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Ecophysiological studies of Calligonum polygonoides Linn. (Phog; Fam: Polygonaceae) and Tecomella undulate (Sm.) Seem (Rohira; Fam: Bignoniaceae)

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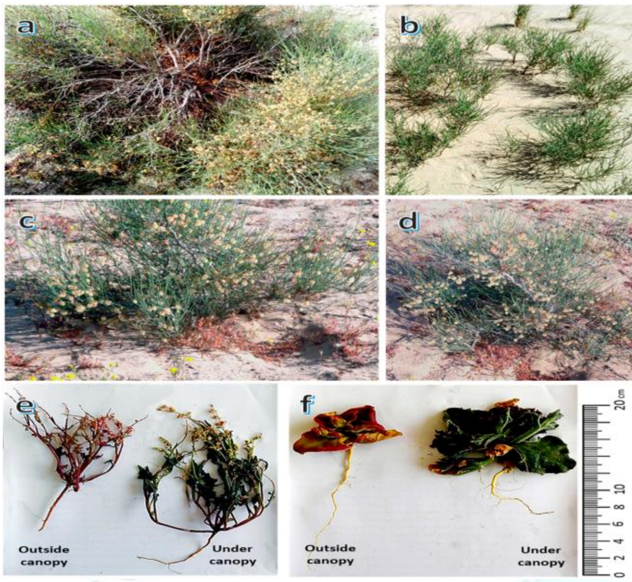
ABSTRACT

Plants are continuously exposed to environmental stimuli that influence development and growth and determine productivity. High and low temperatures, mineral imbalance, excess or insufficient light, and lack of water are stressors that compromise productivity . Water availability is not the only restrictive factor for plant growth in the arid and semiarid zones; nutrients are also usually scarce, and the excess of solar radiation is often an important additional source of stress for plants in these ecosystems . Results reported showed that a combination of drought, high temperature, and irradiation imposed a complex of stresses on seed germination, seedling establishment, and plant survival in arid habitats. Drought is a meteorological and environmental event, defined as the absence of rainfall for a period of time long enough to cause depletion of soil moisture (water stress) and damage to plants, or as an increase in the rate of transpiration accompanied by high temperature (heat stress), hastening the occurrence of injurious dehydration . Drought may be permanent, as in a desert area, or seasonal, as in areas with well-defined wet and dry seasons; it can also be unpredictable, as in many humid climates .

Keywords: *ecophysiological, plants, zones, arid, semi-arid, drought, climate*

I. INTRODUCTION

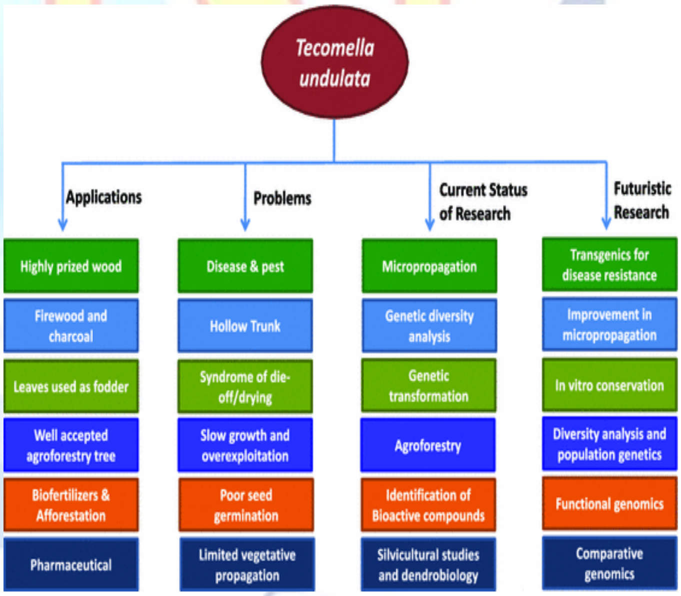
Calligonum polygonoides from the family Polygonaceae is a shrub, stems many-branched; main branches woody, rigid; young branches herbaceous, thin, green; leaves minute. *Tecomella undulata* G. Don. is a popular medicinal plant has long been used in ayurvedic system of medicine. The plant has been found to exhibit diverse pharmacological activities. The present paper gives an account of updated information on its photochemical and pharmacological properties. The review of literature reveals that wide range of phytochemical constituents have been isolated from plant and it possesses important pharmacological activities like antibacterial, anticancer and its utility in treatment of certain ailments like syphilis, swelling, leucorrhoea and leucoderma, [1,2] enlargement of spleen have also been reported. The reports are encouraging hence the herb must be extensively used for its therapeutic benefits. Also the study based on clinical trials should be carried out to support the usage of drug traditionally for treatment of various ailments. *Tecomella undulata* (Family-Bignoniaceae) is commonly known as rugtrora (Hindi), rohira (Punjabi), lohira (Sindi), rakhtroda (Marathi), and rohita (Sanskrit) in different languages and regions of India .[3,4]



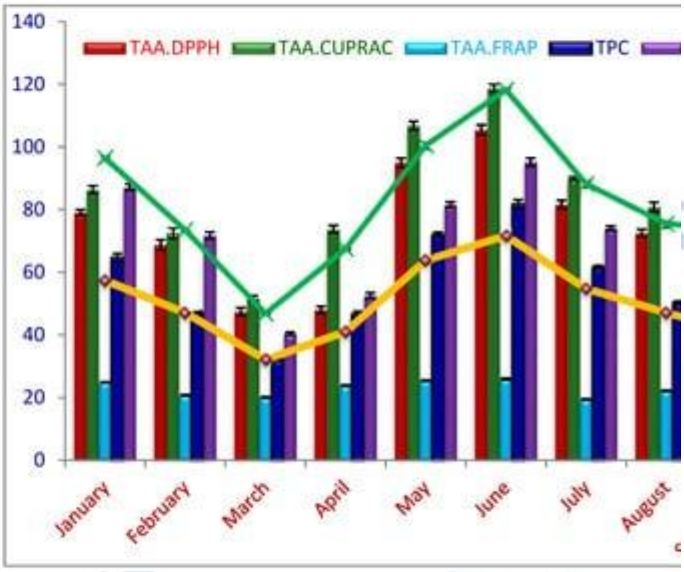
It is widely distributed in Punjab, Rajasthan, Gujarat, Sind and Waziristan regions . It is a shrub or small tree with drooping branches and stellalety grey- tomentose innovations, otherwise glabrous. The leaves are simple 5-12.5 cm in length and 1-3.2cm in width, narrowly oblong, obtuse, and entire with undulate margins. Flowers are inodorous in corymbose few flowered racemes, terminating short lateral branches, pedicles are 6-13 mm long, Calyx 9.5 -11 mm long, campanulate. Lobes are 3mm long, broadly ovate, obtuse, mucronate. Corolla is 3.8-6.3 cm long, orange yellow, campanulate, veined.[5,6] Lobes are 5 subequal rounded. Stamens are exserted and filaments are glabrous. Stigma are 2 lamellate, lobes are spathulate-oblong, rounded. Capsules are 20 by 1 cm slightly curved, linear-oblong, acute, smooth. Valves are thin. Seeds are 2.5 by 1 cm. Wing are very narrow round the apex of seed, absent at its base[7,8].

The drug has been extensively used in ayurvedic system of medicine for treatment of leucorrhoea and leucoderma, enlargement of spleen also used for treatment of urinary discharge due to kapha and pitta. In Bolan it has been extensively employed in the treatment of liver diseases. The bark has been used in treatment of syphilis, painful swellings and cancer traditionally. Also antibacterial activity has been reported in stem extract as well . The plant has been extensively screened for wide range of pharmacological activities. Scientific study demonstrates the hepatoprotective activity of stem bark of *Tecomella undulata* against thioacetamide-induced hepatotoxicity. Researchers evaluated the methanolic extract of plant for its anti inflammatory and analgesic potential by using rat paw edema and tail immersion.[9,10]

Tecomella undulate



The extract showed significant analgesic potential with comparison to standard asprin. There is presence of flavones in *Tecomella undulate* leaf. An iridoid glucoside undulatin assigned as 4'-O-P-coumaroyl-7, 8-dihydro-8-dehydroxymethylbartsioside structurally by chemical and spectroscopic analysis . Researchers demonstrated the presence of quinonoid in heartwood and an iridoid glucoside, 6-O-veratryl catalposide from the plant. Researchers screened the plant for the presence of lapacho . The presence of a new chromone glucoside is found in *Tecomella undulate*. Some studies evaluated the plant bark for the presence of ester glucoside.[11,12]



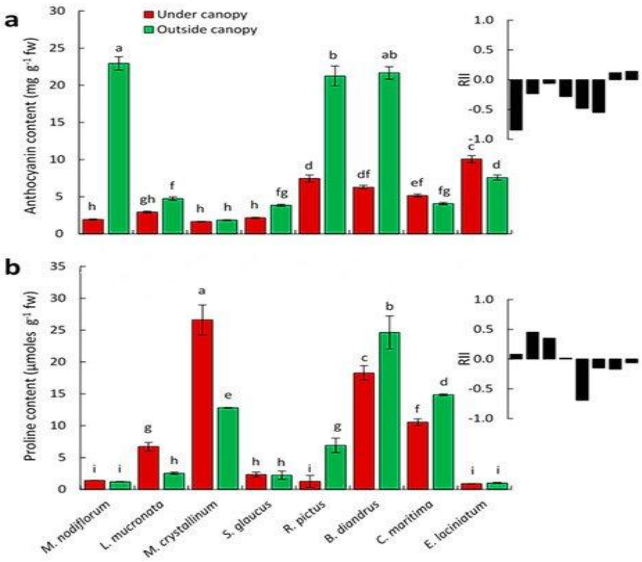
Calligonum polygonoides L. as Novel Source of Bioactive Compounds in Hot Arid Regions

Chlorophyll was extracted in test tubes from a definite weight of fresh healthy leaves in 10 mL of 80% aqueous ethanol . To estimate chlorophyll stability a definite weight of fresh healthy leaves was placed in 10 mL of distilled water and heated in a water bath at 56 ± 1 °C for 30 min. Chlorophyll stability index (CSI) was expressed as percentage between the chlorophyll content in the heated sample and the fresh sample for chlorophyll a or b. Finally, these pigment fractions were calculated as mg g–1 fresh weight (FW). Chlorophyll a/b ratio was also calculated. The fresh shoots were dried in an oven at 70 °C for 24 h, and then the dry shoots were ground into fine powder. In the plant extract several analyses were run including the following [13,14]:

The analysis of soluble osmotically active metabolites included the determination of soluble sugars (as carbon metabolites), total free amino acids, and soluble proteins (as nitrogen metabolites).

II.OBSERVATIONS

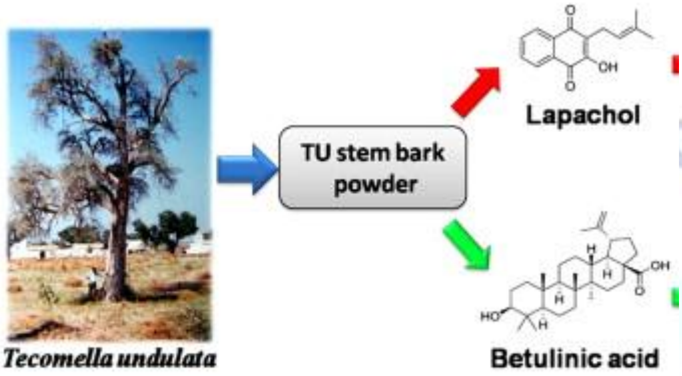
Statistical inferences necessary to evaluate the effects and relative roles (shares) of single factors and their interactions on the parameters tested included analysis of variance (F value), coefficient of determination (η2), and simple linear correlation coefficient (r).



Calligonum polygonoides L. Shrubs Provide Species-Specific Facilitation for the Understory Plants

Data were statistically analyzed using SAS and SPSS programs. The coefficient of determination (η2) has been devised to evaluate the relative effect of each single factor and interaction in contributing to the total response. The simple linear correlation coefficient (r) is used to elucidate the relationship between the internal mineral element contents in the plant tissues[15,16]

The concentrations of chlorophyll a and chlorophyll b in *Calligonum polygonoides* was determined. Chlorophyll a content was higher in summer than in winter in most studied. Concentrations in summer ranged between 0.09 and 0.27 mg g–1 FW, while in winter it ranged between 0.05 and 0.27 mg g–1 FW. Chlorophyll b content was higher in summer than in winter with few exceptions. In winter, chlorophyll b concentrations ranged between 0.050 and 0.186 mg g–1 FW, while in summer they ranged between 0.047 and 0.191 mg g–1 FW The chlorophyll a/b ratio ranged between 0.74 and 2.92 in winter, and 1.27 to 2.93 in summer. The stability index (CSI) of chlorophyll was higher in summer than in winter at most studied. Chl a stability ranged between 20.86% and 97.17% in summer and 39.89% and 96.56% in winter. [17,18] Chl b stability fluctuated between 25.59% and 94.38% in summer, but in winter it ranged between 33.68% and 88.38%. The statistical analysis showed that the effect of single factors and their interactions were significant for chlorophyll parameters tested. Seasonality had a dominant effect (Chl a) followed by interaction. For chlorophyll b the role of interaction was dominant, followed by regionality, and the role of seasonality was minor. Seasonality had the dominant effect on the Chl a/b ratio followed by regionality, while the interaction role was minor. In the case of CSI a interaction had the dominant effect followed by regionality. The reverse held true for CSI b where regionality had the dominant effect, and interaction was subdominant.[19,20]



Calcium and magnesium were more concentrated in winter than in summer . Concentrations of calcium ranged between 2.33 and 7.33 mg g–1 DW in summer, while in winter they ranged between 3.00 and 8.67 mg g–1 DW The highest value of calcium concentrations was recorded in plants collected during winter. The effects of single factors were highly significant. Seasonality had the dominant effect . Concentrations of magnesium ranged between 1.80 and 7.40 mg g–1 DW in summer and 3.40 and 15.40 mg g–1 DW in winter. The highest concentration was detected during winter. [21,22]

Statistical analysis for magnesium concentrations revealed that the effect of single factors and their interactions were highly significant. Seasonality had the dominant effect followed by regionality and interaction. Chlorides concentrations were higher in winter than in summer. The concentrations of Cl– varied from 3.55 to 15.38 mg g–1 DW during summer, and ranged between 9.47 and 37.87 mg g–1 DW during winter. It was revealed that the single factors as well as their interactions were highly significant in affecting Cl– . Regionality had the dominant role, followed by seasonality, and then interaction. Sulfates and phosphates had low values in summer and winter compared with Cl– . Sulfates contents fluctuated between 0.08 and 0.02 mg g–1 DW in winter and 0.05 and 0.01 mg g–1 DW in summer. The highest value of sulfates concentration was recorded . The effect of single factors was highly significant. Regionality had the dominant role followed by interaction. Phosphates concentrations ranged between 0.01 and 0.035 mg g–1 DW in winter, while in summer they ranged between 0.01 and 0.042 mg g–1 DW Statistical treatment revealed that the single factor effects were non significant. The dominant role was occupied by the interaction ($\eta 2$ = 0.45).

III. DISCUSSION

The concentrations of soluble sugars in *Calligonum polygonoides* measured in summer were higher than those measured in winter. The highest value was measured in plant samples collected . The lowest value was recorded . In summer, concentrations of soluble sugars ranged between 22.75 and 157.08 mg g–1 DW, while in winter concentrations ranged between 18.43 and 104.88 mg g–1 DW The effects of single factors as well as their interactions were statistically significant [23,24]. Regionality had the dominant effect followed by interaction. In winter, concentrations of soluble proteins were higher than in summer . Concentrations ranged between 8.48 and 37.88 mg g–1 DW during summer and 12.12 and 49.88 mg g–1 DW in winter. The highest value was recorded, while the lowest value was detected. Regionality had the dominant effect followed by interaction. In comparison with the other metabolites, the content of total free amino acids in *Calligonum* shoots showed low values and ranged between 1.11 and 3.26 mg g–1 DW in winter and 1.33 and 9.06 mg g–1 DW in summer. [25,26]The highest values were recorded. Bifactorial interaction had the dominant effect followed by regionality . Data revealed that chlorophyll a and chlorophyll b in the studied plants were significantly higher in summer than in winter. The Chl a/b ratio ranged between 1.5 and 2.8. According to scientists the 2 main essential (Chl a) and accessory (Chl b) pigments are normally present in the ratio of about 3:1. The decreased ratio of Chl a/b in the leaves may be due to an increase in Chl b relative to Chl a or due to degradation of Chl a. Recently, it has been demonstrated that in higher plants Chl b is converted to Chl a as part of the Chl a/b inter-conversion cycle, which permits plants to adapt to changing light conditions . Generally, the chlorophyll a and b stability index was significantly higher in summer than as estimated in winter. The present data also indicated that chlorophyll b showed more stability than chlorophyll a in summer in response to both higher temperature levels and gradual soil moisture depletion. Osmoregulation is the easier way to overcome the external stress. There are 2 ways to face the environmental stress. The first is quick and depends on the inorganic solutes.

The absorption, excluding or extraction of the osmo-regulator inorganic ions such as Na+, K+,

Ca^{2+}, Mg^{2+}, and Cl^{-} is very helpful for readjusting the osmotic gradient in stressed plants . This will occur immediately.[27,28] The second method depends on the accumulation of organic compatible solutes as soluble sugars, soluble proteins, and amino acids. This process requires a long time in order to synthesize the different organic solutes . To account for mechanisms of osmoregulation through the ionic fraction of the plant osmotic material, an evaluation of the role of ions predominantly found in the plant solution is necessary. Generally, the molar summation of accumulated cations was greater than that of accumulated anions, whether in winter or summer. The plants in summer decrease their biological activity. They accumulate the necessary amounts of organic solutes to maintain the cell turgidity in the live branches. On the other hand, in winter the biological activity will start again and the accumulated organic solutes will be used. As a result, the plants tend to accumulate inorganic solutes instead of organic solutes, which are needed in biological processes. [29,30]Each of the 2 studied plants had its own strategy to accumulate the different inorganic solutes.

IV. RESULTS

Apparently, the control of Ca^{+2} and Cl^{-} uptake from soils and the partitioning of these ions within plants is an essential component of tolerance. The studied plants depended more on Ca^{+2} and K^{+}. These results agreed with researchers. Due to the limited available amounts in the soil, sodium accumulated in lower amounts than potassium. The amounts of calcium accumulated were higher than accumulated magnesium in the studied plants. The succulent species accumulated considerable amounts of Ca^{2+} and Mg^{2+} under drought stress. To ensure a high osmotic pressure to increase the specific heat of cell sap to overcome desert high temperatures, the studied plants increased uptake of Cl^{-} .[31] Chloride is mostly accumulated in the vacuole, and this accumulation increases the osmotic pressure in the vacuole. This reflects the role of Cl^{-} in osmoregulation. Both *Calligonum polygonoides* and *Artemisia judaica* accumulated more SO_4^{-2} in winter than in summer. Plants tend to accumulate more sulfates in dry seasons or habitats to maintain their succulence. In addition, sulfate is needed for biosynthesis of amino acids that contain a thiol (–SH) group. Phosphates appeared in low amounts in the investigated plants. This may be due to the rapid incorporation of phosphates into plant metabolism, or poverty of phosphates in the soil. Content of some inorganic solutes inside plants was correlated significantly with their content in the soil solution.

Organic solutes are compatible solutes furnished by the plants themselves. The organic solutes are needed for biological processes. Under stress plants accumulate them to overcome external stresses. The studied species are frequently adapted for drought conditions prevailing in their habitats during the summer season by accumulating more considerable soluble sugars, soluble proteins, and amino acids than in winter when the prevailing ecological conditions may be more favorable for such plants. The studied plants showed slight increases in soluble sugars accumulation. *Calligonum polygonoides* plants tend to increase their soluble sugars, especially in summer. Plants respond to their environmental stress in 2 ways, either by increasing their water binding molecules or by preventing the incorporation of amino acids into proteins. Soluble protein content in the studied plants increased significantly during winter. The increase in protein content increases the surface exposed to binding water, and bound water is correlated to drought resistance . Some xerophytic species may adjust osmotically to stress through the contribution of nitrogen metabolites .[32]

V. CONCLUSION

Based on data presented in this study, *Calligonum polygonoides* plants are better adapted to drought conditions prevailing in the area under study, more tolerant to drought, and more favorable to the conditions of the arid desert. The literature survey revealed that *Tecomella undulata* is a source of pharmacologically and medicinally important chemicals such as quinonoid and iridoid glucoside like 6-O-veratryl catalposide and undulatin, lapachol and other useful constituents. Clinical trials must be conducted to support its therapeutic use. It is also important to recognize that its extract may be effective not only in the isolation but may have modulating effect when used in combination with other drug.[33]

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