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Ecological Impacts of Weed (*Parthenium hysterophorus* L.) Invasion in Saline Soil

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Abstract- *Parthenium* density and species richness were found to be more in non-invaded (*N-I*) sites as compared to invaded (*I*) sites of Jaunpur district. pH, OC and %N of the soil indicates that the plant survive naturally at higher level of salinity. In pot experiment, plant growth, proline content, TSS content, chlorophyll, N, P and K was not significantly affected up to 1% NaCl (w/w) over the control after 30 and 60DAS. BCF for parthenium plant was >1 up to 2% NaCl treatment. Bacterial population was more in rhizospheric soil then rhizoplane soil under NaCl after 30 and 60DAS, and indicates bacterial-rhizoadaptation. Hence, the *parthenium* plant able to improve soil health and might be useful in the field of restoration ecology.

Index Terms- Parthenium growth, Nutrients, Sodium, Proline, Bacterial population.

I. INTRODUCTION

Parthenium was thought to be initially introduced in India before 1950s [1,2] with food grains imported from the USA, but heavily introduced after 1956 through the transport of Milo (red wheat) from Mexico. After 1956, the weed spread throughout India, and invades in all disturbed land, including farms, pastures, and roadsides. In some areas, outbreaks have been of almost epidemic proportions, affecting crop production, livestock and human health. *Parthenium* is found mostly in hot climates. High temperature (28 to 33 °C) is favorable because it increases the dry matter production of the plant due to maximum photosynthesis [3]. Low winter temperature inhibits the growth of the plant and the seed production [1,3,4]. *Parthenium* density and biomass varies with soil type [5]. The most common soil types on which it is found are alkaline clay, loam soil to heavy black clay soils [6]. Soil with rich clay produces a smaller number of larger seeds, whereas seed mass declines in relatively coarser soils with large number of small seeds [5]. Invasive plants are threat to biodiversity, leading to change in natural habitat and nutrient cycles [7], but only little work has been conducted on change in the soil. Therefore, keeping this view the present study was based on to evaluate the *Parthenium* growth under saline soil.

II. MATERIAL AND METHODS

Study area description and weed status

Surveys on five study areas were done by "walk transect" with stratified & systematic surveying methods for the inspection of *P. hysterophorus* invasion into Jaunpur distric. Phyto-sociological studies were conducted by applying Quadrat method. The species richness (number of species per sampling unit) and the density of *Parthenium* (pl/m^2) were determined for each quadrate sampled. The frequency of each species in *Parthenium* non-invaded and invaded sites was calculated. Jaccard's Similarity Index (JSI) and Sorenson's Similarity Index (SSI) between *Parthenium* non-invaded and invaded area of each site were calculated as JSI=C X 100 /A+B-C, SIS=2C X 100/A+B. Where A= Total number of species in non-invaded plots and B= Total number of species in invaded plots. C= Total number of species common to invaded and non-invaded plots. Plot wise data of vegetation and soil attributes were used in statistical analysis. Mean values of *Parthenium* density, species richness, soil pH, soil organic carbon (OC), soil nitrogen content (N) in invaded sites were compared by using Mann-Whitney U test. The statistical analysis was conducted using the Statistical Package for Social Sciences (SPSS) version 11.5.

Experimental set-up for pot experiment

A growth chamber experiment was conducted according to [8] by using small; autoclaved plastic pots (each filled with 200 g of soil) supplemented with NaCl (w/w) with different concentration 0.5, 1.0, 1.5, 2.0 and 2.5% and equilibrated for 20 days. The similar height of small plants were uprooted from natural terrestrial eco-system and showing in the prepared pots. The treatments were repeated three times with six replicates, and plants were harvested after 30 and 60DAS for further analysis.

Analysis of Na, chlorophylls and osmolytes

Sodium, Nitrogen, Phosphorous and potassium analysis were examined by the method earlier described by [8,9] in leaf and soil. The leaf /soil samples were dried in an oven at 68^0 C for 48 h. The dried leaves were ground and digested in an acid mixture (HNO_3: H_2SO_4: $HClO_4$ = 10:1:3) for determination of Na, N, PO_4 and K. Bioconcentration factor (BCF) of the sodium was calculated by the method [10,11] as BCF=Metal concentration in plant/Metal concentration in soil. Leaf chlorophyll a and b were estimated by spectrophotometrically [12] at 663 nm and 645 nm. Proline and TSS were determined by the method earlier described by [8]. For proline, 0.5 g of leaf tissue was homogenized in a pestle and mortar with 10 ml 3% (w ⁄ v) aqueous sulphosalicylic acid and filtered through Whatman No. 2 filter paper; 1 ml of filtrate was mixed with 2 ml glacial acetic acid and 2 ml ninhydrin in a test tube; boiled at 100^0C for 1 h and placed on ice to stop the reaction. Thereafter, 4 mL toluene was mixed vigorously for 20–30s, and the aspirated chromospheres (toluene) layer brought to room temperature. Absorbance was read at 520 nm against a reagent blank and the amount of proline (µg/g fresh weight) was calculated from a standard curve for proline [13]. 100 mg of fresh leaves were

placed in a test tube containing 5 ml 2.5 N HCl, boiled for 3 h then cooled to room temperature for TSS (total soluble sugar) analysis using the anthrone method [8].

III. RESULTS AND DISCUSSION

Five major sites were selected in the present study of *pathenium* plant status in non-invaded (*N-I*) and invaded (*I*) sites. *Parthenium* density and species richness were found more in *N-I* sites as compared to *I* sites (Table 1). Kohli et al. [14] reported a decline in species richness from 25 to 12 from *Parthenium* non invaded site to high invaded site of Lower Himalaya (India). Similarly, Belz et al., [2] reported that *Parthenium* have allelopathic effect in its root and shoot leachates and thus has the ability to reduce the growth and germination of numerous associated species. The mechanism of decrease of species richness is elaborated [1]. Soil pH and electrical conductivity (ECe=dSm^{-1}) was more in *I* sites over the *N-I* sites. Earlier researcher reported that densities of parthenium and biomass vary with soil type [5]. The most common soil types on which it is found are alkaline, clay, loam soil to heavy black clay soils [6]. In the present study, soil pH was with range 6.9 to 7.7 in *N-I* and 7.2 to 7.8 in *I* sites, while electrical conductivity was with range 9 to 23 dSm^{-1} in *N-I* sites and 18 to 42 dSm^{-1} in *I* sites (Table 1). Temperature (^0C) and rain fall was recorded (data not shown) over the (December 2011 to July 2012) of the *parthenium* grown sites, indicates that the *parthenium* plant survive at maximum range of temperature as well as rain fall. Pandey et al. [3] reported that *parthenium* found mostly in hot climates with range of temperature (28-33°C) are favorable because it increases the dry matter production of the plant due to maximum photosynthesis, while low winter temperature inhibits the growth of the plant and the seed production [1,3,4]. In the present study, with a novel approach to examine the organic carbon (OC) and percent nitrogen (%N) in the soil of *parthenium* grown sites and result revealed that no any clear relation was observed for OC and %N in soil under *N-I* and *I* sites (Table 1), while the level of OC and %N was sufficient to support the growth of the plant [9]. Among results indicate that the *parthenium* plant survive at adverse condition like high ECe, pH and able to maintain the OC and %N in natural environment. Keeping these views, we observed that the growth of *parthenium* plant and soil health in pot experiment under saline condition. Root, shoot length and dry biomass of *parthenium* plant was not significantly affected up to 1% NaCl (w/w) concentration over the control, while reduction was observed from 1 to 2.5% NaCl concentration after 30 and 60DAS (Table 2). In the present study, the proline content increased with increased concentration of NaCl. Plant proline content was not much affected at 1% NaCl (w/w), while at 1.5% NaCl plant proline was sudden increased *ie* 54% and 65.8% over the control after 30 and 60DAS respectively.TSS was increased up to 1.5% NaCl concentration after that TSS was sudden decreased. Proline may act as a mediator of osmotic adjustment, protects macromolecules during dehydration and serve as a hydroxyl radical scavenger [15]. Proline and TSS was increased under saline soil was earlier reported [8,9]. Chlorophyll-a (Ch-a) and Chlorophyll-b (Ch-b) was almost not affected up to 1% NaCl (w/w) concentration, while affected beyond 1% to 2.5% NaCl over the control after both 30 and 60DAS (Table 2). In the present study, percent nitrogen (%N) and percent potassium (%K) in the plant was little increased up to 1% NaCl treated soil with plant, while percent phosphorous (% PO_4) increased up to only 0.5% NaCl treated plant. N, P and K content in the plant was more in 60DAS as compared with 30DAS in all the NaCl treated pot. Earlier report supported that *parthenium* plant induces changes in the physical and chemical properties of soil such as soil texture, soil pH, soil organic matter, soil nitrogen, soil potassium, soil phosphorus etc [16,17].

Table 1: Comparison of mean of *parthenium* density, species richness and soil attributes of parthenium non-invaded (*N-I*) and invaded (*I*) sites of Jaunpur.

Sites	*Parthenium* density		Species richness		Soil pH		ECe of soil		OC% in soil		N% in soil	
	N-I	***I***	***N-I***	***I***	***N-I***	***I***	***N-I***	***I***	***N-I***	***I***	***N-I***	***I***
Chaukiya	29	52	27	12	7.1	7.4	22	24	2.2	2.55	0.38	0.52
Khetsarai	63	108	16	9	7.0	7.2	9	18	2.5	2.02	0.52	0.57
Kuthan	117	212	22	11	7.7	7.6	18	35	3.4	3.06	0.32	0.31
Sahgang	72	157	13	8	7.1	7.5	23	31	2.4	3.00	0.31	0.57
Sipah	21	47	12	8	6.9	7.8	12	42	2.1	1.53	0.42	0.59
SL	<0.001	<0.001	1.21	0.925	<0.001	<0.001	<0.001	<0.001	0.572	.821	0.011	0.018

Data are the average mean of 50 quadrate and soil samples (n =10 X 50) form each location, ECe=(electrical conductivity in dSm^{-1}), and SL (Significance level) based on Mann-Whitney U test.

Sodium accumulation in the plant was increased with increased concentration of NaCl at 30DAS, while maximum 67% sodium accumulates at 1% NaCl (w/w) treated plant after 60DAS (Table 3). Bioconcentration factor (BCF) was >1 indicates that plant behave as a good accumulator of sodium, in the present study BCF was >1 up to 1.5% NaCl (w/w) treated plant, hence the parthenium plant might use in phytoremadiation of metal (*ie*. Na) [10,11]. Plant microbe interaction was observed on the basis of population count (cfu/gm soil) of rhizospheric and rhizoplane soil in the treated pot. Bacterial population was greatly influenced under higher salinity level; maximum bacterial population was found in rhizospheric region as compared with

rhizoplane. This showed rhizo-adaptation of bacteria, most of the rhizobacteria were earlier reported for their plant growth promoting activities, and they help to growth in plant with direct and indirect mechanisms under saline condition [8, 9]. It is interesting finding that bacterial population was not detected at 2 and 2.5% NaCl treated pot in rhizoplane, while bacterial population 5 X 10^5 and 8 X 10^5 cfu/gm soil was found in rhizospheric region at 2.5% NaCl treated pot after 30 and 60DAS respectively (Table 3). Overall rhizospheric bacterial population was unaffected up to 1% NaCl (w/w) treated plant in pot. Bacterial population at 1% NaCl treated pot was 12 X 10^6 cfu/gm soil and 20 X 10^6 cfu/gm soil after 30 and 60 DAS respectively in the rhizospheric soil and around 8 X 10^6 cfu/gm soil was in rhizoplane soil after both DAS (Table 3). Upadhyay et al. [8,9,18] earlier reported that the N, P and K concentrations was increased in wheat plant inoculated by PGPRs under salinity stress conditions, and more bacterial population were found in rhizospheric region as compared with rhizoplane for wheat plant under salinity [9]. The present study revealed that parthenium is an exotic weed, help to mitigate salinity in soil and improve soil health under saline environment. Therefore, the parthenium plant might be use in the field of restoration ecology.

Table 2: Plant growth and biochemical analysis of *Parthenium* plant under different salt concentrations [T1=0.5%, T2=1.0%, T3=1.5%, T4=2.0 and T5=2.5% (NaCl:w/w)] in pot.

TT	Proline		TSS		Ch-a		Ch-b		R L (cm)		S L (cm)		DBM (g)	
	30D	**60D**	**30D**	**60D**	**30D**	**60D**	**30D**	**60D**	**30D**	**60D**	**30D**	**60D**	**30D**	**60D**
C	0.88	0.94	88	124	2.8*	4.3*	2.2*	3.1*	6.2*	8.4*	15.6*	18.5*	4.8*	6.3*
T1	1.14*	1.26*	93	132*	2.6**	4.3*	2.1*	3.0*	6.1*	8.6*	15.2*	18.2*	4.6**	6.3*
T2	1.25*	1.22**	95*	137*	2.5**	4.1*	2.0*	3.0**	6.3*	8.2*	15.7*	18.3**	4.3	6.1**
T3	1.94	2.75	98*	140**	1.7	2.6	1.3	1.5	4.2**	6.3	11.6	12.5	3.2	4.2
T4	2.62**	2.84	72	112*	1.5	2.1	1.1	0.9	4.1**	5.7	11.4	11.6	2.8	2.9
T5	2.68**	2.80	57	81	1.2	1.5	0.9	0.5	3.8	4.0	9.2	10.1	2.4	2.6

Data are average mean of six replicates, * = Significant from control at 0.05 level (t-test), ** = Highly significant from control at 0.01 level (t-test), C (Control), Proline (µg/g Fresh weight), TSS (Total soluble sugars= µg/g Fresh weight), Ch-Chlorophyll (mg/g Fresh leaf), RL (Root length), SL (Shoot length) and DBM (Dry Biomass).

Table 3: Ions and bacterial population status in different NaCl (w/w) treatments (TT) [T1=0.5%, T2=1.0%, T3=1.5%, T4=2.0 and T5=2.5%] *parthenium* plant in pot.

TT	N (%)		PO4 (%)		K (%)		Na (%)		BCF of Na		[a]Cfu/gm Soil		[b]Cfu/gm Soil	
	30D	**60D**	**30D**	**60D**	**30D**	**60D**	**30D**	**60D**	**30 D**	**60 D**	**30 D**	**60 D**	**30 D**	**60 D**
C	0.14*	0.19*	0.2*	0.32*	0.22*	0.24*	0.6	0.9	-	-	125	201	108	181
T1	0.16*	0.21*	0.6*	0.39*	0.21*	0.30	1.4*	1.9*	2.8	3.8	122	205	106	116
T2	0.25*	0.29*	0.6*	0.29*	0.32*	0.28	1.5*	2.8*	1.5	2.8	120	204	80	84
T3	0.22	0.26	0.7	0.16	0.24	0.19*	1.8	2.5*	1.2	1.7	58	64	21	10
T4	0.15*	0.17	0.4	0.12	0.18	0.16	2.1	2.0	1.0	1.0	9	14	Nd	nd
T5	0.11	0.08	0.2	0.3	0.14	0.14	2.2	2.0	0.8	0.8	5	8	Nd	Nd

Data are average mean of six replicates, C =Control), * = Significant from control at 0.05 level (t-test), D= (Days) BCF=Bioconcentration factor, Cfu= colony forming unit ([a])= Bacterial population (1 X10^6) in rhizospheric region,([b])= Bacterial population (1 X10^6) in rhizoplane region and nd=not detected.

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