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IMPACT OF SALTPANS (NaCl) ON C_3 (*CAJANUS CAJAN (L.) MILLSPAUGH*) AND C_4 (*SORGHUM BICOLOR (L.*)) CROP PLANTS IN THREE DIFFERENT AREAS AND THEIR DIFFERENTIAL RESPONSES ON THE SEED GERMINATION PERCENTAGE.

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ABSTRACT

An attempt was made for the first time in the Visakhapatnam district to assess the impact of saltpan effluent on available soils in the farms existing in and around saltpans. A total of thirty soil samples from three sampling farm sites were collected along the coastal line and analysed for physico-chemical parameters. The results obtained conclusively suggest the detrimental impact of saline effluents on soil quality in Area-2 and Area-3, rendering it unfit for agricultural purpose. The present study shows the effect of sodium chloride salinity in the seedlings of C_3 (***Cajanus Cajan***) and C_4 (***Sorghum biocolor***) crop plants in three different areas. Differential responses of the growth parameters such as the percentage of seed germination (GP), germination index (GI) and coefficient of germination velocity(CVG) in two genotypes is observed. The GP, GI and CVG appered to be decreased in Area-2 and Area-3 when compared to Area-1 in both the crop plants.

I. INTRODUCTION

Advances in science and technology since industrial revolution has increasing enabled human to exploit natural resources. Visakhapatnam, a fast growing metropolitan city with accelerating urbanization, industrialization, pharmaceuticals, washing from salt pans and their improper disposal of wastes into the soil and water which has a major threat to the increasing population. This study aimed at identifying the quality of soil in the vicinity of agricultural fields in and around, and also assessing the rate of salinization of the saltpans due to practicing of traditional salt making. Salinity is the accumulation of salt in soil (Joshi & Iyengar, 1982). High salt levels can adversely affect plant growth, soil structure, water quality and infrastructure (Andrew, Jones & Whalley, 1997). Salinization of soil is one of the major factors limiting crop production particularly in arid and semi-arid regions of the world. Salt stress (NaCl) is one of the major pollutants released into the environment due to both natural and man- made activities (Arun, Raviraja & Sridhar, 2001). Excessive exposure of NaCl in ground water, soil, and air causes ill effect not only to humans but also to plants and animals. The general symptoms of NaCl injury in plants are necrotic lessios, chlorosis and burning of leaf tips and margins at salt concentrations greater than 50 mmol/L. **A** number of C_3 and C_4 plant species have been identified that are capable of accumulating higher concentrations of NaCl in their seedlings (Bewley & Black, 1994). Present study involves the screening of different C_3 and C_4 crop plants that accumulate NaCl, so as to identify the NaCl tolerant plants (Atayat, 2001).

Pigeon pea [***Cajanus Cajan*** (L.) Millsp.], a C_3 plant and is an important pulse crop of India. The seeds of pigeon pea are rich in protein content (Peoples *et al.*, 1995) and are commonly used as a source of vegetable protein in daily dietary intake of humans. Pigeon pea is considered to be a profitable and popular crop of India. In combination with cereals, pigeon pea makes a well-balanced human food (Pandey *et al.*, 2014).

Sorghum bicolor, a C_4 plant and is an important cereal crop of India. Sorghum grain is primarily used for livestock feed and ethanol production, and also became popular in the consumer food industry. In spite of such an importance of these crops, there is no much research on their physiological and biochemical responses to industrial pollutants and therefore needs great attention (Zia & Khan, 2002). This study aimed basing on the physic-chemical characteristics on soil samples collected from three different areas away from saltpans and their differential responses of seed germination percentage of both the genotypes (Eshetu & kari, 2002).

II. MATERIALS AND METHODS

(a) Study Area

Visakhapatnam is situated between 17º40’ 30" and 17º40’ 45" NL and 83º16’ 15" and 83º21’ 30" EL. Hanumanthawaka is a place, located 30 km away from saltpans and the soil samples were collected from the farm and treated as **Area-1**. Simannapelli is 8 km away from saltpans, five soil samples were collected from farm and treated as **Area-2**. Pudimadaka (Anakapalli Mandal) has around thirty salt pans. Five soil samples from each sampling site at the farm were collected and treated as **Area-3** (Udayalaxmi, Himabindhu, and Ramadass, G.2010).

(b) Soil Sample collection

Samples were collected in triplicates for each season (January – December, 2016), at exact points on the selected sites, with great care during collection and transportation. At each location, soil samples were collected from three different depths viz. 30 cm, 60cm and 90 cm below the surface and homogenized. The homogenized samples were brought to the laboratory and analyzed for physical and chemical parameters by adopting known standard procedures (APHA, 1998).

(c) Seed germination experiment

Seeds of *Cajanus Cajan* and *Sorghum bicolor* were purchased from research center of Anakapalli mandal, Visakhapatnam. The seeds of two genotypes were surface sterilized with 0.01% mercuric chloride for 3 minutes, washed thoroughly with distilled water and 100 seeds of each plot was placed in Petri dishes lined with moist filter paper and then transferred to the three different fields i.e., Area-1, Area-2 and Area-3 to germinate and the temperature is 30± 1º C (Aiazzi *et al.*, 2002). Counts for germination were taken up to seven days at 24 hours intervals. Seeds with 0.5 cm radical emergence were considered as germinated (Joshi & Khairatkar, 1995).

(d) Germination percentage (GP)

The seed germination data was recorded every 24 hours according to the seedling evaluation procedure up to 7 days were expressed as germination percentage. The percent germination (GP) was calculated using the formula (Cokkizgin and Cokkizgin, 2010).

$$GP = \frac{n_g}{N_s}100 \qquad (1)$$

Where, GP= germination percentage

n_g = number of germinated seeds

N_s = total number of seeds

(e) Germinating index (GI)

Germinating index was recorded according to AOSA (1990) by using the following formula.

$$GI = \sum \frac{Gt}{Dt} \qquad (2)$$

Where, G_t is the number of germinated seed on day t and D_t is the total number of days (01-07).

(f) Coefficient of germination velocity (CVG)

Coefficient of germination velocity was calculated described by Maguri (1962).

$$CVG = \frac{(G_1+G_2+\cdots G_n)}{(1\times G_1+2\times G_2+\cdots n\times G_n)} \qquad (3)$$

Where, G represents the number of germinated seeds counted per day till the end of experiment.

(g) STATISTICAL ANALYSIS

Data were analyzed by using (ANOVA) and the significant differences between treatment means were examined by least significant difference (Zar, 2010). Fifty percent reduction of germination indices and seedling growth were calculated by using linear regression. All statistical analysis was performed using SPSS for windows version 14 and graphs were plotted using Sigma plot 2000.

III. RESULTS AND DISCUSSION

(a) Physico-chemical parameter of soil samples in different Areas

The physico-chemical characteristics of soil samples collected from three different areas in and around saltpans in the vicinity of Visakhapatnam are shown in the Table1, Table2, Table3 respectivily. The parameters of soil from three different sampling sites such as pH, electical conductivity, texture, Available nitrogen (N), Available phosphorous (P), Available potassium (K), Exchangeable Magnesium (Mg), Exchangeable Calcium (Ca), Exchageable Sodium (Na) were listed. The results clearly indicated that the soils have been salinized.

Table 1 Physico-chemical characters of soil samples collected from Area-1.

Parameters	UOM	AREA-1				
		S1	S2	S3	S4	S5
pH	--	6.5	7.1	7.2	7.1	6.8
Conductivity	mhos/cm	1.01	1.04	1.00	1.01	1.07
Texture	--	Sandy/ clay	Sandy/ clay	Silty/ clay	Sandy/ clay	Sandy/ clay
Available Nitrogen as (N)	Kg/ha	250	300	300	390	285
Available Phosphorus as (P)	Kg/ha	80	78	79	70	72
Available Potassium as (K)	Kg/ha	369	360	350	300	324
Exchangeable Magnesium as (Mg)	mg/kg	400	799	400	300	700
Exchangeable Calcium as (Ca)	mg/kg	121.3	121.3	121.3	183.4	205
Exchangeable Sodium as (Na)	mg/kg	168	188	160	250	477

Table 2 Physico-chemical characters of soil samples collected from Area-2.

Parameters	UOM	AREA-2				
		S1	S2	S3	S4	S5
pH	--	7.8	8.5	7.9	8.4	8.3
Conductivity	mhos/cm	3.0	3.0	2.9	3.2	3.0
Texture	--	Sandy/ clay	Sandy/ clay	Silty/ clay	Sandy/ clay	Silty/ clay
Available Nitrogen as (N)	Kg/ha	250	250	300	320	300
Available Phosphorus as (P)	Kg/ha	75	76	66	70	72
Available Potassium as (K)	Kg/ha	301	306	360	300	340
Exchangeable Magnesium as (Mg)	mg/kg	500	799	999	900	990
Exchangeable Calcium as (Ca)	mg/kg	302	302	260	234	242
Exchangeable Sodium as (Na)	mg/kg	420	403	399	400	509

Table 3 Physico-chemical characters of soil samples collected from Area-3.

Parameters	UOM	AREA-3				
		S1	S2	S3	S4	S5
pH	--	9.0	8.8	8.9	9.0	8.9
Conductivity	mhos/cm	3.8	3.8	4.0	3.9	3.8
Texture	--	Silty/ clay	Sandy/ clay	Silty/ clay	Sandy/ clay	Silty/ clay
Available Nitrogen as (N)	Kg/ha	101	300	288	278	280
Available Phosphorus as (P)	Kg/ha	78	56	60	66	86
Available Potassium as (K)	Kg/ha	320	340	360	300	250
Exchangeable Magnesium as (Mg)	mg/kg	2098	1099	1001	2004	2004
Exchangeable Calcium as (Ca)	mg/kg	364	302	364	364	1212.3
Exchangeable Sodium as (Na)	mg/kg	588	590	550	660	690

AREA-1: The field is 30km away from the saltpan effluents.
AREA-2: The field is 8km away from the saltpan effluents.
AREA-3: The field is 1km away from the saltpan effluents.

BASELINE SOIL STATUS

Based on the soil analysis results obtained from the different sampling sites, it is evident that the soil samples are predominantly sandy clay and silty clay type. The pH of the soil samples in Area-1 ranged from 6.5 to 7.3 indicating neutral, where as in Area-2 and Area-3 the pH ranges from 7.8 to 9.01 indicating medium to strongly alkaline. The electrical conductivity of the soil samples varied from 1 to 4 mmhos/cm. Based on the conductivity results it can be concluded that the ionic content of the soil samples are not within the limits that is harmful to germination. Available nitrogen, phosphorus and potassium levels in the soil samples in Area-1, Area-2 and Area-3 reveals that the distribution is from medium to more than sufficient quantities that does not effect the crop. Available sodium, calcium and magnesium in the soil samples of Area-1 is under controlled range,where as in Area-2 is medium polluted and Area-3 is higly polluted (Smitha, Byrappa and Ramaswamy, 2007).

Based on the above characteristics, the soils of Area-2 and Area-3 has been found to have heavy salt concentrations and hence treated as polluted Areas, which are harmful for the growth of crop plants. (Al Khateeb, 2006).

(b) Effect of saltpans (salinity) on germinating seeds of *Cajanus cajan* and *Sorghum bicolor* genotypes on 7th day.

Seed germination is the protrusion of radical from the seed which is adversely affected by salt effluents of saltpans (Kayamakanova, 2009). Salt stress imposes the osmotic stress by accumulation of sodium ions (Na^+) and chloride ions(Cl^-) which decreases soil water potential that ultimately inhibits the imbibition process (Khan and Gul, 2002). The germination of a salt tolerant desert *leghum, Indigofera oblongifolia*, is reported to behave to salt stress in similar manner (Khan and Ahmad, 1998; 2007). Pujol *et al.*, (2000) reported that increased salinity inhibit the seed germination as well as delay in germination in various halophyte species (Khan & Ungar, 1984). Salt stress (Khan and Gul, 2006) effects oxidative stress due to over production of Relative Oxygen Species (ROS) which alters the metabolic activities of crop plants during germination and growth stages (Liu *et al.*, 2006).

According to our results, the overall germination percentage (Fig.2) (Maas and Hoffman, 1977)., germination index(Fig.3) and coefficient of germination velocity(Fig.4) showed the gradual decrease in Area-3 in two cultivars due to high salt concentrations in the soils when compared to Area-2 and control site (Area-1). The number of seeds germinated in both the genotypes is shown in (Fig.1) describes that the seeds germinated in

Area-3 is more decresed than Area-2 and control site(Area-1). The results showed the overall decline of the seed germination is seen more in ***Cajanus Cajan*** than in ***sorghum bicolor*** cultivars.

Table 4. Effect of saltpan effluents on germinating seeds of *Cajanus cajan* and *Sorghum bicolor* genotypes on 1-7 days.

Sr.No	Genotype	Total number of seeds	AREA-1			AREA-2			AREA-3		
			GP	**GI**	**CVG**	GP	GI	CVG	GP	GI	CVG
1.	***Cajanus Cajan***	100	95%	13.5	0.224	63%	9	0.210	47%	6.7	0.182
2.	***Sorghum bicolor***	100	97%	13.8	0.226	73%	10.42	0.218	55%	7.85	0.214

GP= Germination percentage, GI= Germination Index, CVG= Coefficient of germination velocity.

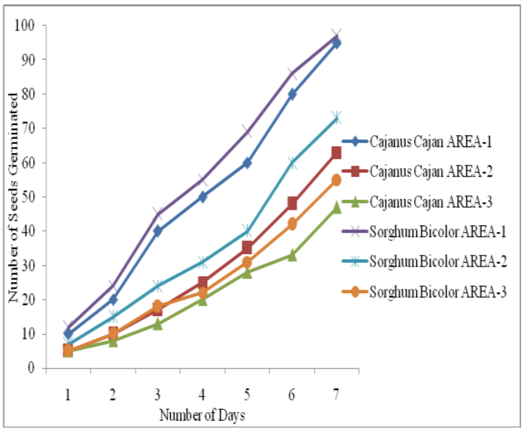

Figure 1. Effect of different saltpan effluents on number of seeds germinated in three different Areas of *Cajanus Cajan* and *Sorghum Bicolor* plants.

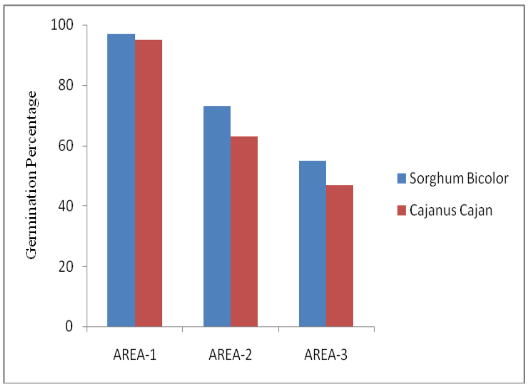

Figure 2. Effect of saltpan effluents on germination percentage of *Cajanus cajan* and *Sorghum bicolor* plants.

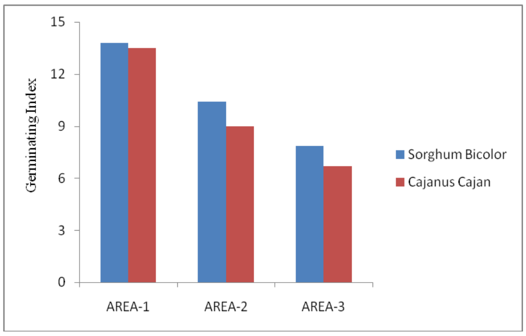

Figure 3. Effect of saltpan effluents on germination index of *Cajanus cajan* and *Sorghum bicolor* plants.

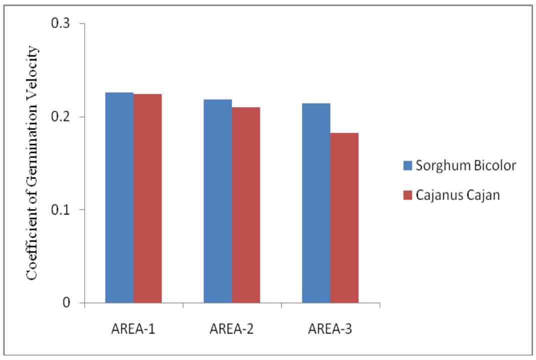

Figure 4. Effect of saltpan effluents on coefficient of germination velocity of *Cajanus cajan* and *Sorghum bicolor* plants.

IV CONCLUSION

Cajanus cajan and ***Sorghum bicolor*** plants are attractive crops because of its adaptability to different cropping systems and short growing cycle. The results in our study have shown the salinity induced changes in germination percentage in the selected three different areas of both the genotypes. The reduction was found to be more pronounced in Area-3 than Area-2 for both the genotypes. Area-1 the seed germination percentage is under controlled conditions. Among two genotypes, the seed germination percentage is more reduced in ***Sorghum bicolor*** than ***Cajanus cajan.*** Further, salinity stress may lead to significant reduction in crop yield. We can improve stress tolerance in pigeon pea and sorghum it is very essential to identify the salt tolerant cultivars to improve the production to a possible extent to meet out the protein and carbohydrate needs of our increasing population.

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