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SOIL SALINITY IMPACT ON WATER AND NITROGEN UPTAKE BY CASUARINA EQUISETIFOLIA AND ALBIZIA LEBBEK

REPORT ON RESEARCHES CARRIED OUT FROM APRIL 1987 TO JUN 1988

By

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1. INTRODUCTION

Reclamation of salt-affected soils, in order to increase agricultural production. requires good understanding of main phenomena that may occur in the field.

The low soil fertility (nitrogen and phosphorus) and the high osmotic potential duo to the salt concentration are the main difficulties of saline soils reclamation. Because of these factors , plants cannot uptake enough nutrients from the soil even they are available.

Researches on the principles salt and water dynamics into soil cari help to crops yields improvment. in that case some researches have been carried out in laboratory and the field. Its concer mainly selection of salt tolerant foret trees, water balance under plantation, salt-affected soils afforestution and salt tolerant Rhizobium ând Frankia strains selection.

Using high salt tolerant trees should likely to bu important way of salt-affected soils reclamation. Microbiological and nuclear tecnnics should give great help to improve plant adaptation and growth mecanisms in saline soils.

2.RESEARCHES PLANED FOR THE TWO FIRST YEARS

Durring the periode, from january 1987 to january 1989, works hereaftar designated were carried out:

- Studies of trees salt tolerance: greenhouse and field experiments:
- Frankia and Rhizobium strains isolation:
- Selecting high nitroyen-fixing and salt tolerant strains;
- Nitrogen fixation potential in saline conditions;
- Water balance study;
- Soil salinity changing under forest plantation;
- Saline soils afforestation;
- Ecophysiology studies: sap potential mesurments.

Most Gf theses studies started during the first year. While others are just started.

3.FOREST TREES SALT TOLERANCE STUDIES

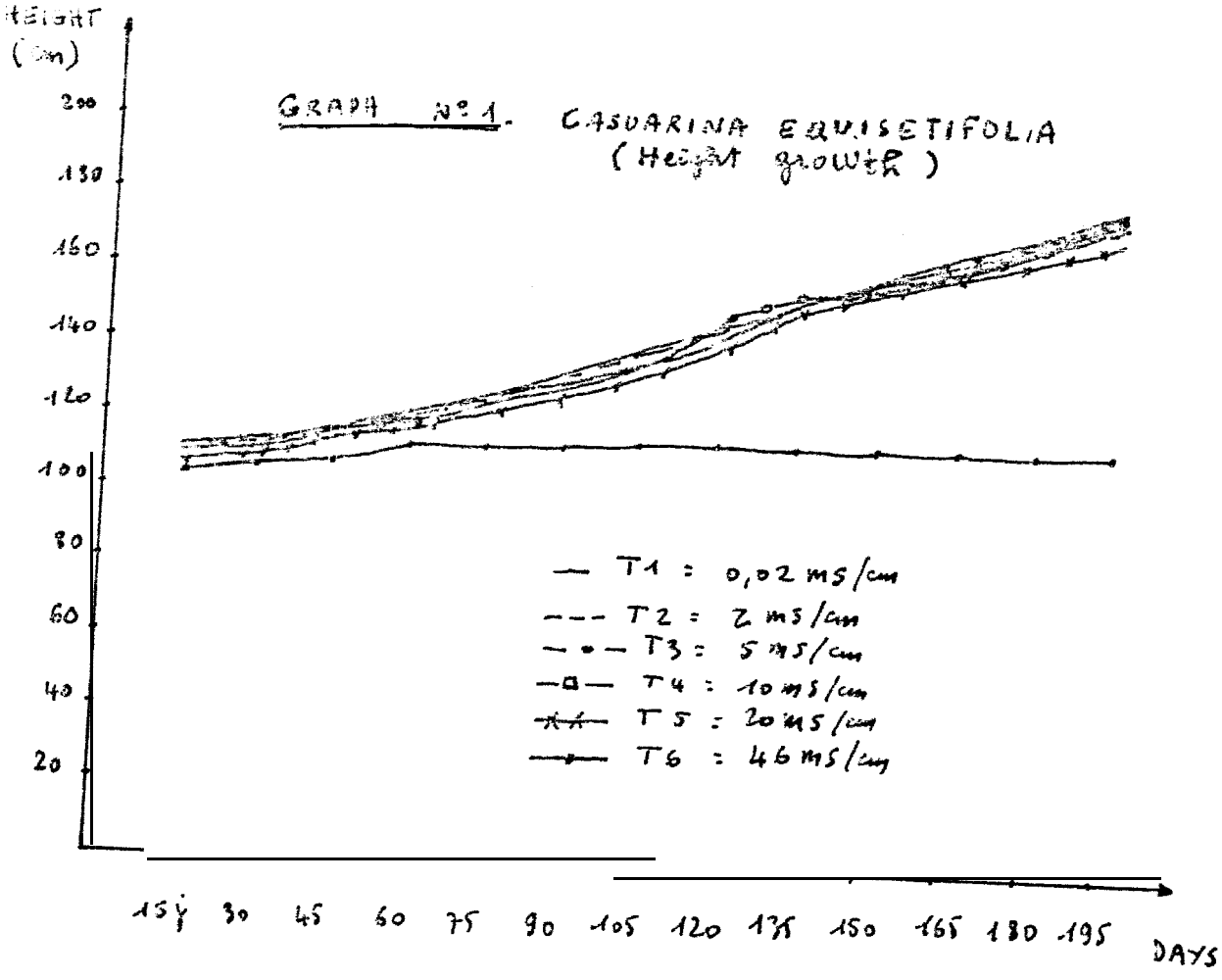
3.1.PRELIMINARY STUDIES

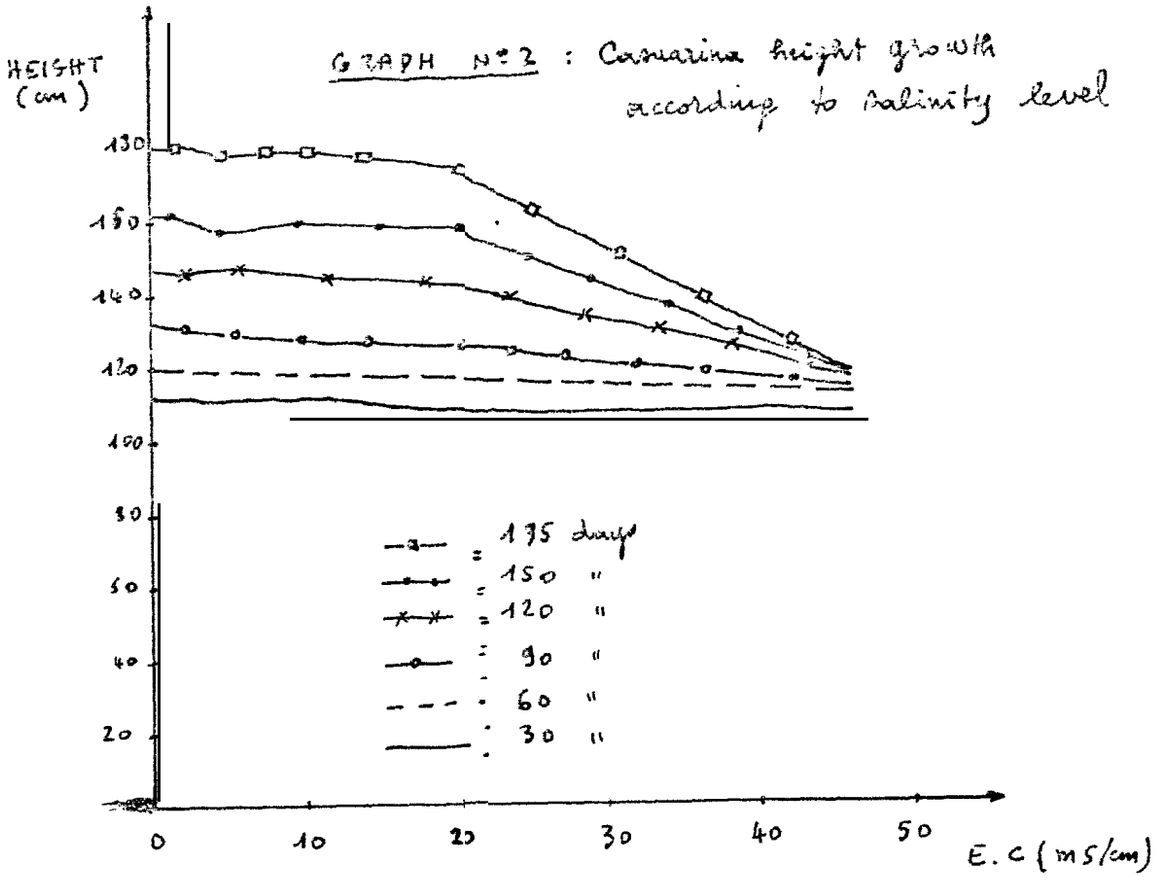
Forest trees salt tolerance studies have started in 1985 with experiences using watering system with saline water in greenhouse. The results showed high resistance level of some species as Casuarina equisetifolia, Melaleuca leucadendron, M.leucadendron and Prosopis juliflora; while others as Eucalyptus camaldulensis and Albizia lebbek are sensitive:. The most tolerant can grow well until an electrical conductivity of 35ms-/cm and the sentive species died at an electrical conductivity more than 20ms/cm.

Graphics 1 and 2 show growth of Casuarina equisetifolia according to salinity level.

In order to transfer laboratory results into field some plantation trials have been done in situ with different kinds of species on two types of saline soils:

- Sandy soil : electrical conductivity = 1.0-3.0ms/cm;
- Sand loamy soil: electrical conductivity < 1.5ms/cm;


HEIGHT
(cm)
200
180
160
140
120
100
80
60
40
20
GRAPH Nº 1. CASUARINA EQUISETIFOLIA
(Height growth)
— T1 : 0,02 mS/cm
--- T2 : 2 mS/cm
— • — T3 : 5 mS/cm
—□— T4 : 10 mS/cm
—x— T5 : 20 mS/cm
—▸— T6 : 46 mS/cm
15 30 45 60 75 90 105 120 135 150 165 180 195
DAYS


GRAPH N°2 : Casuarina height growth according to salinity level
HEIGHT (cm)
130
150
140
120
100
80
60
40
20
0
10
20
30
40
50
E.C (mS/cm)
= 175 days
= 150 "
= 120 "
= 90 "
= 60 "
= 30 "

- Sand loamy soil: electrical conductivity = 1.0-2.5ms/cm;
- Clayed soil : electrical conductiviry <1. 5ms/cm;
- Clayed soil : electrical conductivity = 1 . 5-4ms/cm.

These soils are locared in two different sites; one near Sine river which has sandy soil with thre salinity levels and the other one near smali crick of Saloum river with others types of soils.

Results obtained from these trials correspond to those from greenhouse experiences. Casuarina is more resistant than Albizia which is very sensitive up to 2ms/cm of soil electrical conductivity. The mean heighr of Casuarina, 2 years after plantation, is 350cm in sandy soil at E.C < 2.5ms/cm and 270cm at E.C<4ms/cm and 240cm at E.C>4ms/cm in clayed soil.

3.2.SEED GERMINATION TESTS QN SALINE CONDITIONS

Knowinq salt influence on forest trees seeds germination, expriences suing two types of substrats (hydrophylle cotton and Sand loamy soil) are done in the laboratory with four species trees seeds: Casuarina equisetifolia, Eucalyp tus microtheca, Melaleuca leucadendron and M. acacioides.

3.2.1.SEEDS GERMINATION ON HYDROPHYLLE COTTON

3.2.1.1.Experience methodology

Hydrophylle cotton is used as saedbed, layed on plastic bowls on which 1g of forest trees szeds are puted on. The cotton was wet ted with water of three treatments: fresh water (E.C<0.02 ms/cm), saline water with E.C = 2ms/cm und saline water with E.C = 5ms/cm.

During the all exprience period, the cotton was wetted dealy with the different solutions by injection with seringue (10ml). Experience took 14 days in laboratory inside atuve at temperature of 25oc.

3.2.1.2.Results

Three days after experience started, germination was observed in all bowls. Mildew was also observed ten days after on Eucalyptus and Casuarina in all treatments and on Melaleuca acacioides only in treatment with fresh water.

Table 1 below shows the quantity per gramme of seeds germinated 14 days after.

Table 1 : Germinated seeds per 1g after 14 days.

SPECIES	TREATMENT To E.C<.02ms/cm	TREATMENT T1 E.C=2ms/cm	TREATMENT T2 E.C=5ms/cm
Casuarina equisetifolia	209	240	172
Eucalyptus microtheca	531	569	573
Melaeluca viridiflora	866	898	940
Melaleuca acacioides	698	986	906

We can see from this table variation of seeds germination accordiny to treatments and species.

In general case the results show that germination is bat-ter

with saline water than with fresh water.

Comparison between treatment To and others shows:

- Casuarina gives its test germination in treatment T1 with 14.84% more. It decreases at T2 with 17.70% less.
- Eucalyptus microtheca grows well in T1 and T2 without no sigcificant differencs between both, with respectively 7.16% and 7.34% more.
- Melaleuca viridiflora. gives its best results in T2 with 6.1% more than in To.
- Melaleuca acacioides gives irs bast results in T1 with 41.20% more than in To and decreases in T2.

This means for all species seeds germination increases with salt solution concentration unntil a certain level at which it decreases again. Presence of sal-t in the solution must stimulate seeds germination up to a certain level of salinity depending on specy .

3.2.2.SEEDS GERMINATION ON SOIL SUBSTRAT

3.2.2.1.Experience methodology

Forest trees seeds germinating was experimented also with soil as bedseed. The soil which has been uscd was a sand loamy soil containing less 15% of clay and about 1% of organic carbon.

Six germination boxes were fildad with this soi l on which seeds of Casuarina equisetifolia, Eucalyptus microtheca, Melaleuca leucadendron and M. acacioidaa are sowed. Each germination box is about 50cm wide and 100cm long.

According to specy, different quantifies of seeds were used: 3g for Casuarina, 2g for Eucalyptus and 0.5g for Melaleuca.

Three treatments were applied for watering: fresh water(To) with E.C<0.02ms/cm, saline water(T1) with E.C=2ms/cm and T2 with E.C=5ms/cm(20oC). Water was applied twice per day at 7 o'clock in the marning and 5 o'oclock p.m by spraying with handling spray.

During the ail period of experience, died germinated seeds were daily calculated. Total germinated seeds were calculated at the end of the experience.

3.2.2.2.Results

Five days after experience started, Eucalyptus seeds started to germinate at To and T1. C. eqquisetifolia and M. acacioides gerninated 3 days later at To and T1, while M. viridiflora germinated at To 8 days and at T1 11 days later. With T2 only E. microtheca and C. equisetifolia germinated, respectively, 9 and 10 dnys later. Melaleuca didn't germinate at this salinity.

Table 2 below shows amounts of sceds germinated 75 days after according traatments.

Table 2 : Number of seeds germinated 75 duys after according water salinity.

SPECIES	TREATMENT To E.C<.02ms/cm	TREATMENT T1 E.C=2ms/cm	TREATMENT T2 E.C=5ms/cm
C. eyuisetifolia	835	594	137
E. microtheca	270	326	36
M. viridiflora	884	63	0

M. acacioides	436	280	1

Results shown by this table gives a tendancy of germinated seeds number to decrease when the water salinity is increasing. Excepting E. microtheca, the best results are obtained with To. Treatment T2 shows a great sensibility of E. microtheca and Melaleuca to high salinity level. This means that these species cannot germinate in a medium which has an electrical conductivity more than 2ms/cm.

During experience period, mortality has been observed on some species according to treatments. Table 3 below shows variation of germinated seeds mortality.

Table 3:Germinated seeds died number variation with time according treatments.

SPECIES	TREATMENT To E.C<.02ms/cm				TREATMENT T1 E.C=2ms/cm				TREATMENT T2 E.C=5ms/cm			
	17/6	28/6	5/7	22/7	17/6	28/6	5/7	22/7	17/6	28/6	5/7	22/7
C.equi.	0	0	0	0	0	10	4	7	49	12	14	12
E.micro.	0	0	0	8	71	44	16	2	30	.0	.0	.0
M.virid.	5	.0	.0	.0	13	.0	.0	.0	.0	.0	.0	.0
M.acaci.	6	.0	.0	.0	4	.0	.0	.0	1	.0	.0	.0

3.2.3.DISCUSSIONS

Results obtained from these two experiencies show that forest trees seeds can be germinated by using saline water as watering solution. Seeds can grow well until a certain salinity level up to which germination ratio comparinng with reference solution is not suitable.

Seeds germination depends on the substrat used as it has been shown with hydrolophylle cotton and soil. Soil substrat gives normal tendancy of seeds germination if we consider salinity as limiting factor of trocs grcwth. Difference observed between hydrophylle cotton and soi.1 might be the fact of salt accumulation into soil due to evaporation because the temperature outside is about 340C during experience period. Then with same solution the salt content is higher into soil than in hydrophylle cotton.

3.3.SALINE SOILS AFFORESTATION

3.3.1.EXPERIENCE METHODOLOGY

In order to understand better salinity effect on forest trees growth, trials of forest plantations were carried out in the field. Several forest spccias were used as C. equisetifolia, C. glauca, C. cuninghamiana, P. juliflora, P. chilensis, E. microtheca, M. viridiflosa and M. acacioides. According to our first results showing bad growth of A. lebbek, this specy was not used for these trials, because such other factors like climat or soi.1 physical properties have great on its growth.

Small plants of these species were introduced on different types of soil with different salinity level:

- Bloc 1: Sandy soil: E.C = 0.5-1.5ms/cm(20oC) of diluted extract (1/5);
- bloc 2: Loam sandy soil: E.C = 1.0-2.0ms/cm(20oC);

- Bloc 3: Clay sandy soil: E.C = 2.0-3.0ms/cm(20oC);
- Bloc 4: Clay sandy soil: E.C = 2.0-5.0ms/cm(20oC);
- Bloc 5: Clay sandy soil: E.C > 5ms/cm(20oC).

Randomized complete bloc design was used without any replicate. Each type of soil is considered as a bloc. Each bloc contains 8 small plots representing the species with 25 plants per specy. Plantation was done in august 1987.

The studies consisted to growth evolution with time by taking some measurements of height each three months and to estimate monthly death ratio according to salinity level.

3.3.2.RESULTS

Between August 1987 and Jun 1988 measurements of plants height were taken. Mortality ratio was also calculated. Table 4 below shows results obtained from this experiment 11 months after.

Table 4 : Percentage of plants surviving after 11 months on different types of soils.

SPECIES	BLOC 1		BLOC 2		BLOC 3		BLOC 4		BLOC 5	
	12/87	5/88	12/87	5/88	12/87	5/88	12/87	5/88	12/87	5/88
C.equi.	100%	96%	100%	88%	40%	.0%	24%	.0%	24%	.0%
C.glauca	100%	90%	92%	80%	16%	.0%	4%	.0%	4%	.0%
C.cunin.	100%	100%	44%	36%	36%	.0%	20%	.0%	76%	.0%
E.micro.	-	-	12%	8%	16%	4%	12%	4%	12%	.0%
P.julif.	100%	96%	36%	28%	32%	20%	24%	12%	4%	.0%
P.chilen.	100%	96%	44%	32%	40%	36%	36%	16%	16%	.0%
M.viridi.	100%	96%	16%	12%	16%	.0%	.0%	.0%	.0%	.0%
M.acacio.	100%	100%	92%	80%	80%	72%	52%	.0%	12%	.0%

Results show that plants survival ratio decreases with soil salinity level with time. Up to 2ms/cm species show big difference between them. Some of them as Casuarina, Prosopis and M. acacioides are rather salt tolerant. No specy survives in bloc 5 at the end of the dry season, because electrical conductivity is higher than their salinity tolerant level.

3.4.NITROGEN FERTILIZER USE INFLUENCE ON SALT TOLERANCE BY FOREST TREES.

3.4.1. OBJECTIVEF

The main objectives are to know what is nitrogen influence on salt tolerance by forest trees. Nitrogen fertility is one of the important problems that make salt-affected lands reclamation more difficult.

3.4.2.EXPERIENCE METHODOLOGY

Understanding nitrogen influence on salt tolerance by forest trees, experience using pots of 1m3 capacity as soil containers has been carried out in greenhouse during four months, from March to July 1988. C. equisetifolia and P. juliflora were used.

Five treatments were applied with four replicates. One pot

represent one replicate.

- Treatment To : without nitrogen fertilizer;
- Treatment T1 : 5g of Urea per pot of 1m3;
- Treatment T2 : 10g of Urea per pot of 1m3;
- Treatment T3 : 15g of Urea per pot of 1m3;
- Treatment T4 : 20g of Urea per pot- of 1m3.

Watering solution was saline water with an electrical conductivity of 30ms/cm(20oC). Each plant or pot was watered with 21 once per week.

Measurements of height and phenological observations have been every week. Leaves and small branches are hash for being analysed for minerals determination.

3.4.3.RESULTS

Three weeks after experience started, all C3suariri.a plants died in all treatments with nitrogen. Prosopis showed some symptomatical aspects as leaves fall and yellowing, tut became normal 2 weeks later. During all experience period Prosopis gived good development.

The growth is better in T3 with 2.75 cm more than the reference. It decreases in T4. This means that nitrogen presence stimulâtes plants growth in saline conditions until a certain salinity level up to that it hus no influence on its tolerance. The limit amount seems to he 15g per plants in 1m3 of soil.

According to that appened with Casuarina, it means that nitrogen fertilizer using in saline conditions increases the salinity effects on plants growth. The mortality observed is mainly due to nitrogen addition into soil, because as it was shown in our preliminary studies C. equisetifolia is one of the most resistant forest trees. Without nitrogen it grows well at a salinity of 30ms/cm of electrical conductivity. Chemical components analysis on leaves or branches may gives an anser of the question.

Table 5 below yives leaves, root and branches weight according to treatments.

Table 5: boles, leaves, roots and branches fresh and dry matter weigth of P. juliflora according to treatments.

Plants	To	T1	T2	T3	T4
Dry aerian matter	30.7%	36.62	33.3%	34.6%	34.9%
Fresh leaves	21.2%	21.2%	29.39	22.2%	19.9%
Fresh boles	45.0%	49.4%	50.4%	57.8%	53.7%
Fresh roots	35.2:	31.6%	28.4%	24.0'0	21.7%

Dry matter weight increases with nitrogen amount addtd into soil. Treatments T2, T3 and T4 are not different. Treatment T1 gives the best weight. This means that nitrogen uptake is more important if the amount of the fertilizer used is not exceeding Jg.

The fresh leaves are more important weight in T2. It decreases in T3 and T4. This means that up to 10g the fertilizer amount used has an inverse effect on nitrogen uptake in saline conditions.

Fresh tiges weight increasas with the fertilizer amount up to 15g from which it decreases. Treatment T3 used to he the limiting level of nitrogen fertilizer using in saline conditions with

30ms/cm of electrical conductivity.

Fresh root weight gives inverse results. It decreases when fertilizer amount increases. This that root system development is affected by nitrogen avai labiiity into soil.

4.FRANKIA AND RHIZOBIUM STRAINS ISOLATION

4.1.METHODOLOGY

This study consist to isolate from soil Frankia strains which have high nirrogen potential fixation and salt tolerant. Saline soil samples were taken from field under forest plantation. Soil salinity was about 1ms/cm in extract of 1/5.

The samples are divided into 4 parts. Small ceramic pots are used as soil conraincrs. Samples were sterilized before they have been used. Four treatmenrs are applied:

- 1/4 saline soil + 3/4 non saline soil;
- 1/2 saline soi.1 + 1/2 non saline soil;
- 3/4 saline soil + 1/4 non saline soil;
- 4/4 saline soil.

Casuarina seeds aïe sowed in each pot with four replicates per treatment.

4.2.RESULTS

Germinated seeds decrease when proportion of saiim soil used is high. The best gremination was observed in treatment T1 and T2. Germination ratio is in T3 40-50% and in T4 only about 20%. None of the plants which gat developped by this experience didn't nodulate, then no strain couldn't be isolated.

Rhizobium strains isolation gives same results. Germination was observed only in T1 three weeks after.

In order to find out what is rhe main problem other experiences have been started lacer on.

5.WATER BALANCE STUDIES UNDER FOREST TREES

Having good knowledge on water availability and uptake under forest plantation, water balance measurements studies have been carriecl out in laboratory and in field.

5.1.GREENHOUSE EXPERIENCE

5.1.1.METHODOLOGY

Water balance measurements were taken under Casuarina, Prosopis and Melaleuca trees of one yeav old. Trees were planted in small lysimeter of 4m3 of surface. Six plots were used of whoum each one contains 4 plants.

Small neutron access tubes were inserted into soil on each plot to a depth of 120cm.

Once per week the trees were watered with saline water at 30ms/cm and fresh water. For each specy three plots were watered with saline water and three others with fresh water.

Experience startad on November 1987 and ended on March 1988.

5.1.2.RESULTS

Table 6 below gives water balance changing under Casuarina, Melaleuca and Prosopis plants.

Table 6: Water balance changing between 14/12/87 and 03/02/88 under Casuarina, Melaleuca and Prosopis in saline conditions.

DEPTH	SPECIES		14/12/87	19/01/88	29/01/88	03/02/88
0-15cm	C.equiset.		14.1%	12.4%	12.0%	11.8%
			10.1%	8.2%	8.2%	7.6%
	M.leucad.	1/	14.8%	11.4%	11.1%	10.4%
		2/	13.7%	12.9%	12.3%	12.2%
	P.julif.	1/	12.6%	9.4%	8.1%	6.8%
		2/	12.3%	10.1%	10.0%	9.5%
15-30cm	C.equiset.	1/	18.5%	17.9%	17.5%	17.1%
		2/	14.5%	13.1%	12.8%	12.2%
	M.leucad.	1/	17.4%	14.9%	14.7%	13.5%
		2/	18.3%	17.1%	16.5%	16.2%
	P.julif.	1/	17.6%	14.3%	13.6%	12.7%
		2/	14.8%	12.7%	12.2%	11.7%
30-45cm	C.equiset.	1/	19.2%	19.2%	18.6%	18.4%
		2/	16.6%	14%	13.7%	13.2%
	M.leucad.	1/	18.3%	16.5%	16.2%	15.3%
		2/	19.3%	18.6%	18.0%	17.7%
	P.julif.	1/	18.5%	16.5%	15.6%	14.9%
		2/	15.8%	13.0%	12.7%	12.4%
45-60cm	C.equiset.	1/	20.0%	19.6%	18.8%	18.7%
		2/	17.2%	13.6%	13.3%	13.2%
	M.leucad.	1/	19.0%	16.8%	16.4%	15.6%
		2/	19.9%	19.9%	19.0%	18.9%
	P.julif.	1/	18.8%	16.8%	16.5%	16.5%
		2/	16.0%	13.8%	13.0%	12.9%

1/ : Reference plot watered with fresh water.
2/ : Plot watered with saline water at 30ms/cm.

Results above show that water content changes with time and depth. It decreases under Casuarina trees with 0.3-1.4% in plot watered with fresh water and 2.3-4.0% in saline plots; under Melaleuca it decreases with 3.6-4.3% in plots watered with fresh water and 0.9-3.9% in plots watered with saline water; under Prosopis it decreases also with 3.6-5.6% and 2.8-3.4% respectively.

Water content decreases also with soil depth, from top to down part. Below 45cm depth water content doesn't change to much with time. This means that plants roots have no important influence in this zone.

Difference between species means that their water uptake depends on the specy needs. Casuarina water uptake is less than for Prosopis.

5.2.WATER BALANCE MEASUREMENTS IN FIELD

In field conditions water balance has been measured under forest trees plantation. Two plots were chosen: sandy soil with E.C=0.5-1.5ms/cm and clay sandy soil with E.C=1.5-3.0ms/cm.

Access tubes were inserted into soil near plant roots.

First results showed chat water content changing within soil profil depends on the spccy used and the soi.1 type. ater content remains usualy higher in clayed soil than in sandy soil. The soil water content changing is due to trees uptake and evaporation by capillary rising.

6.GENERAL CONCLUSION

Results obtuined from all these experiences show important interests to continue studies on salt-affected soils to make them more fertile.

To understand better salt influence mecanisms on forest trees manystudies have to be carriad out again in different ways as physiology, soil chemic and physic.

Main results of all experiences which ended will be published separa tly.

REFERENCES

1.Sadio S., 1986: Etude pédologique des facteurs de mortalité des essences forestières introduites en milieux salés au Sénégal. orstom, Dakar , mars 1986,66p+33p annexes.

2.Sadio S., 1985: Recherches sur la tolerance aux sels des essences forestières. Rapport d'activités, orstom/Dakar,18p.

3.Dafni A. and Negbi I.,1978: Variability in prosopis farcta in Israel: seeds germination as affected by temperature and salinity. Israel journal of botany, 27, 3/4, pp.147-159.