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Original article

Anthropogenic impacts on phytosociological features and soil microbial health of Colchicum luteum L. an endangered medicinal plant of North Western Himalaya

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ABSTRACT

Colchicum luteum is currently a rare and threatened medicinal plant species in the Kashmir Himalaya. Due to the subsequent increase in anthropogenic pressure on medicinal plant species, it is imperative to understand the phytosociological and conservational status of the plant in its natural habitat. The objectives of this study were analysed in year 2018–2019 on the phytosociological data, viz. density, frequency, and abundance, as well as the rhizospheric soil microbial diversity of C. luteum in disturbed and undisturbed areas of the Kashmir Himalaya. We examined the distribution pattern, phytosociological data, and conservation status of C. luteum by analysing ecological features like abundance, frequency, and density in all three selected locations in Kashmir, Northern India and were found maximum values at Undisturbed areas. The highest values of density (3.24 ± 0.69 m^2), frequency (57.77 ± 13.55%), and abundance (5.49 m^2) were recorded at undisturbed site Harwan. The total bacterial count (CFU) and Vesicular Arbuscular Mycorrhiza (VAM) spore population from the rhizospheric soil of C. luteum were also analysed, with higher bacterial count i.e., Pseudomonas, Azatobacter, Rhizobium and PSB were (26.2 ± 0.648) (21.88 ± 0.675) (30.11 ± 0.576) and (14.11 ± 0.671) and VAM spore population (g^{-1}) of soil recorded 6.36 ± 0.550 at undisturbed areas viz. Harwan. The bacteria and fungi are likely keystone organisms that form an interface between soils and plant roots. Mutualistic associations with host plants have been observed in various natural and agricultural ecosystems. The present findings could be helpful in formulating conservation strategies for C. Luteum threatened and endangered medicinal plant present in North western Himalayan regions. The plant in disturbed areas that are affected by anthropogenic activities like tourism, grazing, deforestation, urbanization, transport etc. impacts on phytosociological and soil microbial patterns in the area. Because of these abiotic pressures, causes a reduction in plant cover in forest regions, soils become exposed, affecting soil microbial health. Therefore, the study shows the necessity for best practices for medicinal plant and forest management that provide effective monitoring and regulation of human activities in the offshore forest regions and avoid the intrusion of existing reserves.

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1. Introduction

The Himalaya, being one of the most biodiversity-rich regions of the world, is considered the most unusual ecosystem on Earth (Salick et al., 2009, Wani et al 2018a; Olokeogun and Kumar, 2020; Janaki et al., 2021). The area covered by the Indian Himalayan region (approximately 419,873 Km^2) has unique climatic con-

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ditions, physiographic, and soil characteristics which lead to different habitats and significant biological diversity. Due to their having great socio-economic potential, flowering plants are used for a large number of purposes, such as medicines, ornamentals, timber, fodder, etc. There are some important ecological attributes, for example, species richness, diversity pattern, forest composition, and spatial or temporal distribution patterns of species, that are significantly linked with prevailing environmental conditions as well as anthropogenic changes (Gairola et al., 2008; Rawat et al., 2010; Ahmad et al., 2011; Rai et al., 2020). The numerous environmental factors such as elevation and habitat influence the composition and species richness (Rawat and Chandra, 2012). As reported by (Rai and Singh, 2020; Shackleton and Mograbi, 2020; Rather et al., 2022), the floral diversity of any community is determined by the predictability, variability, and severity of the environment in which it develops and is affected by abiotic as well as biotic factors of the environment (Bano et al., 2021).

Human culture depends upon various characteristic assets, among which plants assume a significant job giving food, clothing, timber, fuel lumber, medication, etc. People have been utilising plants since ages to fix various diseases. Out of the total 297000–510000 plant species discovered around the world (Schippmann et al., 2002; Malik et al., 2018), around 70,000 are accepted to be utilised in medical services (Prajapati et al., 2003). A total of 17,500 medicinal species are considered to be in local abundance in India and about 34% are known to have restorative significance (Ved and Goraya, 2008). The majority of these species are under severe stress as a result of overuse and illegal exploitation (Vashistha et al., 2006). Other than the low accessibility of these plants, numerous species are either on the edge of elimination (Nautiyal et al., 2002) or have been endangered (Kala, 2006). The therapeutic utilisation of herbal medicinal plants by Gujjars and Bakerwals (forest local population) in Kashmir from old times remains a challenge to the extinction of rare medicinal plants (Nawchoo and Buth, 1994; Khan et al., 2004). As a result, an infrequent and continuous check of these species in the wild is severely lacking, with the available data being either subjective (Dhar et al., 1997) or ethnobotanical (Dar et al., 1984; Ara and Naqshi, 1992). The plants grow in networks with great ecological conditions. Their ecosystems are unique areas that contain important ecological characteristics, other plant species, and animal communities. The communities are assembled by their "species varieties, formative structures, strength, successional designs" etc. (Bano et al., 2018; Dindaroglu, 2021). The numerical data stresses the species which are predominating in the communities. To know their prevalence, certain phytosociological characters, for instance, densities, recurrence, and plenitude of plant species in an organization, are examined by techniques that incorporate quadrant assessment for all the phytosociological characters. A couple of naturalists have made their commitment to environmental variety (Wassie et al., 2010, Gotelli and Colwell, 2011, Graham and Duda, 2011, Erenso kadu et al., 2014; Nunez-Rios et al., 2020).

The present investigation was carried out on the diversity and distribution of the herbaceous medicinal plant *C. luteum* and the total bacterial count (CFU) of soil and (VAM) spore population (g^{-1}) of soil in the hilly forest areas of the Kashmir. The anthropogenic pressure viz., deforestation, overgrazing, tourism flow, urbanization, and traffic have been the important prevailing forces in ecological degradation and seen prominent and their effect on soil environment and plant ecosystem resulted in less vegetation cover and exhibited diminution in organic matter and impacts on soil microbial health (Butzer, 2005; Verma and Mushtaq, 2013; Wani et al., 2018; Bhat et al., 2021; Hussain et al., 2021). To study the present status of the Colchicum in the present investigation, the diversity and distribution of C. luteum vegetation were studied. In order to study the density, frequency, and abundance of these three sites in the hilly forest areas of Kashmir on C. luteum species, quadrant analysis was adopted at the study site. "Before this investigation, no work has been conducted on C. luteum on its diversity and distribution/ecological features and soil biological rhizospheric characteristics. Therefore, this study was undertaken on such an economically important medicinal plant, *C. luteum*, of the Kashmir valley in the North Western Himalaya".

2. Materials and methods

2.1. Study of population dynamics

The present study was carried out during year 2018–2019 in the Kashmir Himalaya at three different sites, viz., Aharbal, Kulgam (33.6441° N, 74.7776° E) Dhara, Theed Srinagar (34.1663° N, 74.9096° E) and Baera Baal Hills (Harwan) (34.3976° N, 74.3982° E) on the medicinal plant C. luteum L., with an altitudinal range of 2255 to 2275 m above mean sea level respectively. The Kashmir valley is located in the western Himalayas (33.27778° N, 75.3412°E), location of the study area is shown Fig. 1). The identification characters used to confirm the identity of *C. luteum* include the plant's flower, leaves and seeds (Fig. 2.)

2.2. Quadrant analysis (field study)

Quadrat analysis was conducted within the study sites. The analytical characters of the medicinal plant C. luteum were studied in terms of quantitative structures. These include frequency, density and abundance. The quadrat analysis was carried out in different regions of the Kashmir Himalaya, viz. Aharbal (Kulgam), Dhara Theed, (Srinagar) and Baera Baal (Harwan). To study the population dynamics of the selected medicinal plant species. The total of six quadrants of size 10 m × 10 m were laid down in each of the sub-locations. Within each of the 10 m × 10 m quadrant, five quadrants of size 1 m × 1 m were laid to note down the various ecological parameters showed in Fig. 3.

2.3. Phytosociological parameters

$$\textbf{Frequency}(\%) = \frac{\text{Number of quadrates in which the species occurred}}{\text{Total number of quadrants studied}} \times 100$$

$$\textbf{Density} = \frac{\text{Total number of individuals of a species in all quadrates}}{\text{Total number of quadrants studied}}$$

$$\textbf{Abundance} = \frac{\text{Total number of individuals of the species in all the quadrates}}{\text{Number of quadrates in which species occurred}}$$

2.4. Estimation of total microbial count bacterial and (VAM) from rhizosphere soil

(a) Isolation of *Pseudomonas, Azatobacter, Rhizobuim and* phosphate solublizing bacteria (PSB)

Seeley and Vandemark (1981) used modified Pseudomonas Agar Base, modified Azatobacter agar medium containing potassium dihydrogen phosphate/Ferric chloride, modified Rhizobuim medium containing 0.17% agar and potassium hydroxide, and modified Pikovskyas medium containing yeast extract, dextrose and calcium phosphate for PSB. The soil samples were serially diluted up to 10^6 times, and 0.1 ml of the diluted soil suspension was plated on different nutrient medias. For 3–4 days, the plates were incubated at 28 ± 2 °C in a biochemical oxygen demand

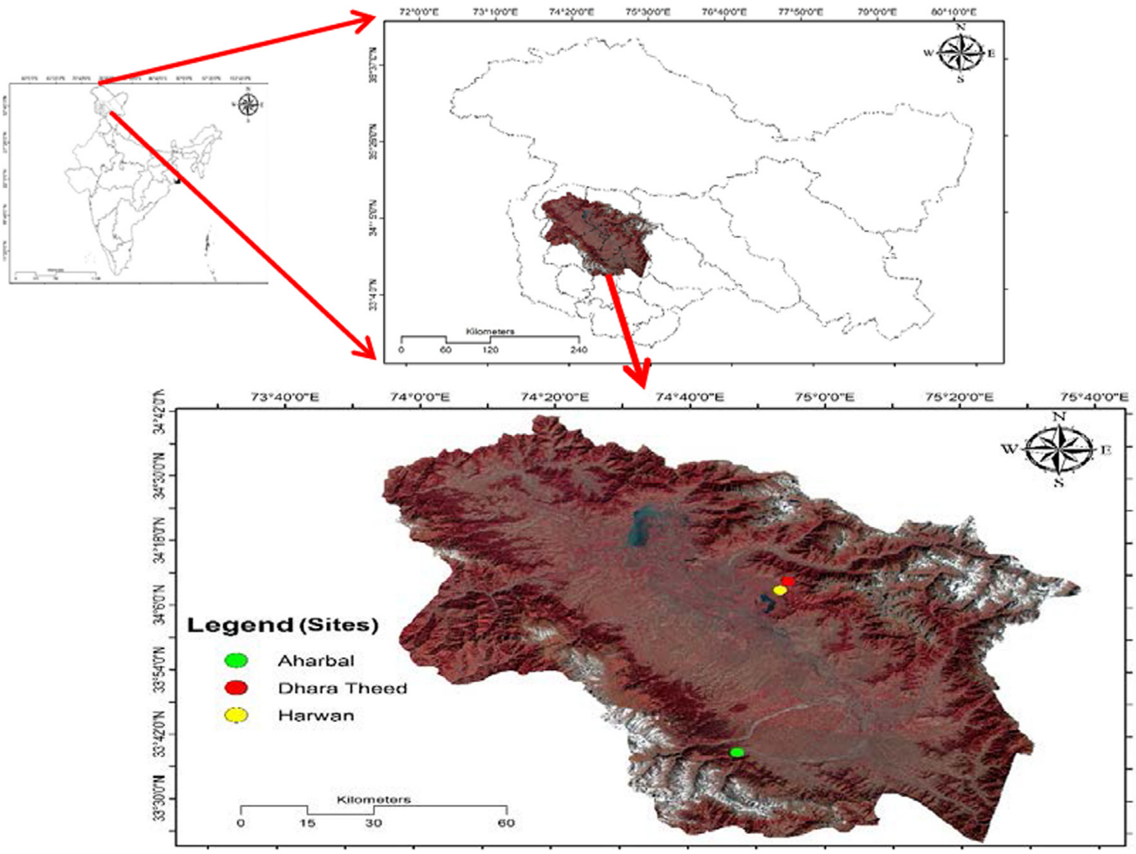

Fig. 1. Location map of the selected study areas in Kashmir, Himalaya viz., Aharbal, Dhara Theed and Harwan.

Fig. 2. Image describes the flower structure of *C. luteum* L., medicinal plant species.

(BOD) incubator. The colonies formed after 3–4 days of incubation were counted by using the colony counter.

(b) fungal population estimation of (VAM) from rhizosphere soil

The Arbuscular Mycorrhiza fungal spores were separated from the soil by wet sieving and decanting techniques (Gerdemann and Nicolson, 1963). The AMF spores were isolated by sucrose gradient centrifugation (Daniel and Skipper, 1982), and were then counted . 10 g of soil was mixed with 100 ml of water in the 500 ml beaker. The soil mixture was agitated vigorously to free the AMF spores from the soil and is allowed to settle for 1 h and 15 min. After this whole duration time, the contents of the beaker were decanted through the sieves, which were arranged in a descending order from 400 m to 25 m in size. The process was repeated three times. Spores were purified by re-suspending the

Fig. 3. Collection of data and samples from the selected areas of Kashmir, Himalaya. Site (I) representing Aharbal; Site (II) representing Dhara Theed; Site (III) representing Harwan.

sieving in the 10% sucrose solution and centrifugation was carried out. Centrifugation was carried out at 7000 rpm for five minutes. The supernatant was removed and poured into the sieves. The spores that hold onto the sieves were carefully rinsed with tap water. These AM fungal spores were identified by single spore or sporocarps were picked up easily from the sieves with the help of syringe needle and mounted on a glass slide with a drop of polyvinyl lacto phenol (PVL) and a cover slip was placed. The spores were identified by using a dissecting microscope.

3. Results

The density, frequency, and abundance at three sites in the forest areas of the Kashmir Valley, viz., Aharbal Kulgam, Dhara Theed, and Baerabal Harwan, were studied during the year 2017–2018 (spring). Among all the three sites, the highest density of the plant Colchicum luetum was shown at Baerabal Harwan (3.24 ± 0.69 m^2) and the lowest average density was shown at Aharbal Kulgam (1.15 ± 0.45 m^2) followed by Dhara Theed (1.38 ± 0.48 m^2) (Table 1 and Fig. 4). The highest frequency was shown at Baerabal Harwan (57.77 ± 13.55%) and the least average frequency was shown at Aharbal Kulgam (23.33 ± 80.90%) followed by Dhara Theed (31.11 ± 10.81%). The highest abundance was shown at Baerabal Harwan (5.49 ± 0.78 m^2) and the least average abundance was shown at Aharbal Kulgam (3.25 ± 1.06 m^2) followed by Dhara Theed (3.34 ± 1.01) (Table 1 and Fig. 4).

The total average bacterial count CFU (g^{-1}) of soil at three sites in the forest areas of Kashmir viz. Aharbal Kulgam, Dhara Theed, and Baerabal Harwan during the year (2017) was highest at the undisturbed site of Baerabal Harwan (26.2 ± 0.648) and the lowest average bacterial count CFU (g^{-1}) of soil was observed at the disturbed sites viz. Aharbal Kulgam (3.22 ± 0.617) followed by Dhara Theed (7.88 ± 0.650) (Table 2 and Figs. 5-7). The highest Azatobacter count CFU (g^{-1}) of soil was observed at the undisturbed site of Baerabal Harwan (21.88 ± 0.675) and the lowest average Azatobacter count CFU (g^{-1}) of soil was observed at disturbed sites viz. Aharbal Kulgam (1.88 ± 0.575) followed by Dhara Theed (5.10 ± 0.633) (Table 2). The highest Rhizobuim count CFU (g^{-1}) of soil was observed at the undisturbed site Baerabal Harwan (30.11 ± 0.576) and the lowest average Rhizobuim count CFU (g^{-1}) of soil was observed at disturbed sites viz. Aharbal Kulgam (6.22 ± 0.654) followed by Dhara Theed (13.33 ± 0.670) (Table 2). The highest Rhizobuim count CFU (g^{-1}) of soil was observed at the undisturbed site Baerabal Harwan (14.11 ± 0.671) and the lowest average Rhizobuim count CFU (g^{-1}) of soil was observed at disturbed sites viz. Aharbal Kulgam (1.99 ± 0.543) followed by Dhara Theed (4.88 ± 0.613) (Table 2 and Figs. 5-7).

The highest (VAM) spore population (g^{-1}) of soil was observed at the undisturbed site Baerabal Harwan (6.36 ± 0.55) and the lowest (VAM) spore population (g^{-1}) of soil was observed at disturbed sites viz. Aharbal Kulgam (2.73 ± 0.34) followed by Dhara Theed (3.23 ± 0.36) respectively (Table 3 and Fig. 8).

The PCA biplots obtained (Figs. 9 and 10) represent the three biplots of correlation between the soil microbes, which include Pseudomonas, Azatobacter, Rhizobuim, and phosphorous-solubilising bacteria, and the phytosological features (frequency, density, and abundance) studied with the geographic area selected, viz. Aharbal, Dhara Theed, and Harwan. The sites selected were not similar to each other and did not positively correlate. On the other hand, soil microbial population and phytosological features correlated positively when comparing data from geographic selected sites and these explained (98.96%) of the variability in the parameters analysed (Fig. 9a).

Correlation-based principal component analysis (PCA) also showed that soil biological attributes Pseudomonas, Azatobacter, Rhizobuim and Phosphorous Solublizing bacteria and the anthropogenic activities at disturbed sites were the main factors that influenced the Phytosociological Features Density, Frequency and Abundance (Figs. 9 and 10). Although PCA indicated a correlation between several groups, including Harwan undisturbed site with Pseudomonas, Azatobacter, Rhizobuim and Phosphorous Solublizing bacteria and Phytosociological Features Density, Frequency and Abundance were significantly and positively correlated with each other (Fig. 9a). Earlier studies are in agreement with current work in that microbial functional traits were shown to predict biogeographical patterns of microorganisms (Tang et al., 2016) also recorded (84.32%) of overall variations while performing the PCA study, and this could be considered an improvement in the overall soil nitrogen, "soil organic matter, soil potassium (available), soil water content and soil total potassium. Soil parameters (PCA-based correlation) were conducted by (Zhalnina et al., 2015) on microbial population supplementary variables (pH, $CaCO_3$, moisture, TC-total carbon, TN-total nitrogen, C/N ratio, NH_3, NO_3-N) on supplementary variables at (genus level at Park Grass Experiment).

4. Discussion

The magnitude of changes in the plant community was investigated using phytosociological attributes, primarily density, frequency, and abundance, which are the most fundamental units of study for any vegetation type. Grazing is one of the most important disturbances in terms of vegetation dynamics and grassland production (Tietjen and Jeltsch 2007, Baba et al., 2017). An examination was conducted to investigate many biotic stresses on grasslands and other forest vegetation types, including grassland total biomass (Baba et al., 2017). These studies make a significant contribution to understanding the impact of deforestation, grazing, tourism, and other factors on vegetation. Other studies showed significant negative impacts on grasslands and might cause grassland

Table 1
Impact of biotic stress on average density, frequency% and abundance of *C. luteum* L., at three locations of Kashmir Himalaya.

Sites	Sub-site	Density	Frequency (%)	Abundance
Aharbal (Kulgam) (Disturbed)	S1	1.43 ± 0.56	26.66 ± 90.88	3.60 ± 1.21
	S2	1.20 ± 0.47	23.33 ± 90.54	3.50 ± 1.11
	S3	0.83 ± 0.33	20.00 ± 70.30	2.66 ± 0.88
Mean ± SE		1.15 ± 0.45	23.33 ± 80.90	3.25 ± 1.06
Dhara Theed (Srinagar) (Disturbed)	S1	1.31 ± 0.36	30.00 ± 90.23	4.00 ± 1.06
	S2	1.46 ± 0.57	33.33 ± 13.33	3.08 ± 1.02
	S3	1.41 ± 0.51	30.00 ± 90.88	2.96 ± 0.97
Mean ± SE		1.38 ± 0.48	31.11 ± 10.81	3.34 ± 1.01
Baerabal Harwan (Undisturbed)	S1	3.43 ± 0.53	56.66 ± 12.01	7.36 ± 0.38
	S2	3.33 ± 0.75	56.66 ± 14.06	4.90 ± 1.11
	S3	2.93 ± 0.80	60.00 ± 14.60	4.21 ± 0.87
Mean ± SE		3.24 ± 0.69	57.77 ± 13.55	5.49 ± 0.78

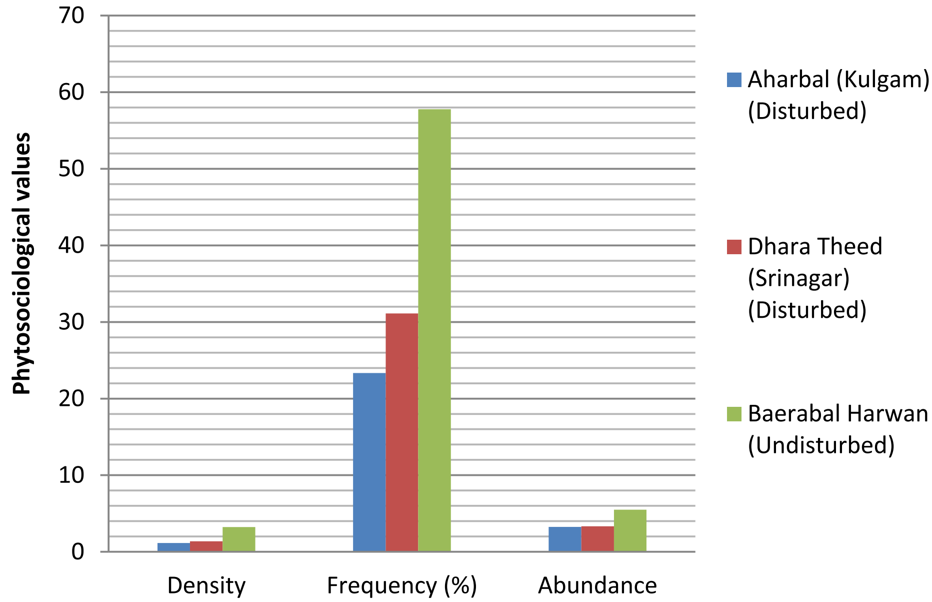

Fig. 4. Frequency, density and abundance of *C. luteum* at three locations of Kashmir.

Table 2
Impact of biotic stress on *Pseudomonas, Azatobacter, Rhizobuim* and Phosphorous solublising bacteria (PSB) count of soil at three locations of Kashmir Himalaya.

Sites	Sub Site	*Pseudomonas* ($\times 10^6$ CFU/g)	*Azatobacter* ($\times 10^6$ CFU/g)	*Rhizobuim* ($\times 10^6$ CFU/g)	PSB ($\times 10^6$ CFU/g)
Aharbal (Kulgam) (Disturbed)	S1	3.33 ± 0.625	2.00 ± 0.567	8.00 ± 0.657	2.33 ± 0.503
	S2	3.00 ± 0.615	1.66 ± 0.610	5.66 ± 0.641	2.0 0 ± 0.534
	S3	3.33 ± 0.612	2.00 ± 0.549	5.00 ± 0.664	1.66 ± 0.567
Mean ± SE		3.22 ± 0.617	1.88 ± 0.575	6.22 ± 0.654	1.99 ± 0.543
Dhara Theed (Srinagar) (Disturbed)	S1	8.00 ± 0.644	5.00 ± 0.643	13.00 ± 0.657	6.0 0 ± 0.612
	S2	7.33 ± 0.650	5.66 ± 0.645	13.66 ± 0.671	5.66 ± 0.657
	S3	5.0 0 ± 0.658	4.66 ± 0.611	13.66 ± 0.682	3.0 0 ± 0.624
Mean ± SE		7.88 ± 0.650	5.10 ± 0.633	13.33 ± 0.670	4.88 ± 0.613
Baerabal Harwan (Undisturbed)	S1	27.6 ± 0.647	21.33 ± 0.687	30.00 ± 0.515	15.0 0 ± 0.667
	S2	26.0 ± 0.663	22.33 ± 0.669	29.33 ± 0.561	13.0 0 ± 0.673
	S3	25.0 ± 0.634	22.00 ± 0.670	31.0 0 ± 0.654	14.33 ± 0.674
Mean ± SE		26.2 ± 0.648	21.88 ± 0.675	30.11 ± 0.576	14.11 ± 0.671

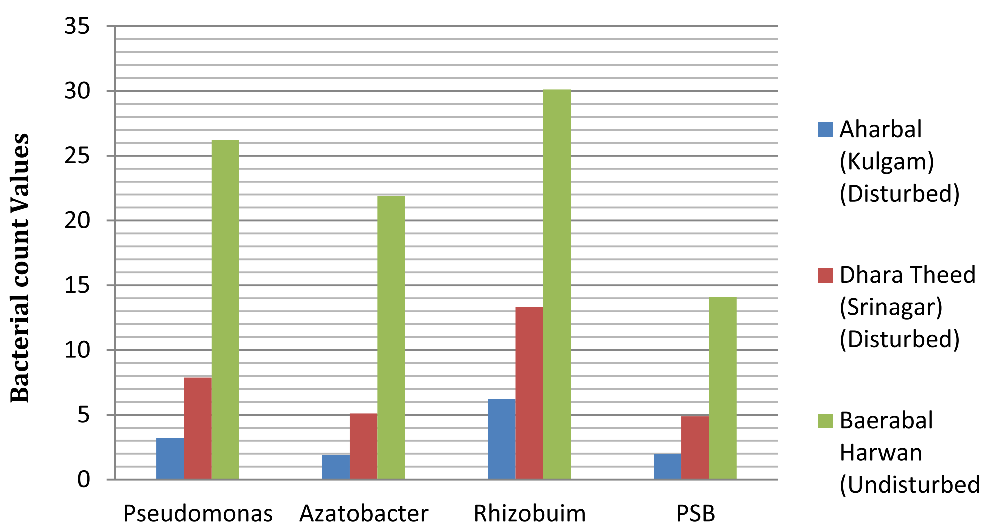

Fig. 5. Total bacterial count CFU (g^{-1}) of soil at three locations of Kashmir Himalaya of *C. luteum* at three locations of Kashmir Himalaya.

degradation (Hao et al., 2018). Moreover, agricultural requirements, commercial exploitation, grazing pressure, human influence, forest fires, etc. are prominent sources of degradation (Singh and Singh 2010, Xie et al., 2020). Workers analysed that depending on 'seasons, deforestation and density of grazers influences both vegetation structure, species diversity as well as spatial

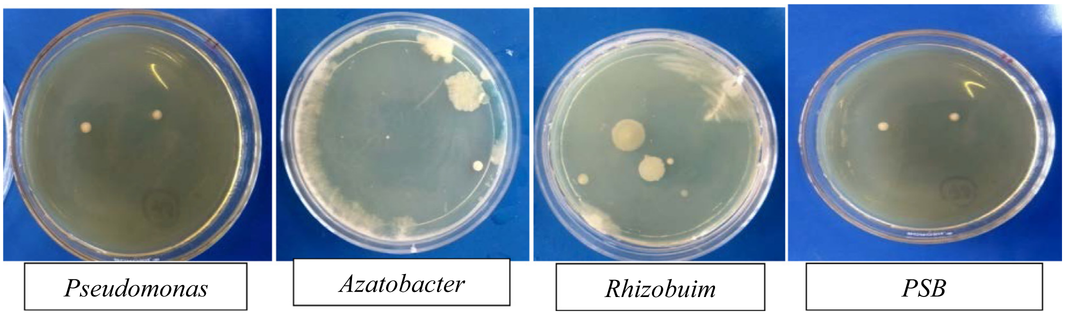

Fig. 6. Total bacterial count at disturbed site of Aharbal Kulgam Kashmir.

Fig. 7. Total bacterial count at undisturbed site of Baerabal Harwan Kashmir.

Table 3
Impact of biotic stress on (VAM) spore population (g^{-1}) of soil at three locations of Kashmir Himalaya.

Site	Area	Sub sites			Mean
		S1	S2	S3	
Aharbal Kulgam	Disturbed	2.5 ± 0.27	2.2 ± 0.45	3.5 ± 0.32	2.73 ± 0.34
Dhara Theed	Disturbed	3.3 ± 0.46	4.2 ± 0.20	2.2 ± 0.38	3.23 ± 0.36
Baerabal Harwan	Undisturbed	5.2 ± 0.78	7.3 ± 0.46	6.6 ± 0.26	6.36 ± 0.55

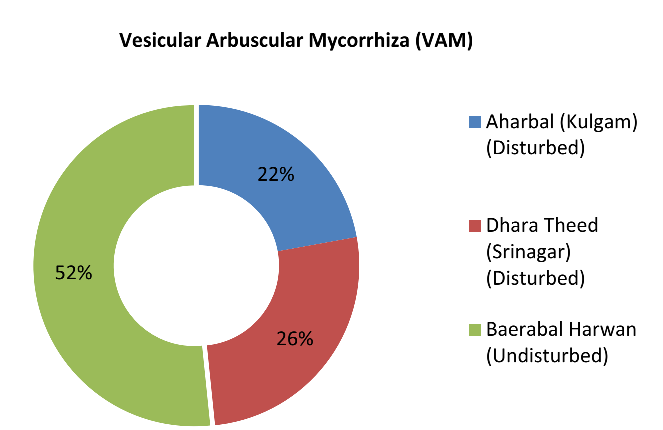

Fig. 8. VAM spore population (g^{-1}) of soil at three locations of Kashmir Himalaya.

heterogeneity' (Adler et al., 2001; Metzger et al., 2005; Martin et al., 2019).

The degree of harm to plant vegetation in woodlands from amusement and the travel industry will be impacted by components. For example, the sort of foundation given, the measure of utilisation of the area, the kind of action, the nature of sightseers, and the period of utilisation are all factors. (Liddle, 1997; Cole, 2004; Wani et al 2018b). Most medicinal plants in the Himalayan region are considered to be endangered or threatened due to some anthropogenic activities, especially as these species are now in danger of extinction (Ganie et al., 2019, Mehta et al., 2020). In any case, the effects of the tourism on endangered plant species in a reserved area, despite the fact that there is proof of negative ecological effects of the tourism on these plant species areas (Kelly et al., 2003, Yang et al., 2021).

In the present study, the phytosociological features, mainly density, frequency, and abundance, of C. luteum at three sites were analyzed, and the results indicate a considerable impact of biotic stress on these features. This spatial examination depicted a marked change in the phytosociological composition of this plant species due to grazing pressure, deforestation, tourism, and loss of vegetation cover at disturbed sites. The striking feature of the present study is that the mean density, frequency and abundance was least at disturbed sites. Similar observations have been made by other authors elsewhere (Vesk and Westoby, 2004; Kukshal et al., 2009; Sher et al., 2010; Baba et al., 2017; Dad 2019; Kunwar et al., 2020), while studying other species of herbaceous vegetation.

The effects of urbanisation and tourist flow in forest woodland zones on plant biodiversity and the vegetation community, including numerous endangered species in Australia, are evident (Pickering and Hill, 2007; Cao and Natuhara, 2020). Another work made by (Alexandru and Ticu, 2012) on street transportation shows higher impacts upon the 'forest timberland, vegetation, and environment, controlled by toxin factors which show up in the individual vehicle measures: noise, vibrations, exhaust gases, dust deposits etc. influence the intensity of the vegetation cover'. The mean frequency, density, and abundance of C. luteum are higher at the undisturbed site of Harwan in the Kashmir Valley. The undisturbed site showed the highest phytosociological values than the disturbed sites, Aharbal Kulgam and Dhara Theed. However, it was dominant at the undisturbed selected site (Baerabal

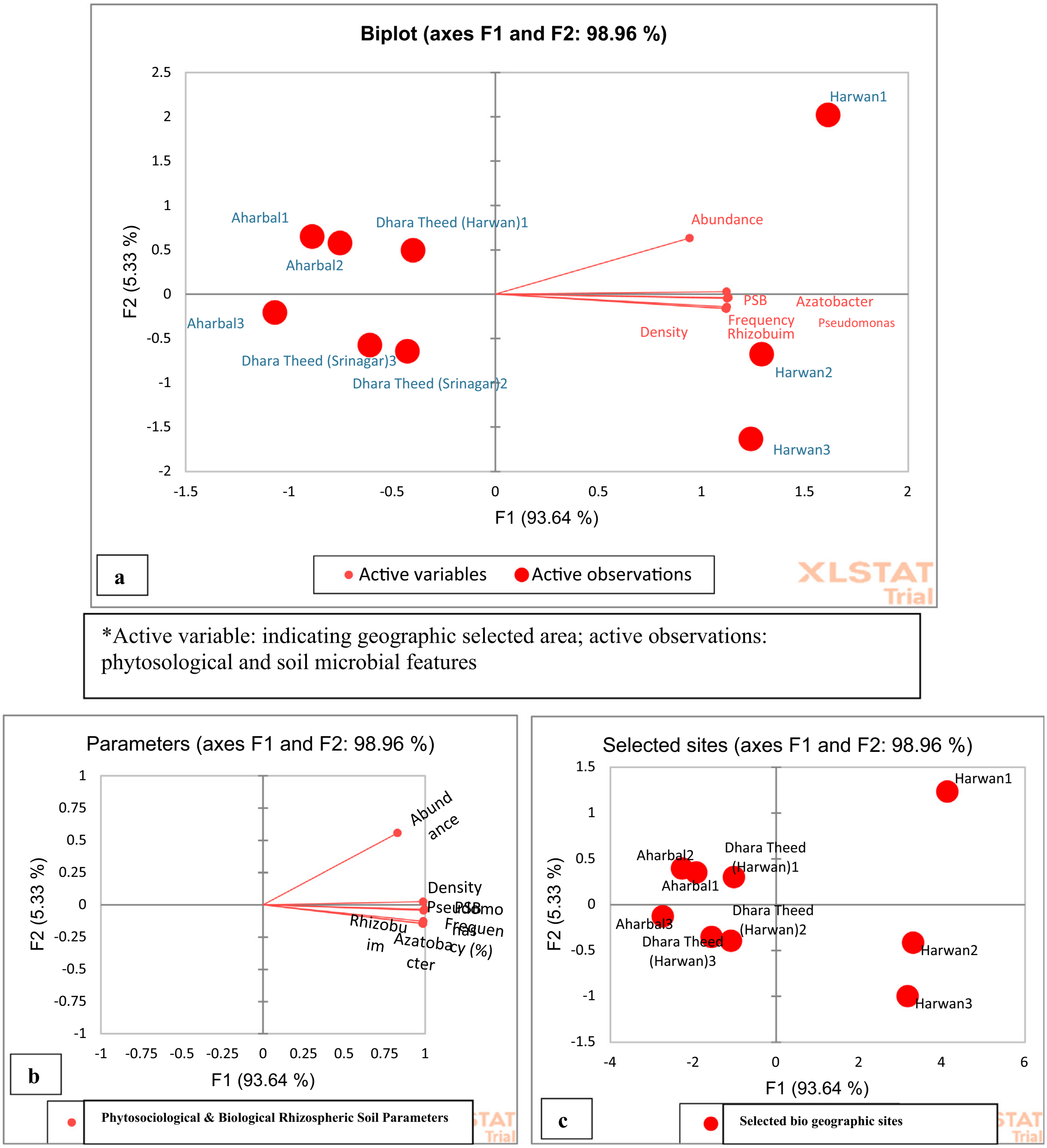

Fig. 9. (a). PCA biplot representing the relation between the selected sites viz. Aharbal, Dhara Theed and Harwan; vs phytosociological features and biological rhizospheric soil viz. density, frequency and abundance and bacteria's which include Pseudomonas, Azatobacter, Rhizobuim and Phosphorus solublizing bacteria (active variables vs. active observations, (b): Representing the contribution of the variables (%) i.e., relation among the sites vs phytosociological features. and **(c):** the observational contribution (%), i.e., the relationship between the sites and the soil bacterial population.

Harwan) in the Kashmir Valley. So this study shows that at the herbaceous level, anthropogenic interference/biotic stress is more at disturbed sites and less at undisturbed sites. Similar observations were made by (Kukshal et al., 2009; Mushtaq and Pandit 2010; Baba et al., 2017). Thus, these sites depicted considerable dissimilarity in all ecological features of *C. luetum*, which could be because of the differences in micro-climatic conditions, impacts of various biotic stresses and other disturbing features as well (Verma et al., 2005, Baba et al., 2017).

Total Bacterial Count CFU (g^{-1}) and (VAM) spore population (g^{-1}) of rhizospheric soil in three Kashmir Himalaya locations. Microorganisms are the most predominant groupings of soil organisms. In the prolific soil, there are 10^6-10^8 cells of microscopic organisms (g^{-1}) of soil. A few gatherings of soil microbes (nitrogen-fixing microscopic organisms and phosphate-solubilizing microorganisms) are valuable as Biofertilizer. A few plants and microbial species have created advantageous or commonly valuable connections. Most microorganisms in the terrestrial biological system are accessible in the soil. The bacterial population is the most prevailing gathering of soil microorganisms. A few gatherings of soil microscopic organisms 'nitrogen-fixing microbes and phosphate-solubilizing microorganisms are helpful as Biofertilizer. Consequently, they convert a lot of dinitrogen (N_2) from the 'atmosphere into structures that the plants can utilise announced by (Ohyama, 2017; Wani et al., 2018c; Naamala and Smith, 2020).

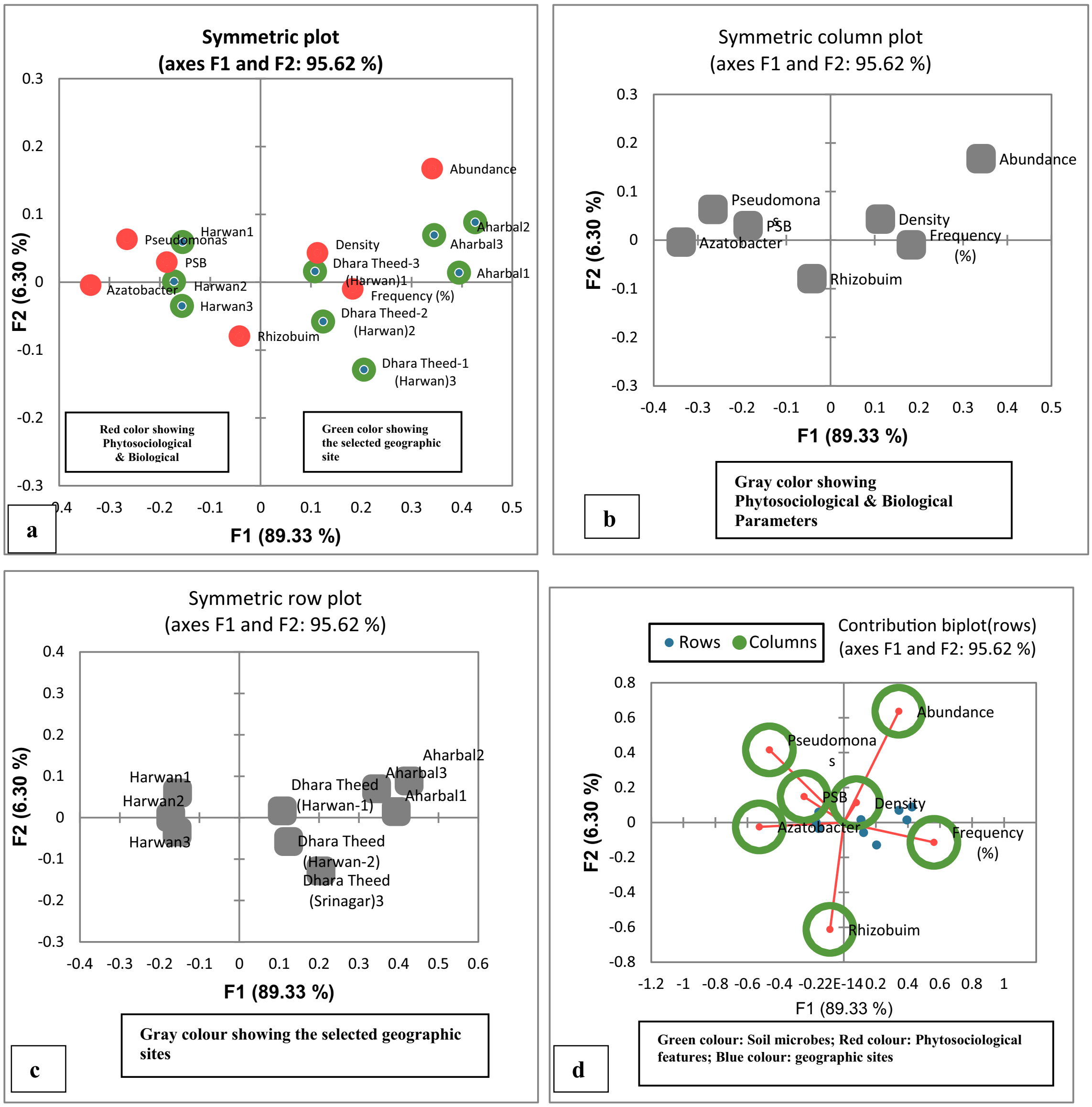

Fig. 10. **(a).** PCA [symmetery plot representing vertical axis = Y(n-i + 1) - median; horizontal axis = median - Y(i); where median is the sample median, Y is sample variable, and i goes from 1 to the index of the median point. 'The interpretation of this plot is that the closer these points lie to the 45° line, the more symmetric the data is']; **(b):** Symmetric column plot showing the data of phytosociological features and biological rhizospheric soil viz. density, frequency and abundance and bacteria's which include *Pseudomonas, Azatobacter, Rhizobuim and* Phosphorus solublizing bacteria data variables which lies close to 45° angle in the columns the data has more symmetric accuracy; **(c):**Symmetric column plot showing the data of phytosociological features and biological rhizospheric soil viz. density, frequency and abundance and bacteria's which include *Pseudomonas, Azatobacter, Rhizobuim and* Phosphorus solublizing bacteria data variables which lies close to 45° angle in the columns the data has more symmetric accuracy; **(d):** Principal component analysis PCA biplot model representing the soil microbial properties and phytosociological features at different slope positions. PCA ordination, axes was greater than 1, which can together explain 89.33% of the total accuracy and contribution within the parameters. Harwan site provides much contribution towards the phytosociological attributes in the selected geographical area with contribution of 93.66 as shown in Fig. 9(a).

The soil samples from, parks and gardens, Biological science soil and Hall of Residence of random soil and reported that total bacterial count of each soil sample ranged from (9.5×10^7) colony forming units CFU (g^{-1}) of soil, 8.0×10^5 CFU/g of soil, 6.5×10^5 CFU/g of soil respectively and also reported that total fungal counts (TFC) of each soil sample ranged from 7.5×10^5 CFU/g of soil, 5.1×10^4 CFU/g of soil, 6.4×10^4 CFU/g of soil Ogunmwonyi et al. (2008). Results were obtained in the present study where higher bacterial counts viz. Pseudomonas, Azatobacter, Rhizobium and PSB were (26.2 ± 0.648) (21.88 ± 0.675) (30.11 ± 0.576) and (14.11 ± 0.671) observed at undisturbed site and lowest at disturbed sites. These results additionally revealed that most noteworthy counts were seen at (PAG) and least were seen at (HOR) and noticed a distinction between the soil pH in PAG and that of BIS and HOR. The soil in PAG had a higher pH than those of BIS and HOR (Ogunmwonyi et al. 2008). Similar outcomes were obtained in the current investigation where higher bacterial tally viz. Pseudomonas, Azatobacter, Rhizobium and PSB was observed at undisturbed site and least at counts were seen at polluted areas.

All the plants growing under natural conditions had VAM fungal spores as a regular component of the soil microflora. The total VAM population was recorded higher at undisturbed sites and the lowest VAM population was recorded at disturbed sites. The VAM spore population is affected by many physical and biological factors. Similar observations were made by Sieverding et al. (1991) and Jamiolkowska et al. (2018).

In the present study, the total bacterial count and total spore population of (VAM) fungal spores in the rhizosphere of soil were studied. The maximum number of bacteria (g^{-1}) of soil was found at the undisturbed site of Baerabal Harwan, while the minimum number of bacteria (g^{-1}) of soil was found at disturbed sites, Aharbal and Dhara Theed, respectively. At disturbed sites, deforestation, grazing, tourism, etc. are higher than at undisturbed sites, which may result in less soil organic matter and aeration. Both of these factors contribute to the growth of the microorganism population. Similar findings were reported by Bhattarai et al. (2015). The dominant bacterial isolates in disturbed and undisturbed areas were Rhizobium, Pseudomonas, Azatobacter and PSB. The highest bacterial count CFU (g^{-1}) of soil was obtained at undisturbed sites. Similar work has also been conducted by other groups (Suliasih and Widawati, 2005; Al-Shammary et al., 2017; Ogunmwonyi et al., 2008; Padder et al., 2021). The (VAM) spore population (g^{-1}) recorded at undisturbed area. Similar work was reported by other authors (Sarkar et al., 2014). The (VAM) population distribution is correlated to the edaphic and climatic conditions, against which every species struggles for existence, and the best-suited species multiples quickly and gets established in soil when there is an anthropogenic pressure on soil. The acidity of the soil is an important factor regulating spore germination and may also influence the distribution of AM fungi that is in accordance with (Porter et al., 1987; Lakshmipathy, 2003). Bacterial populations at undisturbed sites in the Baerabal Harwan region were significant. These results are similar to those of (Torsvik and Ovreas, 2002).

The soil's at undisturbed Harwan area are most notable mean with (VAM) spore population (g^{-1}). Comparative work was accounted for by (Sarkar et al., 2014). The (VAM) dissemination is identified with the edaphic and climatic conditions against which each specie battles for presence, and the most appropriate species products are set up in soil rapidly when there is an anthropogenic tension in soil. Soil acidity is a significant factor in managing spore germination and, furthermore, may impact the distribution of AM in accordance with (Porter et al., 1987; Lakshmipathy, 2003; Silva-Flores et al., 2019). The bacterial population's undisturbed site in the Baerabal Harwan area was significant. These outcomes are comparable with those of (Torsvik and Ovreas, 2002).

The current study determined that the soil biological microbe activity in the undisturbed geographical region of Kashmir was a positive sign because the disturbance in the soil was minimal and there was less anthropogenic activity, so there was a high increase in organic carbon due to the widespread of vegetation cover in particular geobiological areas, which helps to enhance the microbial activity.

5. Conclusion

The results of this study show that the impact of biotic stress like tourism, grazing, deforestation, urbanization, transport, etc. results in decreased vegetation and forest cover, influencing soil health and also the phytosociological features of economically important medicinal plant C. luteum of the Kashmir Himalaya. This study recommends the need for best forest management practices that can provide effective monitoring and regulation of human activities in offshore forest regions while avoiding the encroachment of existing reserves such as herbal plant species. Reforestation programs would provide a method to mitigate the permanent degradation of medicinal plant species and forest soil systems, in addition to the maintenance of forest productivity and long-term soil fertility, and would also provide a way forward to protect the livelihoods of people associated with forests.

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.

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Further Reading

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