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Study of Yield and Yield Components of Exotic *Atriplex* and *Maireana* Species in the Saline Environment of NWFP

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Abstract: The performance of 12 species of *Atriplex* and 4 species of *Maireana* were tested on salty wasteland (saline-sodic) of Gandheri-Nowshera during February to June 1991. Plant height and canopy volume were measured at different intervals while replicate -wise soil salinity/sodicity upto 120 cm depth was assessed at 3 months interval. The site soil was saline-sodic, stratified river alluvium of medium to fine texture with a water table of 1.5 m. Soil salinity (ECe 6.4-65.6 dsm-1) and sodicity (SAR 14.3-63.9) declined with depth. There was more salt accumulation in soil profile during the month of May than in February sampling. Nitrogen and Phosphorus is deficient while Potassium is sufficient in the site soil. Maximum height was observed in *Atriplex lentiformis* (1081). While in *Maireana* species, *Maireana brevifolia* shows excellent performance. Maximum diameters and canopy volume were found in *Atriplex amnicola* (573) and *Atriplex amnicola* (971). On the basis of yield data maximum yield were noted in Atriplex amnicola (971). The relative performance of genotypes based on growth and yield were in descending order, Atriplex amnicola (971), *Atriplex amnicola* (573), *A. lentiformis* (1081), *A. amnicola* (949), *A. Cinerea* (524), *A. undulata* (471), *A. stocksii*, *A. bunburyana* (carnarvon), Maireana brevifolia, *A. amnicola* X *A. nummularia*, *A. spp. Pintheruka*, *A. bunburyana* (Leonora), *A. vesicaria*, *Maireana aphylla*, *Maireana polyptergia* and *Maireana amoena*. From this study we found that Atriplex amnicola and *Maireana brevifolia* were the more productive and best adapted species in the saline environment of NWFP.

Key words: Salt bushes, *Atriplex*, species, genotype, alluvium, adapted, saline environment, salinity, sodicity

Introduction

Forage, fuel production and the prevention of erosion on salt affected wasteland requires the establishment of suitable plant species. To elevate the problem, plants species capable of producing large amount of useful biomass must be introduced.

Khan (1990) reported that better growth in terms of plant height and canopy in *Atriplex lentiformis* and *Atriplex amnicola* while poor growth in *Atriplex vesicaria*, *Maireana pyrimidata*, *Atriplex stocksii* and *Maireana brevifolia*. He further noted that best adapted species producing higher grazeable biomass ranging from 840-1010 kg ha^{-1}/annum were *Atriplex amnicola*, *Atriplex lentiformis* and *Atriplex halimus*. Akbar (1991) found that salt addition progressively and significantly decreased plant height, canopy, fresh and dry yield in *Atriplex amnicola* (971), *Atriplex bunburyana* (Kalgoorlie), *Atriplex vesicaria*, *Atriplex lentiformis* and *Maireana pyrimidata*. He furhter observed that on yield basis *Atriplex amnicola* could be ranked the best one than other species. Sodium contents of the harvested plant materials increased significantly with increasing salinity levels. Potassium contents were reduced significantly with increasing salt levels. Malcolm (1990) reported that *Atriplex undulata* from Argentina is in widespread use on salt affected land in western Australia. *Atriplex undulata* is palatable to sheep and when used as an autumn reserve feed, provided about 900 sheep grazing days per hectare in a 300 mm rainfall zone. Iqbal (1990) observed that salt addition progressively and significantly increased plant height, diameter, fresh and dry yield upto 10 dsm^{-1} in *Atriplex halimus*, *Atriplex lentiformis*, *Atriplex amnicola*, *Atriplex undulata* and *Maireana brevifolia*. While higher salinity reduced plant height, diameter, fresh and dry yield over control. On relative yield basis *Atriplex lentiformis* and *Atriplex amnicola* could be ranked better than *Atriplex undulata*, *Atriplex halimus* and *Maireana brevifolia*. He also observed that sodium content increased manifold with salinity over control. Potassium content was reduced significantly under salt stressed condition.

This study was initiated to evaluate the potential for the use of *Atriplex* and *Maireana* species as forage crop and to investigate about the more productive species of *Atriplex* and *Maireana* for further recommendation to the farmers of NWFP.

Materials and Methods

The research study was conducted on the "Yield and yield components of exotic *Atriplex* and *Maireana* species in the saline environment of NWFP" in saline area of Gandheri, Nowshera. Growth of 12 species of *Atriplex* and 4 species of *Maireana* was monitored in a barren highly saline field. The data regarding plant survival, growth pattern (height and diameter) were collected with time-course, and the plants were harvested for grazeable biomass yield. Salinity and sodicity changes in soil with time-course were assessed.

During the month of October, the seeds of 12 species of Atriplex and 4 species of maireana were sown in plastic tubes filled with soil mixture, soil: humus: and sand (1:1:1) in glass house. The seedlings were hardened with saline water before transplanting. The seedlings of 4-8 cm height depending upon the species were transferred into plastic bags filled with the above soil mixture.

The seedlings were transplanted to the selected barren field (135 cm long and 28 cm wide) where ditches of about 50 cm wide and 25 cm deep were made by ditcher. The row to row and plant to plant distance was 4 m. The RCB design was used with 8 replications in a long array. The plants were fertilized with 50 gram Urea per plant. Soil samples were collected replicate-wise upto 120 cm depth twice during growth period. Soil samples depths were 0-5, 5-15, 15-30, 30-60, 60-90 and 90-120 cm. These samples were analysed and determined the texture of the site soil (Table 1a).

Table 1a: Profile texture[1/] of soil of experimental site

Soil depth (cm)	Replications							
	R1	R2	R3	R4	R5	R6	R7	R8
0-15	Scl	Sl	Sl	Sil	fSl	Scl	Sil	Sicl
15-30	Sicl	Sil	Sicl	Sicl	Sic	Scl	Scl	Scl
30-60	cl	fSl	Sl	lS	cl	lS	Sic	lS
60-90	Sil	Sic	fS	lS	lS	S	lS	S
90-120	fSl	vfSl	S	S	lS	S	S	S

Texture was determined by feel method.
Si = Silt, c = Clay, S = Sand, l = loam, vf = very fine.

Growth measurement: Plants canopy (length, width and height) of each plant were measured on monthly basis starting from March through June. Canopy volume was calculated with the following formula:

Canopy volume (m^3) = h x d1 x d2

where, h is height of standing shoot/branch, d1 and d2 are diameters of plants in length and breadth-wise.The plants were harvested in the mid of June for biomass yield.

Soil analysis: A composite soil sample was analysed for general physio-chemical properties. The replicate-wise samples upto 120 cm depth were collected twice during the growth period were analysed for salinity/sodicity status.
Electrical conductivity and pH of the saturated paste was measured directly by pH meter German type B-124 using glass and calomel electrodes. Soluble calcium + Magnesium were determined by titration with EDTA while Na^+ was determined by flame photometer Zn, Cu, Fe, and Mn in soil samples were determined by DTPA method (lindsay and Norvell, 1978). Organic matter was determined by Walkley and Black method (Black, 1965). Available phosphorus in the soil was determined by Olsen method using $NaHCo_3$ (Black, 1965). Lime was determined by Allison and Moddie acid neutralization method (Black, 1965).

Site characteristics: Soil profiles of the site are stratified with medium to finer materials overlied sandy/loamy sand subsoil strata. The soil is moderately calcareous with medium water intake. The soil is low in organic matter but contains sufficient available phosphorus and micronutrients (Table 1b).

Table 1b: Chemical properties of the soil of experimental site

Item	Units	Soil depth	
		0-15 cm	15-30 cm
$NaHCO_3$	mg kg^{-1}	20.2	26.8
Total N	%	0.046	0.040
Organic matter	%	0.92	0.85
Lime	%	10.6	12.0
NH_4OAC extractable K	mg kg^{-1}	140.00	155.00
DTPA extractable Zn	mg kg^{-1}	0.8	1.1
DTPA extractable Cu	mg kg^{-1}	2.8	2.7
DTPA extractable Mn	mg kg^{-1}	1.8	1.8
DTPA extractable Fe	mg kg^{-1}	4.4	4.3

Data were analysed statisticaly using new Duncan's Multiple Range Test (DMRT) for significance at 5% level of probability.

Results and Discussion

The growth of 12 species of *Atriplex* and 4 species of Maireana plant height, diameter and survival was studied in a barren salty field of the Province. At two intervals soil samples were analyzed for sodicity and salinity status.
Replication and depth-wise soil analysis of two intervals showed a lot of horizontal and vertical spatial variability in respect of ECe, pH and SAR (Table 2a). There was more salt accumulation in the month of may due to high evaporation and temperature in summer season. ECe and SAR decreased progressively with soil depth and minimum values were noted in the lowest depth i.e. 90-120 cm. However there were not much difference in soil pH with soil depth. The site soil could be classified as saline-sodic with high salt accumulation which proved to be wasteland for agricultural crop production.

Plant Height: There were highly significant differences among the species with respect to plant height for each data as shown in Table 3. Plant height was slow during the month of February which might be due to low winter temperature and roots establishment stage, but height increased tremendously upon harvesting. The maximum heights were noted in June. The tallest plants (77 cm) were obtained from Atriplex lentiformis (1081), followed by *A. bunburyana* (Carnarvon). *A. Spp. Pintheruka, M. brevifolia* and A. Amnicola x A. nummularia in decreasing order. A. stocksii, *A. vesicaria, M. polyptergia* and *M. amoena* remained short in size. Malcolm *et al.* (1988) noted that A.lentiformis (1081) remained tallest (erect) while most species were spreading in nature.

Crown diameter and canopy volume: Data in Table 5 shows that A.Amnicola and A. undulata could be ranked as prostrate, while the other species were either erect or bushy in nature.
Canopy volume increased logarithmically with growth period and maximum volumes were noted in the month of June, which might be due to optimum temperature for the growth of most species. Based on ranking of June growth data, higher canopy volumes were found in *A. amnicola* (971) *A. amnicola* (573), *A. cinerea* (524), *A. undulata* (471), *A. lentiformis* (1081), *A. amnicola* (949). Lower canopy volume were found in *A. vesicaria, M. aphylla, M. amoena, M. polyptergia*. Remaining species have intermediate canopy volumes as of above mentioned species. Similar higher canopy volumes *of A. lentiformis* and *A. amnicola* were noted by Khan (1990). Differences in growth habit of genotypes had also been reported by researchers (Khan 1990, Iqbal 1990, Akbar 1991 and Hyder *et al.*, 1987) in terms of plant diameters and canopy volumes.

Grazeable dry matter yield: Data given in Table 6 indicated that yield of grazeable biomass of salt bushes (*Atriplex* and *Maireana* species) was recorded in June 1991 were significantly difference in the yield of high yielding species, but non-significant among themselves. Species like *A. amnicola* (971), *A. amnicola* (573), *A. lentiformis* (1081) and *A. amnicola* (949) showed excellent performance

Table 2a: Salinity/sodicity status of soil of experimental site

Property	Units	1st sampling (20/2/91) Soil depths (cm)				
		0-15	15-30	30-60	60-90	90-120
ECe	dSm^{-1}	26.4±5.2	22.9±4.9	13.6±4.1	9.3±5.5	6.4±1.9
pHs	--	8.3±0.1	8.3±0.2	8.2±0.2	8.2±0.2	8.3±0.2
SAR (m mol 1^{-1})		40.9±31.5	37.7±27.7	28.1±13.4	18.8±10.6	14.3±6.9

Table 2b: Salinity/sodicity status of soil of experimental site

Property	Units	2nd sampling (20/5/91) Soil depths (cm)					
		0-5	0-15	15-30	30-60	60-90	90-120
Ece	dSm^{-1}	65.6±19.8	39.8±9.0	30.1±8.7	20.1±9.1	9.9±2.4	8.9±1.5
pHs	--	8.4±0.2	8.7±0.3	8.5±0.3	8.6±0.2	8.7±0.2	8.6±0.2
SAR (m mol 1^{-1})		63.9±59.5	29.9±20.8	23.3±13.1	18.3±14.6	17.1±13.5	18.6±5.6

Values given are means ± standard deviations.

Table 3: Height of plants of Atriplex and Maireana species with time-course grown in saline field

Species	Dates				Centimeter
	5/3/91	5/4/91	5/5/91	5/6/91	Ranking
A.amnicola (573)	13.7±2.9 ab	19.9±5.0 cd	28.6±6.1 ef	41.3±12.5 d-g	9
A.amnicola (971)	11.4±2.7 abc	23.8±5.7 bc	34.8±8.6 b-e	47.0±2.3 bcd	6
A.amnicola (949)	11.3±1.0 abc	20.6±3.3 bcd	30.1±6.2 def	43.1±5.3 cde	8
A.amnicola x A.nummularia	9.8±2.1 bcd	19.5±4.7 cd	40.5±7.9 b	54.1±7.2 bc	5
A.lentiformis (1081)	13.5±2.4 ab	29.7±8.3 a	55.9±9.9 a	77.1±24.1 a	1
A.cinerea (524)	12.2±2.4 abc	17.9±6.3 cde	28.8±10.6 ef	33.0±5.8 efg	11
A.undulata (471)	10.3±4.2 bcd	22.4±5.7 bc	36.4±7.9 b-e	44.6±8.6 b-e	7
A.bunburyana (Carnarvon)	14.5±1.6 a	26.7±4.8 ab	41.0±6.2 b	56.8±9.5 b	2
A.bunburyana (Leonora)	12.7±3.4 abc	21.1±5.1 bcd	32.0±8.4 c-f	40.3±7.7 def	10
A.vesicaria	8.6±3.1 bcd	13.2±2.2 efg	18.6±2.9 gh	20.4±5.9 hi	15
A.Spp. Pintheruka	11.8±2.8 abc	23.0±4.4 bc	40.0±4.3 bc	55.8±11.0 b	3
A.stocksii	7.4±1.1 cd	16.0±3.5 de	28.3±4.9 ef	30.8±7.2 fgh	12
M.brevifolia	9.9±2.6 bcd	31.3±7.0 bcd	38.1±10.5 bcd	54.3±8.1 bc	4
M.polyptergia	7.3±3.8 cd	11.1±4.1 fg	15.4±5.1 gh	19.8±5.2 hi	16
M.aphylla	9.9±2.4 bcd	15.2±2.1 def	23.4±2.7 fg	27.6±8.3 ghi	14
M.amoena	5.2±1.9 d	13.2±3.4 g	21.8±4.1 h	28.8±8.5 i	13

Values are means ± standard deviations of height data (cm). Mean values followed by same letters in each column are non-significant from each other at 5% level of probability.

Table 4: Diameters of plants of Atriplex and Maireana species grown in saline field

Species	Dates						Centimeter
	5/4/91		5/5/91		5/6/91		
	D1	D2	D1	D2	D1	D2	Ranking
A.amnicola (573)	49±17.4	41±17.1	85±23.7	70±17.4	145±35.9	130±35.4	3,1
A.amnicola (971)	55±15.1	48±3.6	86±20.1	63±24.5	162±41.4	123±30.1	2,3
A.amnicola (949)	34±6.7	29±7.1	60±12.4	47±10.1	113±21.9	96±19.2	5,5
A.amnicola x A.nummularia	24±6.4	18±5.8	42±11.9	34±9.7	84±18.9	71±18.8	8,9
A.lentiformis (1081)	23±4.5	19±2.0	36±7.4	32±6.2	95±6.3	83±10.8	6,6
A.cinerea (524)	41±16.2	34±16.5	79±24.8	50±21.5	176±54.1	126±52.3	1,2
A.undulata (471)	29±10.7	26±9.9	55±16.2	45±13.9	131±38.3	101±23.2	4,4
A.bunburyana (Carnarvon)	22±5.9	18±9.2	32±10.2	25±6.3	65±19.7	53±18.8	12,12
A.bunburyana (Leonora)	22±5.1	18±5.5	34±10.6	27±7.8	64±24.9	49±13.5	13,13
A.vesicaria	36±9.6	33±9.4	55±6.9	52±6.1	79±28.7	73±27.0	9,8
A.Spp. Pintheruka	21±5.6	17±5.9	34±5.9	28±6.7	73±22.1	60±13.9	10,10
A.stocksii	23±5.8	19±5.8	40±6.6	36±5.9	82±6.2	74±6.9	7,7
M.brevifolia	18±5.9	17±5.2	35±9.3	29±9.1	65±16.8	55±13.1	11,11
M.polyptergia	9±4.3	7±2.7	13±7.3	10±4.8	21±10.4	19±10.6	16,16
M.aphylla	14±3.7	10±2.6	18±5.4	15±4.9	38±18.3	29±12.9	14,14
M.amoena	11±3.9	11±3.8	19±5.5	18±5.8	31±9.8	28±9.9	15,15

D1 = Length-wise diameter. D2 = Width-wise diameter

Values are means + standard deviations of diameters (cm).

Table 5: Canopy volume of Atriplex and Maireana species with time-course grown in saline field

Species	Dates			
	5/4/91	5/5/91	5/6/91	dm^{-3} Ranking
A.amnicola (573)	51 ± 38 b	239 ± 166a	906 ± 499 abc	2
A.amnicola (971)	69 ± 37 a	220 ± 102 a	979 ± 424 a	1
A.amnicola (949)	22 ± 11 cde	91 ± 46 bc	502 ± 241 cde	6
A.amnicola x *A.nummularia*	10 ± 7 fgh	65 ± 39 bc	354 ± 187 def	7
A.lentiformis (1081)	13 ± 5 e-h	69 ± 34 bc	630 ± 285 bcd	4
A.cinerea (524)	28 ± 19 c	115 ± 60 bc	808 ± 433 ab	3
A.undulata (471)	20 ± 14 c-f	99 ± 74 bc	614 ± 353 bcd	5
A.bunburyana (Carnarvon)	11 ± 5 cd	36 ± 18 bc	218 ± 138 efg	9
A.bunburyana (Leonora)	9 ± 4 gh	32 ± 16 bc	138 ± 79 efg	13
A.vesicaria	17 ± 8 d-g	55 ± 21 bc	145 ± 84 fg	12
A.Spp. Pintheruka	9 ± 5 gh	40 ± 19 bc	252 ± 119 efg	8
A.stocksii	8 ± 4 gh	41 ± 16 b	187 ± 47 fg	11
M.brevifolia	8 ± 5 gh	44 ± 28 bc	207 ± 118 efg	10
M.polyptergia	1 ± 1 h	3 ± 4 c	12 ± 15 g	16
M.aphylla	2 ± 9 h	7 ± 3 c	37 ± 27 fg	14
M.amoena	2 ± 1 h	8 ± 4 c	31 ± 24 g	15

Values are given are means of Canopy ± Values are standard deviations (dm^{-3}).
Mean values followed by same letters in each column are statistically non-significant from each other at 5% level of probability.

Table 6: Grazeable biomass yield of Atriplex and Maireana species grown in saline field

Species	Biomass yield	
	$g\ p^{-1}$	Ranking
A.amnicola (573)	959 ± 344 ab	2
A.amnicola (971)	991 ± 243 a	1
A.amnicola (949)	716 ± 286 abc	4
A.amnicola x *A.nummularia*	624 ± 255 bc	7
A.lentiformis (1081)	829 ± 267 ab	3
A.cinerea (524)	671 ± 239 bc	5
A.undulata (471)	644 ± 354 bc	6
A.bunburyana (Carnarvon)	506 ± 260 cd	8
A.bunburyana (Leonora)	254 ± 144 def	12
A.vesicaria	174 ± 124 ef	13
A.Spp. Pintheruka	418 ± 221 cde	10
A.stocksii	309 ± 194 def	11
M.brevifolia	443 ± 268 cde	9
M.polyptergia	76 ± 60 f	15
M.aphylla	79 ± 52 f	14
M.amoena	59 ± 34 f	16

1. Values given are means of yield and ± values are standard deviations.
2. Means values followed by the same letters are statistically non-significant among themselves at 5% level of probability.

undulata (471), *A. amnicola* x *A. nummularia* and *A. bunburyana* (carnarvon)species also showed good performance, while poor performance was observed in Maireana species.

It is concluded from the growth and yield data of salt bushes that the species like Atriplex amnicola (971), A. amnicola (573), *A. amnicola* (949), *A. lentiformis* (1081) and *A. cinerea* showed encouraging performance and higher yield in the saline enviroment of NWFP. Many research workers such as Mozafar *et al.* (1970), Wallace *et al.* (1982), Soufi and Wallace (1982), and Brownell (1964) carried research on different salt tolerant bushes and found that different *Atriplex* species like *A. nummularia*, *A. vesicaria*, *A. halimus* and *A. canescens* showed good results and higher yield when grown in saline soil.

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