae are the store house of sulphated polysaccharides. Species of *Porphyridium*, a red alga, has high content of sulphated polysaccharides known as carrageenan which are antiviral in nature[42]. A study shows that a layer of sulphated polysaccharides on sanitary items destroys SARS-COV-2 on the surface[43]. Apart from algal derived compounds, tea tree oil and eucalyptus oils with biologically active compounds has natural virucidal properties which can be possibly used to coat surfaces for gaining antiviral properties[44].These essential oils showed significant antiviral action against wide-rangingorganisms such as bacterial, fungal, and virus-related species, and mainly were found to be active in inactivation of airborne influenza virus as soon as it was applied on the mesh surfaces as the pre-coating of the mesh fibers[44]. Recently, a study showed that by modifying cyclodextrins, a naturally occurring glucose derivatives from starch rich natural sources, non-toxic antiviral materials can be developed which have a competence to destroy viruses on coming in contact with the materials[45]. Thus, it exhibits virucidal properties. The oleuropein, a polyphenolic compound derived from olive leaves, have been acknowledged as a good inhibitor to an extensive range of viruses by hindering the manufacturing process of enzymes required for viral replication[46]. Purple Tabebuia (*Tabebuia impetiginosa*) is a very common tree found in South and Central American nations. The inner bark of the species has been advertised as an enhancement to decrease inflammation and encourage loss in weight. The quinoids derived from the purple tabebuia can be instrumental in inhibiting virus reproduction by chemically impairing the DNA and RNA present in the viral proteins[47]. These interesting natural extractions tend to be very capable for becoming antiviral coating contenders. In future, these compounds will play an essential role in developing both natural antiviral materials and drugs.

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Table 1: Recommended medicinal plant extracts for treating and preventing COVID-19 worldwide. (*ATM- African Traditional Medicine; CTM- Chinese Traditional Medicine; KTM- Korean Traditional Medicine)

Medicine name	Type of Medicine	Commercial label	Traditional medicine name
For Preventive Measures and Mild Symptoms			
Tinosporacordifolia	Liquid mixture	SamshamaniVati	Ayurveda
Andrographis paniculata	Liquid mixture	Nilavembukudineer	Siddha
Cydonia oblonga Zizyphusjujube Cordia myxa	Liquid mixture	Behidana Unnab Sapistan	Unani
Arsenicum Album 30	Tab/Liquid	Arsenicum album 30	Homeopathy
Coronil	Tab	Coronil	Ayurveda
Anu Taila	Nasal Inhaling Liquid	Anu Taila	Ayurveda
Artemisia afra Artemisia annua	Organic drink	CVO Tambavy	ATM
AraliaeContinentalis Radix	Powder/Liquid	AraliaeContinentalis Radix	KTM
Bupleuri Radix	Powder/Liquid	Bupleuri Radix	KTM
AngelicaeDecursivae Radix	Powder/Liquid	AngelicaeDecursivae Radix	KTM
Poria Sclerotium	Powder/Liquid	Poria Sclerotium	KTM, CTM
Ginseng Radix	Powder/Liquid	Ginseng Radix	KTM, CTM
Aurantii	Powder/Liquid	Aurantii Fructus Immaturus	KTM, CTM
Platycodi	Powder/Liquid	Platycodi Radix	KTM, CTM
Cnidii	Powder/Liquid	CnidiiRhizoma	KTM, CTM
Schizonepetae	Powder/Liquid	Schizonepetae Spica	KTM, CTM
Saposhnikoviae	Powder/Liquid	Saposhnikoviae Radix	KTM, CTM
Glycyrrhizaeglabra	Powder/Liquid	Glycyrrhizae Radix	KTM, CTM
Cnidii	Powder/Liquid	CnidiiRhizoma	KTM, CTM
Bupleuri	Powder/Liquid	Bupleuri Radix	KTM, CTM
Mori Folium	Powder/Liquid	Mori Folium	KTM, CTM
Mentha	Powder/Liquid	MenthaeHerba	KTM, CTM
Scutellariae	Powder/Liquid	Scutellariae Radix	CTM
Trichosanthis	Powder/Liquid	Trichosanthis Semen	CTM
Gypsum Fibrosum	Powder/Liquid	Gypsum Fibrosum	CTM
Benincasaepericarpium	Powder/Liquid	Benincasae	CTM
Rehmanniae	Powder/Liquid	Rehmanniae Radix Crudus	CTM
LoniceraeFlos	Powder/Liquid	LoniceraeFlos	CTM
Saposhnikoviae Radix	Powder/Liquid	Saposhnikoviae Radix	CTM
Chuanxiong Rhizoma	Powder/Liquid	Chuanxiong Rhizoma	CTM
Persicae Semen	Powder/Liquid	Persicae Semen	CTM
Mori Radicis Cortex	Powder/Liquid	Mori Radicis Cortex	CTM
Rhei	Powder/Liquid	Rhei Radix et Rhizoma	KTM, CTM
LepidiiseuDescurainiae Semen	Powder/Liquid	LepidiiseuDescurainiae Semen	KTM, CTM
For Moderate Symptoms			
Ayush -64	Tab	Ayush -64	Ayurveda
Agastya Haritaki	Powdery extract	AgasthyaRasayanam	Ayurveda
Anuthaila	Extraction made in oil	Sesame Oily extract	Ayurveda
AdathodaiManapagu	Liquid mixture	AdathodaiManapagu	Siddha
VishasuraKudineer	Tab	Poly-herbal preparation	Siddha
Bryonia Alba	Tab	Bryonia	Homeopathy
Rhus Toxico Dendron	Tab	Rhus tox	Homeopathy
Atropa belladonna	Tab	Belladonna	Homeopathy
Bignonia sempervirens	Tab	Gelsemium	Homeopathy
Eupatorium perfoliatum	Tab	Eupatorium	Homeopathy
Amomi Tsao-ko Fructus	Powder/Liquid	Amomi Tsao-ko Fructus	KTM
Alumen	Powder/Liquid	Alumen	CTM
Cicadae Periostracum	Powder/Liquid	Cicadae Periostracum	CTM
Tetrapanacis Medulla	Powder/Liquid	Tetrapanacis Medulla	CTM
Paeoniae Radix Rubra	Powder/Liquid	Paeoniae Radix Rubra	CTM
PinelliaeRhizomaPraeparatum cum alumine	Powder/Liquid	PinelliaeRhizomaPraeparatum cum alumine	CTM

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For Severe Symptoms			
Astragali	Powder/Liquid	Astragali Radix praeparata cum melle	CTM
Citrireticulatae	Powder/Liquid	CitriReticulataePericarpium	CTM
Atractylodismacrocephalae	Powder/Liquid	AtractylodisMacrocephalaeRhizoma	CTM
Codonopsis	Powder/Liquid	Codonopsis Radix	CTM
Fritillariaethunbergii	Powder/Liquid	FritillariaeThunbergii Bulbus	CTM
Anemarrhenae	Powder/Liquid	AnemarrhenaeRhizoma	CTM
Magnoliaeofficinalis	Powder/Liquid	Magnoliae Officinalis Cortex	KTM, CTM
For Post Recovery Symptoms			
Samchulkunbi-tang	Powder/Liquid	Samchulkunbi-tang	KTM
Ophiopogon japonicas	Extract used as intravenous injection	Saeng-maek-san	KTM
Schisandra chinensis			
Panax ginseng			
Massa MedicataFermentata	Powder/Liquid	Massa MedicataFermentata	CTM, KTM
Phellodendri	Powder/Liquid	Phellodendri Cortex	CTM, KTM
Schisandrae	Powder/Liquid	Schisandrae Fructus	CTM, KTM
Hordei	Powder/Liquid	Hordei Fructus Germinatus	CTM, KTM
Liriopis	Powder/Liquid	Liriopis Tuber	CTM, KTM
Alismatis	Powder/Liquid	AlismatisRhizoma	CTM, KTM

Table 2: A table of herbs which may have the capability to prevent the SARS-CoV-2 and other viruses

S. no.	Plant names	Invitro applications	Aim	Virus
1.	*Acacia nilotica*	Reducing Caginess	–	HIV-PR
2.	*Allium sativum*	Proteo-lytic and haem-agglutinating action and viral duplication	–	SARS
3.	*Andrographis paniculata*	Clampdown	NLRP3, capase-1, and IL-1β	SARS-COV and likely SARS-CoV-2
4.	*Boerhaaviadiffusa*	ReducingCaginess	ACE	–
5.	*ClerodendruminermeGaertn*	Inactivation	Ribosome	SARS-CoV-2
6.	*Clitoriaternatea*	Metalloproteinase inhibitor	ADAM17	–
7.	*Coriandrum sativum*	ReducingCaginess	ACE	–
8.	*Cynara scolymus Cassia occidentalis Cosciniumfenestratum*	ReducingCaginess	ACE	–
9.	*EmbeliaRibes*	ReducingCaginess	ACE	–
10.	*Eugenia jambolana*	ReducingCaginess	Protease	–
11.	*Euphorbia granulata*	ReducingCaginess	–	HIV-1 PR
12.	*Glycyrrhiza glabra*	Hindering of viral duplication; Intonation of membranechangeability		SARS; HIV-1
13.	*Gymnemasylvestre*	The reticence of virus-related DNA production	–	–
14.	*Hyoscyamus niger*	Reticence and Nebulizer	Ca2+	–
15.	*Ocimumkilimandscharicum*	ReducingCaginess	–	HIV-1
16.	*Ocimum sanctum*	ReducingCaginess	–	HIV-1
17.	*Punica granatum*	ReducingCaginess	ACE	–
18.	*Salacia oblonga*	ReducingCaginess	angiotensin II, AT1 signal	–
19.	*Sambucus ebulus*	ReducingCaginess	–	Enveloped virus
20.	*Solanum nigrum*	-	–	HIV-1
21.	*Sphaeranthus indicus*	ReducingCaginess	–	Mouse corona virus and Herpesvirus
22.	*Strobilanthescallosa*	Hindering	–	HCoV-NL63
23.	*Strobilanthescusia*	Hindering	–	HCoV-NL63
24.	*Vitex negundo*	ReducingCaginess	–	HIV-1
25.	*Vitex trifolia*	Reduction in cough	–	SARS-COV
26.	*Terminalia chebula*	Reducing cough and respiratory infection		Influenza A

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III. Plants as a Companion of Human Beings

The period of social isolation and lockdown brought new challenges to human beings from a psychological point of view. Several changes in the behaviours and habits of the families were noted, which can mainly develop changes in the psychological health of the people from all age groups. Difficulty in concentrating, cantankerousness and anxiety can be detected in them[12]. The people-plant interaction offers steadiness through interaction with the nature, facilitating contacts with other people and constructing the aesthetics of surroundings. With this understanding, gardening as an activity can be developed as an occupational therapy. Gardening as a healing remedy was first recognized and recommended by Dr. Benjamin Rush, for dealing with mental health. This effective practice was used for helping the war veterans cope up with their distress and, from that moment onwards, it was implemented to support the treatment of diverse types of mental illness diagnosis[48]. A substantial percentage of the population in large urban metropolises stays in small properties where the space for gardens is absolutely nil. Large apartment cooperatives may have designed places but, with the constraint on societalliving, they are very little in size or are completely not used. This gardening of indoor plants develops another alternative to come nearer to the nature. Some indoor plants like *Sansevieria trifasciata* and *Chlorophytum comosum*canbe grown easily and acts as efficient phytofilters for remediation of numerous pollutants from cigarette smoke[49]. *Zamioculcaszamiifolia* filters formaldehyde (used in various materials, paints, cosmetics, etc.)and toluene (found in paints, adhesives, oil, tanned materials, disinfectants, etc.)[50].These potted vegetations growing indoors help people devote most of their time, as well as develop plentiful of possibilities for experimenting with growing combinations of different plants. It is a simple answer to develop good air quality, while improving to the aesthetics of the location and contributing towards a huge range of benefits in the psychological, physiological and cognitive regions[51]. Many lonely millennials across the world turned to gardening as a resort for comforting their mind and mental well-being during the lockdown[52]. In US, the search term “gardening” reached a peak of daily searches during the prime lockdown phase which was from April 26th to May 2nd[53]. Throughout this time period of social isolation, numerous experts from the arenas of gardening, landscaping and ornamentation have made their living on social medias and have engrossed millions of individuals in pursuit of learning and development. Simple topics such as *how to maintain your plants*, *make your plantlets at home* and *use of cut flowers in diverse activities* were brought to the general public. There are reports that as many as 20 million people participated in many such activities from around the globe simultaneously[11]. Such practices have helped many people cope with the distress and depression faced during the lockdown.

IV. Conclusion

The COVID-19 pandemic has led several scientific and clinical researchers to try to recommend operative drugs to eradicate the disease. The traditional medicines from India, China, Korea, Africa and Iran have centuries of practice in stoppage of pandemic and epidemic transmittable viruses are worth exploring to develop them as alternate contender for regulating SARS-COV-2 infection in patients. Currently, due to the lack of a vaccine or drug, the world has a good capability to explore the traditional medicine decoction and tablets. Confidently, positive outcomes from clinical trials are slowing explaining that phytodrugs alone or in blend with conventional synthetic medicine can help patients to recover from COVID-19. An editorial emphasized on the necessity of funding and exploring traditional medicine data in the background of the present, and probably upcoming, pandemics[54]. It is crucial to develop advance healing medicinal technologies to guard humans from the infection in tandem with phytoremedies can be easier to safeguard against the disease. There is an urgent need study more and conduct clinical trials of the different herbal medicines so as to tackle the infection of novel SARS-CoV-2. Apart from the medicinal uses of plants, we also need to explore natural antiviral surface protective agents so as to develop a sustainable and eco-friendly system to kill viruses on any surface. Increase in mental pressure and depression can also be solved through developing companionship with plants. We all know that how hard times were during the lockdown period and with many people living away from their homes, gardening and floricultural activities helped people maintain a good psychological health. Thus, plants play an integrated role during a pandemic from providing medicinal solutions to improving mental health.

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