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Eco-Physiological Studies of Some Halophytes Naturally Occurring in Tehsil Deedwana, District Deedwana-Kuchaman, Rajasthan, India

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Abstract: ***Deedwana tehsil of State Rajasthan is facing a tragic problem of salinity. Almost 60% of total 160252.99 ha of land is under salt stress. This has created a deleterious impact on, not only the soils of these lands but also on the yield of the crops therein. Eco-physiological studies of some halophytes of these areas have shown that there are very characteristic structural features have been developed in these plants. Possible factor for this is soil which undergoing degradation due to increased ionic levels. This research paper presents an eco-physiological investigation of three halophytes, Salsola baryosma, Suaeda fruticosa, and Trianthema triquetra, in the arid region of Deedwana, Rajasthan, India. The study aims to understand the adaptive strategies and physiological responses of these plants to the extreme salinity conditions prevailing in their habitat. Field surveys were conducted to assess the distribution and abundance of the selected halophytes, followed by collection of plant samples for laboratory analysis.***

Physiological parameters were measured to evaluate the plants' water use efficiency and salt tolerance. The results revealed that Salsola baryosma, Suaeda fruticosa, and Trianthema triquetra exhibited distinctive physiological adaptations to cope with high salinity. The study is also involved the impact of salt accumulation on halophytic vegetation grown in these soils. This research enhances the current knowledge of halophyte eco-physiology and provides valuable insights into the potential application of these adaptive mechanisms in agriculture, soil reclamation etc.

The findings from this study contribute to understanding of the eco-physiology of halophytes in arid regions and may hold implications for future land reclamation and agriculture practices in saline-affected areas. The knowledge gained from this research can also aid in the conservation and management of these valuable halophytic species, which play a crucial role in the ecological balance of the region.

Keywords: Eco-physiology, Halophytes, Salsola baryosma, Suaeda fruticosa, Trianthema triquetra, land reclamation, Arid and Semi-arid vegetation, hyperthermia, photosynthetic pigments, cell membrane permeability, thermal stress, adaptation Deedwana, Deedwana-Kuchaman.

I. INTRODUCTION

India occupies a special status in terms of ecosystem, species and genetic diversity because of its location in the tropical zone, physical features and eco-climatic conditions. Rajasthan is the largest State of India and is situated in the north-western part of India between $23^0$3'N and $30^0$12'N latitude and $69^0$30E and $78^0$17'E longitude, occupying an area of 3,42,239 sq.km. The elevation of land surface varies from 214 to 1375 m. In shape, it is an irregular rhomb with north-south and east-west diagonals, the former about 784 km. and the latter 850 km. long.

The remarkable feature of Rajasthan is the Aravalli range, perhaps the oldest folded mountain range in the world. It intersects Rajasthan from end to end, diagonally running from Delhi to the plains of Gujarat for a distance of about 692 km. Within Rajasthan, the range runs from Khetri in the north-east to Khed Brahma in the south- west for a length of about 550 km. The elevation of the Aravalli range gradually rises in south-west direction, as it is 335 m at Delhi and in Rajasthan 792 m at Khetri, and 1727 m at Mt. Abu. Further south- west wards, the elevation gradually decreases to the plains in Gujarat. It has a wide range of habitats, climatic factors, physiography, soil types, and geological antiquity. Phytogeographically, the state of Rajasthan forms the eastern extremity of the great arid and semi-arid belt of the world; the great Sahara Desert belt passes through the western part of the Rajasthan State. The major part of eastern and south-eastern regions forms the western part of the Gangetic plains; the southern region is a part Deccan plateau.

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Deedwana is located in the center of the Rajasthan state at 27.4° N and 74.57°. The present study is a report based on a survey of Angiospermic plants of Deedwana tehsil of Deedwana-Kuchaman district (newly formed district from preexisted Nagaur district) over five years. Regular and periodical visits to different habitats were made during these years of intensive survey. A total of three hundred thirty-one species, grouped into two hundred eighteen genera, assigned to sixty-five families according to Bentham and Hooker's system of classification have been recorded from Deedwana tehsil.

Halophytes plants that have adapted to thrive in high-salt environments possess specialized mechanisms that enable them to tolerate and utilize the excess salt present in their surroundings. Halophytes play a crucial role in maintaining the ecological balance of saline habitats and contribute to biodiversity in these challenging environments. They have garnered significant scientific interest due to their exceptional ability to survive and grow under extreme conditions, which provides valuable insights into plant adaptation and stress tolerance mechanisms. Understanding the physiological and biochemical adaptations of halophytes can have implications for various fields such as agriculture, environmental conservation, and biotechnology.

Eco-physiological studies of halophytes are of great importance for several reasons. Firstly, halophytes are known to produce unique and diverse chemical compounds as a result of their adaptation to saline environments. Secondly, Eco-physiological studies contribute to our understanding of the adaptive strategies employed by halophytes to survive in high-salt conditions.

Eco-physiological investigations taken up for the present studies of some selected halophytic species viz *Salsola baryosam*a, *Suaeda fruticosa,* and *Trianthema triquetra* occurring in Deedwana tehsil of State Rajasthan. Halophytes are a unique group of plants that have evolved to thrive in highly saline environments. Unlike most terrestrial plants, which are sensitive to high salt concentrations, halophytes possess remarkable adaptations that allow them to tolerate and even utilize saline conditions for their survival.

II. REVIEW OF LITERATURE

Most of the areas have been reviewed by Jain (1970) Bhandari (1978), Sharma (1980). Publication of Flora of the Indian Desert (Bhandari, 1990), Flora of north-east Rajasthan (Sharma & Tiagi, 1979) and Flora of Rajasthan (Shetty & Singh, 1987) have further added to our knowledge of the flora and floral composition of Rajasthan. Quereishi (2002, 2017, 2018) and Sharma & Aggarwal (2008), have significantly contributed to our knowledge about the vegetation of Deedwana and Nagaur. In recent years a large number of publications dealing with the Halophytic flora and floral composition of Rajasthan have been published. Vegetation Ecology of Halophytic Communities of Saline Arid studied by Hari and Dagar (2004). Contribution about halophytes of saline lands provided by Kumar (2015). Mangalassery Dayal and Patel, (2017b). Mohammed & Sen, (1987, 1988). Intensive botanical exploration of the Nagaur district of Rajasthan is in progress including a study of phytodiversity of Deedwana block. Some authors studied the Desert Plants in detail such as Ramawat (2010), Joshi, Bhanupriya, and Jaya Arora (2018). Phytochemical analysis of some selected species of the family Convolvulaceae occurring in Central Rajasthan has been carried out recently by Sharma and Tomar (2023).

III. AIM OF STUDY

The aim of this research is to conduct comprehensive eco-physiological studies on some selected halophytes, namely *Salsola baryosma*, *Suaedafruticosa*, and *Trianthema triquetra*, in the region of Deedwana, Rajasthan, India. The primary objectives of this study are as follows:

1) The research aims to understand the adaptive strategies employed by *Salsola baryosma, Suaedafruticosa*, and *Trianthema triquetra* to thrive in the highly saline conditions prevailing in Deedwana region
2) To assess the stability of photosynthetic pigments, specifically chlorophylls and carotenoids, in selected halophyte species under hyperthermic conditions.
3) To evaluate the impact of hyperthermia on cell membrane permeability in the selected halophyte species.
4) To understand the physiological responses of halophytes to hyperthermia and the potential mechanisms underlying changes in photosynthetic pigments and cell membrane permeability.
5) To investigate the relationship between hyperthermia, photosynthetic pigments, and cell membrane permeability in halophyte species.

IV. METHODOLOGY

For the eco-physiolocal study of halophytes, three most common halophytic species viz. *Salsola baryosma, Suaeda fruticosa* and *Trianthema triquetra* have been selected.

Details of habitats, phenology and soil characteristics were regularly recorded during the collection tours. Soil texture was determined by shaking a known quantity of soil kept into the top most mesh of the soil sieve and weighing each fraction separately. The percentage of each fraction calculated and soil type being designated according to the international system of the soil classification. For soil pH determination, 5 gm sample of oven dried soil was shaken in 100 ml distilled water and the solution was filtered after 8 hours. pH was noted on Digital Systronics 335 pH meter.

Moisture content was determined by heating a known weight of fresh plants at a temperature of 110^0 C for 24 h and weighting them again after heating.

Percentage moisture content was calculated from the following formula: Percentage moisture content =Fresh weight - Dry weight × 100/ Fresh weight;

Total bound water was calculated by vacuum drying of plants of known weight following by heating at 100^0 C for 24 h and weighting them again. Percentage bound water was determined by the following formula: Percentage bound water = Initial wt. - Final wt. × 100/Initial wt.

To study the Foliar mineral contents, samples of dry leaf powder of the selected species were analyzed for quantitative estimation of Nitrogen, Phosphorus, Calcium, Magnisium, Sodium and Potassium as per procedures described below:

For estimation of Nitrogen, the Micro-kjeldahl procedure has been adopted. 100 mg of dried and powdered plant material was transferred to 100 ml kjeldahl digestion flask. The material was wrapped in a Whatman filter paper and the package as such was put in the digestion flask. 5ml of concentrated H_2SO_4 and 0.1 gm of digestion catalyst were added to it. The mixture was heated slowly to commence the digestion until frothing stopped and fumes of H_2SO_4 started evolving freely. Temperature was subsequently increased till acid started boiling, and the contents turned apple green. Digestion was continued for at least another 30 minutes more after the contents became apple green. After cooling flask, little distilled water was added and the final volume was made up to 100 ml in a volumetric flask. 35 ml of the digest was distilled with 15ml of 40% NaOH in the micro-kjeldahl distillation assembly. Distillate was collected in 5 ml of Boric acid+mixed indicator. Condensate was titrated with 0.01 N HCl. At the end point the contents turned brown from blue. Nitrogen contents were calculated using the following formula:

% N = (AB) x NHCl x 1.4 x V/v x S where, A = Sample reading (ml); S =Weight of plant material (gm); V = ml of total digest, and v = ml of digest distilled.

For estimation of Phosphrus, 100 mg of dried plant material was taken in porcelain or silica basin and 5ml of Mg $(NO_3)_2$ solution was added to it. The mixture was heated at low temperature until the material was dry. The dried material was made into ash in a muffle furnace at 550^0C for about 2 hours. This ash was dissolved in 5 ml of 50% HCl, it was then filtered and the final volume was made to 100ml after several washings of filter paper by small portions of water. This ash solution was used for detemination of Phosphorus. 50 ml of this ash was used for development of blue colour by adding 2ml Ammonium molybdate and 5 drops of Stannous chloride solution. Optical density was taken at 690 nm and concentration of Phosphorus was found out with the help of the standard curve. Calculation of total Phosphorus was done employing following formula: P%= MgP/L of solution x V /100 x S x100; Where, V = Total volume of ash solution made; S = Weight of the plant material ashed.

For the estimation of Calcium, Magnisium, Sodium and Potassium, 1gm of dried plant material was taken in a porcelain or silica basin. It was ignited at 550^0C for at least 2 hours or more in a muffle furnace. After ashing was over, it was allowed to cool and 5ml of 50% HCl was added to it. This was covered by a watch glass and heated at low temperature for about 15 minutes. 1 ml HNO_3 was added to it which was evaporated to dryness, this process was continued for further one hour to dehydrate silica, now 1ml of 50% HCl was added to dissolved the residue. After adding some water warmed for complete dissolution. This mixture was filtered through a Whatman No. 44 filter paper volume was made to 100 ml in a volumetric flask after several washings of filter paper by water.

This ash solution was used for determination of Calcium, Magnicium, Sodium and Potassium. 5 ml of sample solution prepared as above was taken and 100 ml of NaOH solution were added to it. 100-200 ml of Murexide was added till the colour turned to pink. This solution was then titrated with solution until the colour changed to purple at end point.

1) Quantity of Calcium was calculated as per following formula:

Calcium % = A x 400.8 x V / v x 1000 x S; Whereas, A = Volume of EDTA used; V = Total volume of ash solution (100 ml); v = Volume of ash solution titated (5 ml); S = Weight of plant material taken in gm (1 gm).

2) Quantity of Magnesium was calculated as per following procedure:

Magnesium was determined from the same solution from which the Calcium was determined. Magnesium was determined as the difference between the titration carried out for Calcium and Magnesium and titration carried out for Calcium alone. For determination of Magnesium, first the EDTA titration reading for Calcium alone was determined.

For determination of Calcium and Magnesium same amount of sample as used for the Calcium determination (5 ml) in a conical flask was taken and 100 ml of distilled water was added. 15 ml of buffer solution and 100-200 mg of Eriochrome black T indicator were then added and titrated with EDTA solution until at the end point, the colour changed to blue.

Magnesium was calculated as per following formula: Mg % = (B-A)□ x 400.8xV / v x 1.645 x S

Whereas, A = Volume of EDTA for Ca alone; B = Volume of EDTA for Ca + Mg; V = Total volume of ash solution (100 ml); v = Volume of ash solution titrated (5 ml), and S = Weight of plant material taken (1 gm).

3) Quantity of Sodium and Potassium was calculated as per following procedure:

Sodium and Potassium were determined flame photometrically from the ash solution of the leaf powder. Same solution left after the determination of Calcium and Magnesium was used.

Na % = Mg Na /L of ash solution x V/ 1000 x S, and

K % = Mg K /L of ash solution x V/ 1000 x S; Where, V = Total volume of ash solution (100) S = Weight of plant material in gm (1 gm).

4) Quantity of Free proline was estimated in the organs according to Bates *et al.* (1973) method.

200 mg of plant material was homogenised in sulphosalicylic acid. After centrifugation supernatant was used for free proline estimation. A suitable amount (1 ml in case) of aliquot was mixed with 1 ml of glacial acetic acid and 2 ml ninhydrin reagent. The test tubes were placed in boiling water for 45 minutes and then transferred to ice bath. 4 ml of toluene was then thoroughly shaken. The upper pink coloured organic phase was removed by separating funnel. Optical density was recorded at 540 nm. Standard curve was prepared using pure proline. To determine heat and drought resistance of the halophytic species of *Suaeda fruticosa*, *Salsola baryosma*, *Trianthema triquetra* thermal treatment of 40^0, 42^0 and 45^0 were given to 1 g fresh leaves in 20 ml distilled water (Sulliyan, 1967) in a water bath for 1 h, 2h, 3 h and 4 h time periods along with controls at room temperature. The leaves were then homogenised in 10 ml of 80 % acetone. Photosynthetic pigments (total chlorophylls and total carotenoids) were measured according to Robbelen's method (1957) by Systronics 105 MK 1 spectrophotometer set at 100 % transmittance using pure acetone as a blank. Optical density was recorded at 650 nm and 430 nm respectively. Efflux of soluble sugar and proteins were taken as criterion of membrane permeability (Kaloyears, 1958). Sugars were measured according to Yem & Willis (1954) and proteins according to Lowry *et al.* (1951) method.

- Soil texture was determined by shaking a known quantity of soil kept into the top most mesh of the soil sieve and weighing each fraction separately. The percentage of each fraction calculated and soil type being designated according to the international system of the soil classification. For soil pH determination, 5 gm sample of oven dried soil was shaken in 100 ml distilled water and the solution was filtered after 8 hours. pH was noted on Digital Systronics 335 pH meter.
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  Calculation of total Phosphorus was done employing following formula:
  P%= MgP/L of solution x V /100 x S x100;
  Where, V = Total volume of ash solution made; S = Weight of the plant material ashed.

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Optical density was recorded at 540 nm. Standard curve was prepared using pure proline. To determine heat and drought resistance of the halophytic species of *Suaeda fruticosa*, *Salsola baryosma*, *Trianthema triquetra* thermal treatment of 40^0, 42^0 and 45^0 were given to 1 g fresh leaves in 20 ml distilled water (Sulliyan, 1967) in a water bath for 1 h, 2h, 3 h and 4 h time periods along with controls at room temperature. The leaves were then homogenised in 10 ml of 80 % acetone.

Photosynthetic pigments (total chlorophylls and total carotenoids) were measured according to Robbelen's method (1957) by Systronics 105 MK 1 spectrophotometer set at 100 % transmittance using pure acetone as a blank. Optical densitywas recorded at 650 nm and 430 nm respectively. Efflux of soluble sugar and proteins were taken as criterion of membrane permeability (Kaloyears, 1958). Sugars were measured according to Yem & Willis (1954) and proteins according to Lowry *et al.* (1951) method.

V. RESULTS AND DISCUSSION

The vegetation of Deedwana tehsil in general, tolerates higher temperature and intense solar radiation for most of the year. This includes rainy season also, which is otherwise the most congenial period for the growth performances, of plants under natural habitats. The mean temperature during rainy season is on an average 30^0C during day which is much higher compared to other parts of Indian sub-continent, Ecological adaptations of the selected species of halophytes under hostile conditions of Deedwana tehsil, Rajasthan have been investigated to evaluate the underlying eco- physiological characteristics of these plants.

A. Calcium And Potassium Ratio (Table 1)

Ca:K ratio was investigated in the selected species of some halophytes found in Deedwana tehsil, Rajasthan and the data have been presented in Table 1 and Text Fig.1. This ratio has been found to be highest in *Sueada fruticosa* and lowest in *Trianthema triquetra*. *Salsola baryosma* has been found to occupy an intermediate position in this respect.

B. Foliar Mineral Contents (Table 1):

In this study the mineral contents of dried leaf samples of selected species of some halophyts collected from various localities of Deedwana tehsil, Rajasthan were anlysed (Table 10). The Nitrogen content has been found to be maximum in Trianthema *triquetra* while the least quantity of Nitrogen has been recorded in *Sueada fruticosa.* Similarly, Calcium and Sodium contents have also observed to be lower in *Sueada fruticosa.* Phosphorus, Potassium, Calcium, Magesium and Sodium contents have been recorded to be higher in *Salsola baryosma* as compared to the other investigated species (Table 10; Text Fig. 6).

The present investigation of foliar mineral contents of dry leaves of the selected species of halophytes has been taken up for the first time. It is evident form Table 10 that the amount of various minerals is variable in different species and their leaf litter upon decomposition liberates variable quantities of these minerals in the form of humus, which results in the growth of specific associates with these species under natural habitats.

Table-1

		Salsola baryosma	Suaeda fruticosa	Trianthema triquetra
CALCIUM & POTASSIUM RATIO	Total Calcium (Ca) contents (µg / g.d.w.)	1.3	1.4	1.6
	Total Potassium (K) contents (µg / g.d.w.)	2.6	2.0	4.6
	Ratio (Ca:K)	0.5	0.7	0.34
FOLIAR MINERAL CONTENTS {(Element (% of dry matter)}	N	1.85	1.45	1.2
	P	0.80	0.74	0.55
	K	1.95	1.70	1.3
	Ca	1.50	1.25	1.15
	Mg	0.60	0.55	0.35
	Na	0.04	0.02	0.02
Percentage MOISTURE CONTENTS and TOTAL BOUND WATER	Moisture Content %	79.5	82.4	86.2
	Total bound Water %	15.2	10.3	11.5
TOTAL FREE PROLINE CONTENTS (µg / g d w) in different	Root	4.2	2.1	1.6
	Stem	4.3	3.1	1.9
	Leaves	7.0	4.85	2.25

organs				
PHOTOSYNTHETIC PIGMENTS	Chl a	0.560	0.710	0.930
	Chl b	0.330	0.670	0.632
	Total Chlorophyll (mg /g)	0.850	1.250	1.450
	Total Carotenoids (mg / g)	0.660	0.425	0.390

Table-2

Effect of hyperthermia on photosynthetic pigments stability	Tempe-rature	Hours	Compo-unds	Salsola baryosma	Suaeda fruticosa	Trianthema triquetra
Total Chlorophylls	40^0C	1h		3.19	3.48	4.30
		2h		5.18	6.10	7.55
		3h		22.10	23.75	28.30
		4h		24.2	25.75	30.50
	42^0C	1h		8.15	11.20	13.50
		2h		10.40	15.30	21.10
		3h		23.90	26.40	37.90
		4h		31.90	37.10	40.50
	45^0C	1h		3.7	4.15	5.50
		2h		10.90	13.50	16.10
		3h		44.10	45.10	48.70
		4h		48.15	45.10	55.90
Total Carotenoids	40^0C	1h		6.35	6.75	5.95
		2h		7.85	7.92	6.25
		3h		31.15	29.10	23.95
		4h		36.80	35.10	24.80
	42^0C	1h		13.10	11.50	9.20
		2h		21.80	20.70	16.75
		3h		44.75	36.50	31.90
		4h		44.75	37.95	35.00
	45^0C	1h		15.10	13.25	11.10
		2h		15.70	13.50	12.25
		3h		50.70	46.00	42.50
		4h		56.75	52.95	48.50
Cell Membrane Permeability	40^0C	1h	Sugars	10.10	11.25	12.45
			Proteins	20.25	12.45	25.10
		2h	Sugars	17.50	16.36	15.45
			Proteins	26.30	28.45	31.80
		3h	Sugars	22.50	23.94	21.45
			Proteins	32.40	31.35	29.50
		4h	Sugars	31.25	30.25	28.90
			Proteins	41.90	36.65	31.65
	42^0C	1h	Sugars	21.82	23.96	31.60
			Proteins	41.35	38.40	35.50
		2h	Sugars	27.65	30.00	33.45

			Proteins	51.25	48.25	38.25
		3h	Sugars	37.10	36.35	37.00
			Proteins	62.70	55.40	43.00
		4h	Sugars	35.10	37.10	45.96
			Proteins	67.35	60.75	48.30
	45^0C	1h	Sugars	34.75	40.00	47.50
			Proteins	45.97	51.86	52.50
		2h	Sugars	37.96	41.52	51.25
			Proteins	51.94	51.32	48.75
		3h	Sugars	42.65	43.00	57.75
			Proteins	52.85	52.55	57.25
		4h	Sugars	45.65	48.37	59.00
			Proteins	54.50	56.65	66.56

C. Moisture Contents And Total Bound Water

Observation relating to the ecological parameters like moisture contents and total bound water contents of these selected species of halophytes have been presented in Table 1. It is clear from this table that the percent moisture contents are higher in *Trianthema triquetra* (86.2 %) and lower that of *Salsola baryosma* (79.5 %). However, total bound water is found to highest in *Salsola baryosma* (15.2 %) and least quantity of bound water has been recorded in *Sueada fruticosa* (10.3%).

As mentioned earlier, Deedwana tehsil of Rajasthan is chracterised by harsher climatic conditions. The present eco-physiological investigation of the selected species of halophytes have been taken up to study the mechanism of stress- physiology of these taxa. Estimation of free proline, photosynthetic pigments and effect of hyperthermia on chlorophyll and carotenoids degradation and cell membrane permeability have been taken as criteria of physiological adaptations of these selected species of halophytes.

1) Quantitative Estimation Of Proline

Roots, stem and leaves of *Salsola baryosma, Suaeda fruticosa* and *Trianthema triquetra*, were studied for their proline contents. In general, it was observed that the leaves of each species contained the highest quantity of proline as compared to their roots and stem. Organ wise, in root, Salsola baryosma (4.2 µg / g d w) possessed a higher quantity of proline than *Suaeda fruticosa* (1.6 µg / g d w) and *Trianthema triquetra* (2.1(µg / g.d.w.). Similarly, in stem *Salsola baryosma* (4.3 µg / g d w) possessed more proline than *Suaeda fruticosa* and Trianthema triquetra. The amount of proline contents in leaves of Salsola *baryosma* (7.0 µg / g d w) was again higher than those of Suaeda *fruticosa* (4.85 µg / g d w) *Trianthema triquetra* (2.25 µg / g d w). On the basis of proline contents, *Trianthema triquetra* may thus be regarded as the most drought tolerant species while *Suaeda fruticosa* may be considered as the least drought tolerant species among the selected species of halophytes.

2) Photosynthetic pigments (Table 1):

Total chlorophylls and total carotenoids in mature leaves of the selected species of Deedwana tehsil, Rajasthan were estimated. It was observed that *Trianthema triquetra* had highest total chlorophyll contents (1.450 mg /g) and *Salsola baryosma* (0.850 mg /g) had the lowest total chlorophyll contents. The total carotenoid contents were highest in *Salsola baryosma* (0.660 mg /g) and lowest in *Trianthema triquetra* (0.390 mg /g).

3) Effect of hyperthermia (Table 2):

In order to study the effect of heat and drought tolerance, fresh leaves of the selected species of some halophytes viz., *Suaeda fruticosa, Salsola baryosma* and *Trianthema triquetra*, were subjected to various degree of temprerature for specified time.

An hour treatment at 40^0C caused maximum total chlorophyll degradation (4.30 %) in *Trianthema triquetra* while in *Salsola baryosma* it was 3.19 %.

Similarly, 4-hour treatment at same temperature showed that a further degradation in total chlorophyll content which was highest in *Trianthema triquetra* (30.50 %) and the lowest in *Salsola baryosma* (24.20 %) Consequently a temperature treatment at 42^0C for 4 hours led to further loss of total chlorophyll contents.

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Trianthema triquetra again revealed maximum thermal decay in total chlophyll contents (40.50 %) compared to *Salsola baryosma* which showed minimum degradation (31.90 %). Further loss of chlorophyll contents was observed in 4-hour treatment at 45^0C was 55.90 % in *Trianthema triquetra* whereas in *Salsola baryosma* it was found tobe 48.15 %. Thus, a sudden deterioration in total chlorophyll contents between the three successive temperatures was found to occur after a 4-hour treatment at 45^0C in all investigated species of halophytes.

Specified periods of temperature treatment given to the all-selected species of halophytes and the consequent degradation of carotenoid content in response to these temperatures are recorded in table 15. It was observed that an inverse relationship in the degradation patter of the two different types of photosynthetic pigments namely chlorophylls and carotenoids was evident in these species of halophytes.Thus, *Salsola baryosma* having minimum degradation of total chlorophyll content and being thereby more heat tolerant, showed maximum carotenoid content degradation (56.75 %) at 45^0C.This percentage of total maximum carotenoid content degradation was lower in *Trianthema triquetra* (48.50 %).

4) Cell membrane permeability (Table 2):

Leaves of mature plants of the selected species of halophytes of Deedwana tehsil, Rajasthan were subjected to different temperature for specified periods. The data relating to efflux of soluble sugars and protiens as a criterion of membrane permeability (Kaloyears, 1958) have been represented in Table 16-18. *Trianthema triquetra* exhibited least membrane stability whereas *Salsola baryosma* was found to possess a comparatively more stable membrane. Leaching of sugars and proteins are higher in *Trianthema triquetra* at all temperatures as is evident from Table 15-18. Values for leaching of sugars and proteins in *Salsola baryosma* are lower. Thus, it can be inferred that this species exhibits maximum tolerance to higher temperatures. Maximum damage to cell permeability by abrupt maximal increase in percentage of sugars and proteins in leachates was observed at 45^0C between 3 h and 4 h treatment in all the selected species of halophytes as in evident from Table 2. Thus, it can be concluded that *Salsola baryosma* is more heat tolerant than the remaining two species.

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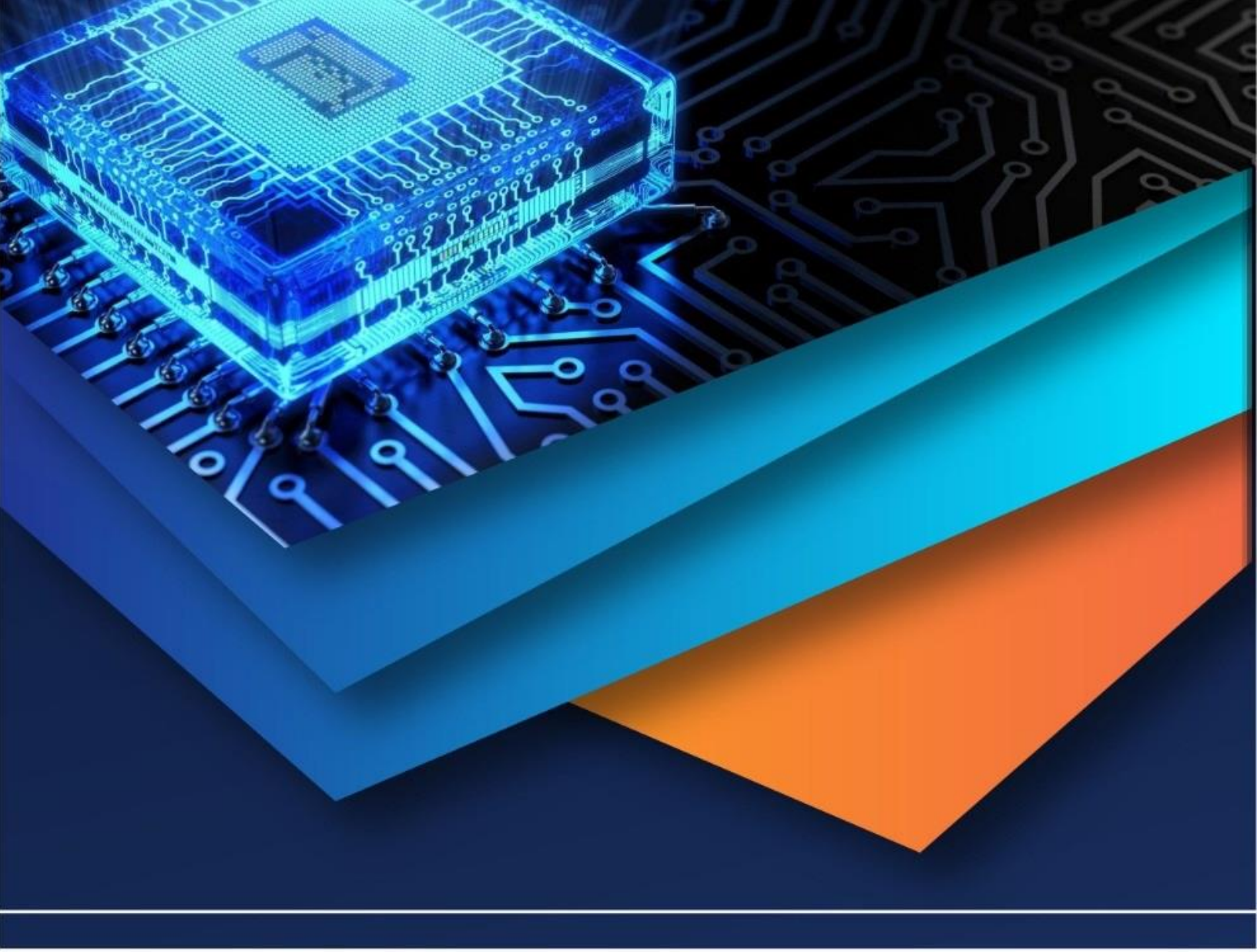

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