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Research Article

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Microsymbiont enhances survival of teak seedlings and nutrient status of soils under saline soils

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ABSTRACT : Seedlings of teak were planted under different salinity levels *viz.,* normal soil (<4 ECe soil), saline soil (4-8 Ece) and highly saline soil (8-12 ECe) and seedlings were inoculated with *Azetobactor* + vesicular-arbuscular mycorrhizal (VAM) fungi, *Azospirillium* + vesicular-arbuscular mycorrhizal (VAM) fungi and combination of all three. Experiment repeated for two years and data recorded at the end of each experiment on nutrient satus of soil pH, ECe N, P, K, Ca, Mg, Na, micronutrient (Fe, Zn, Mn and Cu) and survival per cent of seedlings. Triple inoculation (*Azetobactor*+*Azospirillium*+VAM) significantly influenced on the nutrient status of soil and survival per cent of teak seedlings as compared to uninoculated seedlings under salt condition. Which was followed by dual inoculation of *Azospirillium* and VAM.

KEY WORDS : Microsymbiont, Salinity levels, Nutrient status of soil, Survival per cent

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INTRODUCTION

Teak is the common name for the tropical hardwood tree species *Tectona grandis* Tectona grandis is native to South and southeast Asia, mainly India, Indonesia, Malaysia and Myanmar, but is naturalized and cultivated in many countries, including those in Africa and the Caribea. Myanmar accounts for nearly one third of the world's total teak production. Salinity is a general term used to describe the presence of elevated levels of different salts such as sodium chloride, magnesium and calcium sulphates and bicarbonates in soil and water (Ouda *et al.,* 2008). The beneficial effect of microsymbiont on the plant nutrition is well known, but the role in salinity related factor has been studied very less frequently. Screening of plants for salt stress in the net house has mostly been conducted in soil medium. This mimics some field condition more closely than any other method especially when factors such as toxicity of reduced ions and redox potential of soil are considered. Saline soils are distributed throughout the world especially in the arid and semiarid regions. Nutrient deficiency frequently compounds the problems of saline soil of the tropics. High salinity affects plant growth trough the osmotic effect, toxicity of salt ions and the changes in physical and chemical properties of soil. It also suppresses the nutrient uptake by plant roots and reduces nutrient status of plant. The use of chemical fertilizer is the most common approach to improve soil fertility and it sometimes results in increased the salt concentration. In such condition biofertilizer along with an organic manure appears to be more effective choice than the chemical fertilizer in maintaining soil health. Saline site conditions are usually associated with stunted growth and poor overall quality of teak. Hence, the present study is an attempt to investigate the

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survival of economically important tree species *Tectona grandis* in the saline condition in association with Mycorrhiza and other microbes with the objectives to improve survival per cent and nutrient status of soil.

EXPERIMENTAL METHODS

The present investigation was under taken during the year 2011-2012 and 2012-2013 at College of Forestry, Navsari Agricultural University, Navsari (Gujarat). Teak stumps used in the experiment were collected from Experimental Farm of College of Forestry. The bulk surface soil samples having neutral value *i.e.* (<4 ECe) collected from the Instructional Farm ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari and high salinity level soils *i.e.* 4-8 and 8-12 ECe were collected from the Danti farm of Navsari Agricultural University, Navsari and was processed to pass through 2 mm sieve. From the collected bulk soil sample, a representative sample was preserved for initial analysis of soil properties. The details regarding physical, chemical and fertility parameters of these soils are furnished in Table B. The experiment was carried out in Completely

Table A: Methods used for the determination chemical properties of soil

Sr. No.	Soil characteristics	Methods employed for determination
(i)	ECe (dSm^{-1}) at 25ºC (1:2.5 soil: water ratio)	Conductometric method (Jackson, 1967)
(ii)	Available N (kg ha^{-1})	Alkaline potassium permanganate method (Subhiah and Ashija,1956)
(iii)	Available P_2O_5 (kg ha^{-1})	Olsen's method (Jackson,1967)
(iv)	Available K_2O (kg ha^{-1})	1 N N NH_4OAC Extraction method (Jackson,1967)
(v)	Available Ca, Mg, Na (kg ha^{-1})	1 N N NH 4 OAC Extraction method (Jackson,1967)
(vi)	Available micronutrients (Fe,Zn,Mn and Cu) (kg ha^{-1})	DTPA Extraction method

Table B : Initial physico-chemical properties of soils

Particulars	2011-2012			2012-2013		
Soil type	S_1 (Navsari)	S_2 (Danti)	S_3 (Danti)	S_1 (Navsari)	S_2 (Danti)	S_3 (Danti)
Initial chemical properties						
pH (1:2.5)	7.20	7.98	8.23	7.23	8.03	8.26
EC	0.32	2.03	3.32	0.30	2.17	3.28
ECe (dSm^{-1})	1.17	7.23	10.98	1.22	7.48	10.56
Organic carbon (%)	0.58	0.60	0.54	0.56	0.60	0.55
Available N (kg ha^{-1})	226	204	186	228	198	189
Available P_2O_5 (kg ha^{-1})	49.23	44.56	52.93	52	48	54
Available K_2O (kg ha^{-1})	542.0	972.0	1485.0	564	986	1517
Available S (ppm)	13.16	14.36	17.43	12.47	15.13	16.78
Exchangeable Ca (me/100g)	37.23	28.52	23.15	38.12	27.92	22.78
Exchangeable Mg (me/100g)	14.26	15.32	16.24	14.48	16.32	17.37
Exchangeable Na me/100g	0.38	1.54	2.22	0.42	1.59	2.35
Exchangeable K (me/100g)	0.50	0.90	1.32	0.52	0.95	1.46
CEC (me/100g)	53.28	46.51	43.26	53.47	46.48	43.32
ESP	0.71	3.31	5.13	0.79	3.42	5.42
DTPA extractable micro nutriment cations (ppm)						
Fe	14.56	12.86	11.42	17.4	13.5	9.6
Mn	18.32	14.23	15.23	18	16	6.5
Zn	1.12	0.98	0.75	2.2	1.60	0.27
Cu	3.47	2.32	2.16	3.8	2.1	1.2
Water stable aggregates (%)						
<1.0 mm	28.20	22.50	24.36	27.4	18.6	10.1
>1.0 mm	52.34	38.40	27.72	57.8	39.2	18.5

Randomized Design with factorial concept in three salinity levels normal soil as S_1 (<4 ECe soil), saline soil as S_2 (4-8 ECe) and highly saline soil as S_3 (8-12 ECe) as treatments and seedlings were inoculated with *Azetobactor* with vesicular-arbuscular mycorrhizal (VAM) fungi as (M_1), *Azospirillium* with vesicular-arbuscular mycorrhizal (VAM) fungi (M_2) and the combination of all three (M_3).

Pot culture technique used :

Polythene bags of size 20 cm x 15 cm and 200 gauges (thickness) were used. In order to maintain the salinity at the required level no hole were made in the polythene bags for drainage off excessive soil solution. Each bag was filled with 1.6 kg of the treated soil as per the treatments. In each bag one seedling was planted and bags were maintained around field capacity 36.575 for maintaining the field capacity in each bag, the uniform quantity of water was added throughout the period of investigation. No water was allowed to drain out of the bag (seedlings watering with rain water so less chances of extra salt accumulation). So that required salinity was maintained in the bag throughout the experimentation period. Seedlings were finally removed after 12 month of investigation.

Soil analysis :

All soil samples were air-dried in the shed. For separation of coarse fragments the air-dried samples were allowed to pass through 2 mm sieve after breaking the aggregates by hand and mechanical force. For analysis of sample in the laboratory, the dried samples were properly grinded by wooden mortar and pestle and were made to pass through 2 mm sieve. The processed soils (<2 mm) were transferred to clean bags and labeled (one label was kept inside the bag and another pasted outside) indicating sample number, treatment, repetition etc. Then, these samples were kept in proper place for laboratory analysis purposes.

Method of soil analysis :

All the soil samples were analyzed for chemical properties by using following standard procedures as mentioned below :

Electrical conductivity of saturated paste extract :

The soluble salts are generally expressed in terms of electrical conductance of the saturation paste extract. In the laboratory saturated extract was obtained by suction or pressure from an equilibrated saturated soil paste.

Survival per cent :

Survival per cent under different microsymbiont inoculated treatments and salinity levels were recorded at the intervals of 4 month. By noting surviving plant population out of total planted at the initial stages.

Stasistical analysis :

To test the significance among the different microsymbiont, salinity level and water stress for both teak and Eucalyptus were subjected to analysis of variances. The data were also analyzed for working out the correlations following the procedure described by Panse and Sukhatme (1967). The method of analysis of variance was done using Factorial Completely Randomized Design.

EXPERIMENTAL RESULTS AND ANALYSIS

The results obtained from the present study have been discussed in detail under following heads :

Nutrient status of soil :

The result pertaining to changes in soil chemical properties due to different treatments is presented in Tables 1, 2 and 3. The chemical properties *viz.*, pH, ECe, N, P, K, Ca, Mg, Na and micronutrients differed significantly due to individual effect of microsymbionts interaction. Significantly lower values of pH and ECe (Table 1) were recorded under triple inoculated microsymbiont treatments M_3 (7.23 and 0.84) as compared to control M_4 (7.26 and 1.36) which was followed by M_2 and M_3. The per cent reduction in pH (0.41 to 0.27%) and ECe (38.23 to 22.05 %) under microsymbiont treatment as compared to uninoculated soils. The application of triple combination of microsymbiont (M_3) increased of available N (222 and 221 kg/ha, in 1st and 2nd trial) which was at par with M_2. The per cent increase of available N was about 5.71 - 3.43 per cent in 1st trail and 5.74- 3.45 in 2nd trail as compared to the un-inoculated control treatment (M_4) (Table 1).

Available P_2O_5 was recorded significantly lower in M_3 (47.64 and 49.25 kg/ha, respectively under 1st and 2nd train under normal soils) which was followed by M_2. The availability of P_2O_5 decreased by 9.48, 5.62 and 3.76 in 1st trail and 9.21, 5.54 and 3.64 per cent in 2nd trail, respectively M_3, M_2 and M_1 as compared to their control (M_4) treatment (Table 1).

Similarly in case of K_2O, the treatment of triple microsymbiont (M_3) showed minimum values of K_2O (540 and 538 kg/ha, respectively in both trails) which was followed by M_2 (Table 2).

The results presented in Table 2 for Ca, Mg and Na reveals that the effect of microsymbiont on exchangeable Ca, Mg and Na was found to be significant. Among different Microsymbiont tried, M_3 (VAM +*Azospirillium*+*Azotobacter*) exceed to decline the salt concentration of soil as on the basis pooled analysis data. Soils of triple microsymbiont inoculated recorded significantly lower amount of exchangeable Ca (36.1 and 36.5 me/100), Mg (12.00 and 11.00 me/100g) and Na (0.34 and 0.36 me/100g), respectively at 2011-2012 and 2012-2013. Which was followed by M_2 and M_1. Whereas, significantly maximum salt concentration was found under un-inoculated soils. The per

Table 1 : Effect of different microsymbiont inoculation on the ECe, pH, N and P_2O in soils under teak seedling

Microsymbiont	ECe (dSm-1)						pH					
	2011-2012			2012-2013			2011-2012			2012-2013		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
M_1	1.06	6.06	10.28	1.11	6.11	10.32	7.24	8.07	8.26	7.20	8.03	8.22
	(-22.05)	(-1.46)	(-0.19)	(-21.27)	(-1.45)	(-0.28)	(-0.27)	(-0.24)	(-0.24)	(-0.27)	(-0.24)	(-0.24)
M_2	0.94	6.05	10.13	0.99	6.10	10.18	7.24	8.07	8.26	7.20	8.03	8.22
	(-30.88)	(-1.62)	(-1.65)	(-29.78)	(-1.61)	(-1.64)	(-0.27)	(-0.24)	(-0.24)	(-0.27)	(-0.24)	(-0.24)
M_3	0.84	5.25	9.61	0.89	5.30	9.66	7.23	8.06	8.25	7.19	8.02	8.21
	(-38.23)	(-14.63)	(6.69)	(-36.87)	(-14.51)	(-6.66)	(-0.41)	(-0.37)	(-0.36)	(-0.41)	(-0.37)	(-0.36)
M_4	1.36	6.15	10.30	1.41	6.20	10.35	7.26	8.09	8.28	7.22	8.05	8.24
S.E.±		0.11			0.11			0.007			0.007	
C.D. (P=0.05)		0.33			0.33			0.02			0.02	
	N (kg ha^{-1})						P_2O_5 (kg ha^{-1})					
	2011-2012			2012-2013			2011-2012			2012-2013		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
M_1	217.22	206.00	171.00	216.22	205.00	170.00	50.65	46.32	57.31	52.27	47.94	58.90
	(3.43)	(3.00)	(2.39)	(3.45)	(3.01)	(2.40)	(-3.76)	(-4.09)	(-3.35)	(-3.64)	(-3.96)	(-3.28)
M_2	220.00	209.00 (4.5)	174.00	219.00	208.00	173.00	49.67	45.32	56.33	51.24	46.93	57.91
	(4.76)		(4.19)	(4.78)	(4.52)	(4.21)	(-5.62)	(-6.16)	(-5.00)	(-5.54)	(-5.98)	(-4.90)
M_3	222.00	211.00 (5.5)	176.00	221.00	210.00	175.00	47.64	43.33	54.34	49.25	44.92	55.93
	(5.71)		(5.38)	(5.74)	(5.52)	(5.42)	(-9.48)	(10.28)	(-8.36)	(-9.21)	(10.01)	(8.16)
M_4	210.00	200.00	167.00	209.00	199.00	166.00	52.63	48.30	59.3	54.25	49.92	60.90
S.E.±		1.33			1.33			0.50			0.50	
C.D. (P=0.05)		3.77			3.77			1.43			1.43	

(Note : Figures in parenthesis is per cent reduction (-) and per cent increase (+) in values as compared to their control condition)

Table 2: Effect of different microsymbiont inoculation on the K_2O_5, Ca, Mg and Na in soils under teak seedling

Microsymbiont	K_2O (kg ha^{-1})						Ca (me/100g)					
	2011-2012			2012-2013			2011-2012			2012-2013		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
M_1	548	995	1496	545	993	1494	36.3	27.4	23.2	36.7	27.8	23.9
	(-0.72)	(-0.40)	(-0.26)	(-0.90)	(-0.40)	(-0.26)	(-2.15)	(-2.83)	(-3.33)	(-2.13)	(-2.79)	(-2.09)
M_2	544	991	1492	542	989	1490	36.2	27.3	23.4	36.6	27.7	23.5
	(--1.44)	(-0.80)	(-0.53)	(-1.45)	(-0.80)	(-0.53)	(-2.42)	(-3.19)	(-2.5)	(-2.4)	(-3.14)	(-3.68)
M_3	540	987	1488	538	985	1486	36.1	27.2	23.0	36.5	27.6	23.4
	(-2.17)	(-1.20)	(-0.80)	(-2.18)	(-1.20)	(-0.80)	(-2.69)	(-3.54)	(-4.16)	(-2.66)	(-3.49)	(-4.09)
M_4	552	999	1500	550	997	1498	37.1	28.2	24.0	37.5	28.6	24.4
S.E.±		1.45			1.44			0.20			0.20	
		4.08			4.07			0.56			0.56	
	Na (me/100g)						Mg (me/100g)					
	2011-2012			2012-2013			2011-2012			2012-2013		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
M_1	0.37	1.54	2.17	0.39	1.56	2.19	12.3	13.8	16.65	11.4	12.7	15.6
	(-2.63)	(-0.00)	(-0.45)	(-2.5)	(0.00)	(-0.45)	(-3.90)	(-1.42)	(-2.63)	(-3.38)	(-3.05)	(-3.10)
M_2	0.36	1.53	2.16	0.38	1.55	2.18	12.3	13.6	16.1	11.2	12.5	15.1
	(-5.26)	(-0.64)	(-0.91)	(-5.00)	(-0.64)	(-0.90)	(-3.90)	(-2.85)	(-5.84)	(-5.08)	(-4.58)	(-6.21)
M_3	0.34	1.50	2.14	0.36	1.52	2.16	12.0	13.2	16.0	11.0	12.3	14.9
	(-10.52)	(-2.59)	(-1.83)	(-10)	(-2.56)	(-1.81)	(-6.25)	(-5.71)	(-6.43)	(6.77)	(-6.10)	(-7.45)
M_4	0.38	1.54	2.18	0.40	1.56	2.20	12.8	14.0	17.1	11.8	13.1	16.1
S.E.±		0.004			0.004			0.14			0.15	
C.D. (P=0.05)		0.01			0.01			0.39			0.40	

(Note : Figures in parenthesis is per cent reduction (-) and per cent increase (+) in values as compared to their control condition)

cent decrease in Ca, Mg and Na under inoculated treatment ranged from 2.69-2.13 (Ca) and 6.77-3.38 (Mg) and 10.52-2.5 (Na) per cent at both the trails.

Looking to the data of it is evident that M_3 (VAM + *Azospirillium* + *Azotobacter*) exceeds to retain more micronutrient concentration in soil as compared to other treatments. The triple inoculation of microsymbiont (M_3) retained significantly higher amount of Fe (15.44 ppm), Zn (1.26 ppm), Mn (19.07 ppm) and Cu (3.44 ppm) at the 1st trail which was at par with M_2 for Fe, Zn and Mn and followed by for Cu (Table 3). Whereas minimum concentration micronutrients were found under un-inoculated soils for both species. Similar trend of results was found in 2nd year of investigation.

The per cent increase due to inoculation of microsymbiont ranged from 0.45-0.006 per cent, 17.75-5.98 per cent, 6.77-2.57 per cent and 18.27-6.64 per cent, respectively for Fe, Zn, Mn and Cu (Table 3).

Interaction effect of microsymbiont and saline soils

In case of salinity levels pH, ECe available P_2O exchangeable Ca, Mg and Na gradually increased with increasing salinity and available N, K_2O, and micronutrients tended to decline with increasing salinity. In the interaction studies it was found that nutrient status of soil found significant in the S_1 (<4 ECe soil) when it inoculated with triple microsymbiont which was followed by double inoculation of *Azospirillium* and VAM. All the inoculated treatment played better to retain available nutrients in the soil as compared to un-inoculated. Similar findings were given by Proha *et al.* (2009). Soil pH increased in the *Azotobacter* and AM treated soil but lower as compared for to un-inoculated, similar variation noticed N, P, K and micronutrients in the *T.* grandis treated soil. Sreenivasan and Krishnaraj (1992), Nagwani *et al.* (1998) also demonstrated similar results in test soil.

Survival per cent :

Up to the initial 4th and 8th month there was no any mortality occurred so there was survival of initial 8 months was 100 per cent but after 8 months of experiment there was some mortality recorded in the uninoculated treatment and reduced up to 97.8

Table 3: Effect of different microsymbiont inoculation on the micronutrients in soils under teak seedling

Microsymbiont	Fe (ppm)						Zn (ppm)					
	2011-2012			2012-2013			2011-2012			2012-2013		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
M_1	15.40	13.81	12.32	15.43	13.82	12.34	1.14	0.87	0.62	1.24	0.97	0.72
	(0.06)	(0.07)	(0.24)	(0.19)	(0.07)	(0.16)	(6.54)	(17.56)	(10.71)	(5.98)	(15.47)	(9.09)
M_2	15.41	13.81	12.33	15.44	13.82	12.34	1.17	0.98	0.64	1.27	1.08	0.74
	(0.12)	(0.07)	(0.32)	(0.25)	(0.07)	(0.16)	(9.34)	(32.43)	(14.28)	(8.54)	(28.57)	(12.12)
M_3	15.44	13.82	12.34	15.47	13.87	12.37	1.26	1.10	0.68	1.36	1.20	0.78
	(0.32)	(0.14)	(0.40)	(0.45)	(0.43)	(0.40)	(17.75)	(48.64)	(21.42)	(16.23)	(42.85)	(18.18)
M_4	15.39	13.80	12.29	15.40	13.81	12.32	1.07	0.74	0.56	1.17	0.84	0.66
S.E.±		0.02			0.003			0.02			0.02	
C.D. (P=0.05)		0.01			0.01			0.08			0.08	
	Mn (ppm)						Cu (ppm)					
	2011-2012			2012-2013			2011-2012			2012-2013		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
M_1	18.32	14.21	14.74	18.32	14.21	14.74	3.11	2.07	1.96	3.21	2.17	2.06
	(2.57)	(4.94)	(4.98)	(2.57)	(4.94)	(4.98)	(6.87)	(10.69)	(11.36)	(6.64)	(10.15)	(10.75)
M_2	18.62	14.91	15.04	18.62	14.91	15.04	3.20	2.16	2.05	3.30	2.26	2.15
	(4.25)	(10.11)	(7.12)	(4.25)	(10.11)	(7.12)	(9.96)	(15.50)	(16.47)	(9.63)	(14.72)	(15.59)
M_3	19.07	15.21	15.13	19.07	15.21	15.14	3.44	2.34	2.23	3.56	2.44	2.33
	(6.77)	(12.33)	(7.76)	(6.77)	(12.33)	(7.83)	(18.21)	(25.11)	(26.70)	(18.27)	(23.85)	(25.26)
M_4	17.86	13.54	14.04	17.86	13.54	14.04	2.91	1.87	1.76	3.01	1.97	1.86
13		0.25			0.25			0.048			0.047	
		0.71			0.71			0.39			0.13	

(Note : Figures in parenthesis is per cent reduction (-) and per cent increase (+) in values as compared to their control condition)

per cent in both the trails. It can be seen from the data (Table 4) that triple inoculation of VAM + *Azospirillium* + *Azotobacter* (M_3) performed best with respect to survival rate of seedlings as compared to other inoculation and un-inoculated treatment. As the survival percentage of microsymbiont inoculation treatment increased by 2.24 per cent.

Table 4 : Response of different microsymbiont inoculation to the survival per cent of teak seedlings under different salinity levels

Microsymbiont	Survival (%)		
	S_1	S_2	S_3
		2011-2012	
M_1	100.0 (2.24)	98.9 (3.45)	94.7 (0.31)
M_2	100.0 (2.24)	100.0 (4.60)	95.6 (1.27)
M_3	100.0 (2.24)	100.0 (4.60)	96.7 (2.43)
M_4	97.8	95.6	94.4
S.E.±		1.50	
C.D. (P=0.05)		4.24	
		2012-2013	
M_1	100.0 (2.24)	97.8 (2.30)	94.4 (3.62)
M_2	100.0 (2.24)	100.0 (4.60)	95.6 (4.93)
M_3	100.0 (2.24)	100.0 (4.60)	95.6 (4.93)
M_4	97.8	95.6	91.1
S.E.±		1.28	
C.D. (P=0.05)		3.61	

(Note : Figures in parenthesis is per cent reduction (-) and per cent increase (+) in values as compared to their control condition)

Besides individual results when time comes to note performance of interaction of microsymbiont and salinity levels it was revealed that triple inoculated or in fact all the inoculated treatment improve survival per cent of teak seedlings in normal as well as highly saline soils. In case of salinity levels it was noted 100 per cent survival of seedlings grown under normal soils (S_1) which was reduced in highly saline soils. Whereas survival per cent under M_3 was 100 per cent which was reduced in highly saline soils by 3.3 per cent in 1st trail and 4.4 per cent in 2nd trail. This was interpreted on the basis of performance of uninoculated treatment. Higher survival per cent in the triple inoculation and normal soil might be due to inherent capacity of soil to provide nutrients and beneficial symbiosis among three microsymbiont. As some of the cross reviews Sun and Dickinson (1995) and Akhtar *et al.* (2008) observed that survival of *Eucalyptus camndulensis* in Pakistan was not affected by soil salinity (8-31 dSm^{-1}). Feikema and Baker (2011) also noted survival of different Eucalyptus species was significantly less in the high salinity treatment whereas survival of some *Eucalyptus camldulensis* remained unaffected.

Conclusion :

Thus, it can be concluded that seedling of teak survive better under triple microsymbiont inoculation VAM, *Azospirillium* and *Azetobactor* under the normal soils. besides this research trials has broadened our understanding of the response of microsymbiont symbiosis in ameliorating salty soils by improving its nutrient status and removing exchangeable salts from the soil. This concept might become applicable during the wasteland management especially saline soil affected areas.

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