The Ecoscan 10(1&2): 63-66, 2016
AN INTERNATIONAL QUARTERLY JOURNAL OF ENVIRONMENTAL SCIENCES
www.theecoscan.com

EFFECT OF SEA WATER IRRIGATION AND SOWING TIME ON SEED YIELD AND COMPONENT OF SALICORNIA (*S. BRACHIATA* ROXB.)

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ABSTRACT

A field experiment wascarried out on costal salt affected soil *Typic Halaquepts* at coastal salt affected soils of Coastal Soil Salinity Research Station, NAU, to study the effects of date of sowing and levels of irrigation, individually and in combination on the performance of *salicornia*. The treatment consisted of three dates of sowing *viz*., D_1: 1st week of June, D_2:3rd week of June and D_3:1st week of July were allotted to main plot and three levels of irrigation *i*.e., I_{-1}: 0.6 IW/CPE, I_2:0.8 IW/CPE and 1.0 IW/CPE in sub plot treatments. There was significant effect of date of sowing and levels of irrigation onfresh biomass and seed yield. Sowing of *salicornia* during 3rd week of June or 1stweek of July recorded significantly higher growth parameters *viz*., plant height, canopy spread, number of main branch, spike per branch and fresh and dry biomass yield (7.38and 7.10 t/ha). Further irrigation scheduled at 0.8IW/CPE ratio yielded significantly higher than the rest of the irrigation regimes (7.38t/ha). The interaction effect was also significant on fresh biomass yield of *salicornia*. Treatment combinations involving 0.8 IW/CPE ratio with sowing date D_3 produced significantly higher fresh biomass (34.24 t/ha) as compared to early sowing (23.78 and 31.12 t/ha).

KEY WORDS
Salicornia
Seawater
Irrigation
Date of Sowing

Received : 26.08.2015
Revised : 29.01.2016
Accepted : 11.03.2016

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INTRODUCTION

Land is a limiting entity and the arable land productivity is not sufficient to withstand the growing population demand. We need production alternatives to sustain the demand. Production alternatives include development of salt-tolerant plant that already exists in salt flat areas (Ungar, 1987). There is abundance of exotic species of plants that can be domesticated in stress areas. One of the exotic species that can articulate in saline ingresses salt marsh is *salicornia*. An obligate halophyte *salicornia*, is inhabited to salt flats marshes. *Salicornia* is a genus of succulent, halophyte (salt tolerant)plants that grow in salt marshes, on beachesand among mangroves. *Salicornia* species are native to North America, Europe, South Africa and South Asia. Common names for the genus include glasswort, pickle weedand marsh samphire; these common names are also used for species not in *salicornia*. The *salicornia* species are small, usually less than 30 cm tall, succulent herbs with a jointed horizontal main stem and erect lateral branches. The leaves are small and scale-like and as such the plant may appear leafless. *Salicornia* species can generally tolerate immersion in salt water. *Salicornia* is efficient halophytes to be cultivated in saline and sodic soils of the coastal semi-arid regions of Gujarat. *Salicornia* (*marcher*) naturally growing in coastal areas of South Gujarat. Due to over exploitation of this halophyte for fresh biomass consumption, it has become rare in its natural habitat. Commercial cultivation of Salicornia in salt affected land near sea has tremendous potential in south Gujarat costal area. Agronomical practices *viz*., method of sowing and land preparation for this crop was standardized but information about date of sowing is not available. Gujarat having the longest sea coast in India needs imperative concern. The paper deals with effect of sea water irrigation and sowing time on seed yieldand component of Salicornia (*S. brachiata* Roxb.)

MATERIALS AND METHODS

Field experiment was conducted at the Coastal Soil Salinity Research Station, Danti-Umbharat of Navsari Agricultural University in the South of Gujarat near the Arabian Sea during 2011-12. Geographically, Danti- Umbharat is situated at 20^0 83′ N latitude and 72^0 50′ E longitudes with an elevation of 2.5 meter above sea level on the western coastal belt of India.The salt affected clay soil belong to Onjal-1 series is sub-grouped as *TypicHalaquepts*while Att series is *Fluventic Halaquepts*. A field experiment with nine treatment combinations comprising of three levels each of date of sowing as main plot treatment (D_{-1}: 1st week of June, D_2: 3rd week of June and D_3: 1st week of July). Irrigation schedules were determined keeping 60mm depth of irrigation. The amount of water required for appling 60mm depth of water was measured open channel flow using parshall flume (IS 14371:1996). Cumulative Pan Evaporation data were recorded from the observatory U.S. class-A open pan evaporimeter. They different IW/CPE levels, 0.6, 0.8 and 1.0 were calculated. The measured amount of irrigation was given according to ratio of applied depth of irrigation (IW) (60mm) and Cumulative Pan

Evaporation (CPE) (Doorenbos and Kassam 1979). Seawater from the Arabian Sea was applied as irrigation water source. The seeds were supplied from Coastal Soil Salinity Research Station, NAU, Danti-Umbharat, Navsari. Healthy seeds of *Salicornia brachiata* Roxb., obtained from the previous year cultivation was selected. The recommended dose 250:75:50 kg NPK/ha was applied. N was applied in three splits *i.e.*, 50 per cent as basal, 25 per cent at 60 days after sowing and 25 per cent at 120 days after sowing. The seed rate was 2.5 kg ha^{-1}. The biometric observations, yield, oil content *etc.*, recorded/ determined during the course of investigation were analysed statistically by standard statistical method given by Panse and Sukhatme (1967). The plant heights, plant canopy, number of main branches per plant, number of spike per branch, spike length and segment per spike were recorded at the time of fresh biomass harvesting stage are presented in Table 1.

RESULTS AND DISCUSSION

All growth parameters were significantly affected due to main plot treatments as well as sub plot treatments, in case of plant height and spike length were not significantly affected due to sowing dates (D). The interaction effect of D x I was significant only on plant canopy. In case of different date of sowings, D_2 (3rd week of June) recorded significantly higher values of all the growth parameters than D_1 (1st week of June) and D_3(1st week of July). Among all the irrigation levels, 0.8 IW/CPE (I_2) recorded significantly taller plant, wider canopy, more number of main branches per plant, number of spike per branch, spike length and segment per spike than 1.0 IW/CPE (I_3) and 0.6 IW/ CPE (I_1) irrigation levels. The combination of crop sown on 3rd June and irrigated at 1.0 IW/CPE (D_2I_3) recorded significantly higher values of plant canopy (125 cm^2) than rest of the combinations (Table 2). The result revealed that except plant height, effect of date of sowing could influence all the growth parameters significantly. In all the cases, D_2 *i.e.,* sowing of *salicornia* during 3rd week of June showed superiority over D_1 *i.e.,* 1st week of June. However in most of the cases, D_2 was found to be at par with D_3 (1st week of July). This might be due to salt stress during early growth period if higher when sowing this done during 1st week of June as salt concentration in surface soil is higher than late sowing in 3rd week of June and 1st week of July. Similarly Sumrah *et al.,* (2003) and Babu *et al.,* (2014) found the effect of salt stress on shoot length of cotton.This implies that optimum sowing time for *salicornia* crop in coastal areas at South Gujarat is between 3rdweek of June to 1st week of July. In other words, this period is matching with regular period of onset in monsoon of South Gujarat region. The results related to canopy, number of main branches per plant, number of spike per branch, spike length and number of segments per spike depicted. With respect to effect of irrigation levels on growth parameters, it was found to be significant on all the parameters *viz.,* plant height, canopy, number of main branch per plant, number of spikes per branch, spike length and number of segments per spike. Among three irrigation level I_3 *i.e.,* scheduling irrigation at 1.0 IW/CPE recorded significantly higher values of all the growth parameters as compared to I_1 (0.6 IW/CPE). Though, I_3 showed superiority over I_1, yet it was at par with I_2 in all the parameters except plant canopy where in I_3 was found superior over I_2.

Yield

The results pertaining to the fresh biomass yield, dry biomass yield, seed yield and oil content of *salicornia* seeds presented in table 3 indicated that individual effect of date of sowing (D), level of irrigation (I) significantly influenced all the yield attributes of salicornia. Among the dates of sowing, D_3: 1st week of July recorded significantly higher fresh biomass yield and seed yield than D_1:1st week of June and D_2: 3rd week of June. Similarly, delayed sowing significantly affected yield of beet root was recorded by Sumrah *et al.* (2003). In case of dry biomass yield and oil content D_2: 3rd week of June recorded higher yield than D_1:1st week of June and D_3: 1st week of July. Among the irrigation levels, 0.8 IW/CPE (I_2) was recorded higher fresh biomass yield, dry biomass yield, seed yield and oil content, but it was statistically at par with treatment 1.0 IW/ CPE (I_3) (Joshi and Iyenger (1982) and Keiffer*et al.* (1994)). The interaction effect of date of sowing and irrigation level was also found to be significant on fresh biomass yield and oil content. The combination D_2I_2 recorded significantly higher fresh biomass yield (38.05 t ha^{-1}) and oil content (27.55%) over rest of the possible combinations. In case of fresh biomass yield, it remained statistically at par with the treatment combination D_3I_2, D_2I_3 and D_3I_3. Similarly, beneficial effects of

Table 1: Effect of date of sowing and irrigation level on different growth parameters of *salicornia*

Treatment	Plant height (cm)	Plant canopy (cm^2)	Number of main branch per plant	Spike per branch	Spike length	Segment per spike
Date of sowing						
D_1: 1st week of June	30.77	72	20.98	382	8.28	10.03
D_2: 3rd week of June	32.22	112	25.23	478	8.39	14.92
D_3: 1st week of July	31.54	103	23.95	462	8.37	12.53
SEm±	1.000	3.2	0.58	7.50	0.86	0.20
CD at 5%	NS	11	2.00	26	NS	0.68
CV%	10.99	11.72	8.56	5.89	35.65	5.43
Irrigation levels						
I_1 : 0.6 IW/CPE	27.55	79	19.49	392	6.39	8.75
I_2 : 0.8 IW/CPE	34.06	92	24.47	458	8.67	14.35
I_3 :1.0IW/CPE	32.92	116	26.20	472	9.99	14.38
SEm±	0.787	4.1	0.72	19.30	0.29	0.42
CD at 5%	2.34	12	2.13	57	0.87	1.24
CV%	8.65	14.88	10.62	15.16	12.18	11.53
Significant interaction	-	D x I	-	-	-	-

D_2I_2 were also observed on growth parameters. This might have ultimately resulted in the higher fresh biomass yield of *salicornia*. Contrary to this, the dry yield of *salicornia* was affected significantly only due to main effect of D and I and not by their interaction. In dry biomass yield, I_2 and I_3as well as D_2 and D_3 were at par with each other but conspicuously more than I_1 and D_1. Though not significant, but here also D_2I_2 maintained their superiority over rest of the combinations. The results suggest that only individual effect of D and I was found to significant on seed yield of *salicornia*. Here also, I_2/I_3 and D_2/D_3 maintained their superiority over I_1 and D_1. The reasons for recording higher values of growth parameter and biomass as well as seed yields of *salicornia* with D_2 and I_2 are as follow. All the above favorable conditions ultimately culminated into significantly higher growth and biomass as well as seed yields of *salicornia* in delayed sowing and frequently irrigated crop as compared to that of early sowing and less frequently irrigated *salicornia* crop. The growth and yield advantages under frequent irrigation/lower salt concentration in soil during initial growth stages by sea water dilution due to rain was also reported by Joshi and Iyenger (1982) and Keiffer *et al*. (1994). The yield advantage in delayed sowing was also reported by Sumrah *et al*. (2003) comparing different species of *salicornia* in their study where in they compared day light period under growth chamber condition. Similarly, Ventura *et al*. (2011) also reported early maturity induced due to exposure of plant to longer day length during initial growth stage of *salicornia* grown under south Israel condition. In the present study, while harvesting for fresh biomass (just before flower initiation) plants were kept for seed production. From the seeds oil content was determined. Significant differences with respect to oil content in seeds due to D, I and D x I effects were observed. Sowing of *salicornia* during 3rd week of June seems to be optimum time of sowing for getting higher oil content in seed. Similarly, higher level of irrigation resulted into more oil content in *salicornia* seed than less irrigation. Almost similar trend was observed for oil yield per hectare. Irrespective of treatments the mean oil content in *salicornia* seed is 25.72 per cent which is comparable with most of the oil seed crops grown in normal soil with irrigation facility and that too in salt affected land with sea water irrigation. Grattan *et al*, (2003) reported *salicornia*, which is one of the most salt tolerant of the vascular plants, is sold as a salad supplement in Europe and produces oil in its seed that is equal in quantity and quality to soybean oil. Further Tikhomirova *et al*. (2008) determined biochemical composition of the *Salicornia europaea* oil and found that plant lipids are characterized by a high unsaturation degree mainly due to alpha linolenic and linoleic acids. *Salicornia bigelovii* oil is similar to safflower oil in fatty acid composition (Glenn *et al*., 1991). This suggests that in coastal areas of South Gujarat *salicornia* has an excellent scope for salad as well as edible oil purposes.

Table 2: D x I effect on plant canopy (cm^2) of *salicornia*

D x I	I1	I2	I3	D-Mean
D1	45	65	108	72
D2	93	119	125	112
D3	99	93	115	103
I-Mean	79	92	116	
SEm±	7.10	CD at 5%	21	

Table 2: Effect of different treatments on fresh and dry biomass yield, seed yield and oil content

Treatment	Fresh biomass yield (t ha^{-1})	Dry biomass yield (t ha^{-1})	Seed yield (t ha^{-1})	Oil content (%)
Date of sowing				
D_1: 1st week of June	23.78	5.74	634	25.16
D_2: 3rd week of June	31.12	7.38	821	26.41
D_3: 1st week of July	34.24	7.10	839	25.58
SEm±	1.24	0.30	21.4	0.08
CD at 5%	4.28	1.05	74	0.27
CV%	14.41	15.61	9.67	1.07
Irrigation levels				
I_1 : 0.6 IW/CPE	22.15	5.63	613	24.71
I_2 : 0.8 IW/CPE	34.92	7.38	865	26.26
I_3 :1.0IW/CPE	32.08	7.20	816	26.19
SEm±	1.03	0.36	22.6	0.07
CD at 5%	3.07	1.06	67	0.20
CV%	12.05	18.34	10.25	0.92
D x I				
$D_1 I_1$	16.28	4.58	520	24.71
$D_1 I_2$	29.47	6.19	706	24.56
$D_1 I_3$	25.59	6.44	675	26.21
$D_2 I_1$	19.66	6.67	606	25.13
$D_2 I_2$	38.05	7.81	955	27.55
$D_2 I_3$	35.66	7.65	902	26.56
$D_3 I_1$	30.49	5.65	712	24.29
$D_3 I_2$	37.24	8.15	935	26.66
$D_3 I_3$	35.00	7.51	871	25.80
SEm±	1.79	0.62	39.2	0.12
CD at 5%	5.32	NS	NS	0.35

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