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Impact of Water and Soil Compositions on the Growth of *Sonneratia alba* in ThuaThien Hue, Vietnam

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Abstract: *Impact of soil andwater environment on growth of S. alba forests in newly planted forests in ThuaThien – Hue Vietnam, including studies on the growth of S. alba on different three sites; soil under the canopy of planted forests, relationship between planted forests with soil and water. Research methods arrange experiments on different sites; Determine soil and water properties under the forest canopy, analyzed the relationship of some soil and water properties with growth. The studies were randomly arranged with 3 repetitions, soil samples were collected and analyzed at the Southern Forest Science Institute, measurement indicator include tree N (density), D_0 (ground diameter), H (top height), He (tree quality). Soil properties are collected under the forest canopy from 1 to 4 years old, each site has 3 soil samples, taken at a depth of 0-20 centimeters, 20 – 50 centimeters, each layer of soil collectedfrom 0.5 -1 kilogram, the following indicators area such as pH-H_2O, humus (%), total nitrogen (N%), phosphorus (P_2O_5%), potassium (K_2O%), Al^{3+} (me/100mg), Fe^{2+} (me/100mg), Fe^{2+} (me/100g), SO_4^{2-}(me/100g), mechanical composition (% ratio of clay, silt and sand (%). Water samples analyzed by the southern Forest Science Institute. Research results determine forest growth on different sites of planted forest; Comlexility and competiveness indexes of forest, wood reserves and biomass; the influence of site location on forest stability; element of the soil under the forest canopy; Relationship between water and planted forests. Relationship between planted forests and soil and water characteristics. Propose application of site research results; cultivation techniques; afforestation to protect river and coastal environments. The conclusion of the project is that site one (I) and site to (II) are effective, planting forest can change Al^{3+} and SO_4^{2-} improving the environment at the soil layer from 0 – 50 centimeters; water properties that also have the ability to improve the environment are Al^{3+}, Fe^{2+} and SO_4^{2-}; plantation forest growth depends on the content of N, P and Al^{3+} in the soil layer from 0 -50 centimeters; plantation growth depends on water element such as salinity %, Al^{3+}, Fe^{2+}, SO_4^{2-} content. The above issues contribute to orienting the selection of sustainable plants for afforestation in ThuaThien – Hue and other regions in Central Vietnam with similar mangrove soil conditions.*

Keywords: *Soil environmental, water environmental, young forest growth, Sonneratiaalba,ThuaThien – Hue, Central Vietnam*

1. INTRODUCTION

Water into the air. Therefore, forests and the environment (climate, terrain, soil, human activities...) are closely related to each other (Nguyen Van Them, 2002, 2021).

The impact of mangrove forests on the environment is a concern for ecologists and silviologists, environmental managers and protectors, irrigators... Information about the relationship between forest and environment helps forest scientists develop forest principles and silviculture methods. Environmental managers and protectors use this information to manage the environment and develop environmental treatment measures. Irrigation specialists use this information to develop flood and flood prevention measures, limit erosion and riverside and coastal soil erosion...

Some authors (Thai Van Trung, 1999; Phan Nguyen Hong et al., 1999) have studied the distribution of mangroves in the coastal areas of our country. Some authors have also studied the element of soil under mangrove canopy (Ngo Dinh Que, 2003), mangrove biomass (VienNgoc Nam, 1998; Nguyen Hoang Tri, 1999), mangrove growth and planting techniques (Dang Cong Buu, 2006). However, these studies have not yet clarified the dynamics and relationships between soil and water element and mangrove growth. Lack of this information causes difficulties in making decisions about mangrove planting and measures to protect and improve riverine and marine environments.

Previous studies on mangroves in Vietnam have focused on determining the distribution area, species composition, structure and growth of mangroves, mangrove sites, mangrove nursery and planting techniques, productivity, and material cycle. at RNM. In this study, we inherit the results of this research that were left out on *S. alba* planting in the coastal area of ThuaThien Hue province.

Previous studies on mangroves in Vietnam have not yet clarified the changing dynamics of soil and water element under the mangrove canopy, the intensity and trend of the interrelationship between environmental factors and mangrove growth. In this study, we analyze the changing dynamics of some soil and water properties under the canopy of mangroves, and the intensity and trend of the relationship between soil and water properties with the growth of newly planted forests of white mangrove forests.

2. RESEARCH MATERIALS AND METHODS

Identify suitable sites for planting of S. alba plantations

Divide 3 types of sites according to the criteria (I) beach exposure time, tides (h/day), (II) average salinity (‰), and (III) mechanical composition and formation of soil. To determine the impact of installation on *S. alba*sites: Plant on three types of sites. Address enveloping includes three types (I, II and III) according to the classification of Ngo Dinh Que (2003). *S. alba*plantations is grown from 6-month-old seedlings. Sow the soapberry in a polyethylene bag measuring 25*30cm. Planted seedlings are plants that grow well, have straight stems and are pest-free; Root diameter (D0) and height (H) are greater than 0.5cm and 50cm. The time to plant *S. alba*is mid-March. The time to plant *S. alba*during the day is when the tide is at its lowest. Seedlings are planted in rows. The rows of trees are arranged perpendicular to the coast. The initial forest planting density is 3,300 trees/ha (1.5*2.0m). Fix the tree with 3 bamboo holes with a diameter of 2 - 3cm and a height of 100 - 150cm. Plug-in machines have a depth of 40 - 60 cm; Then the tree is pressed into the box at 2/3 of the trunk. The experimental plot was protected by a bamboo fence to reduce large waves and rope algae. The experiments on each address were arranged to be repeated 3 times.

The experimental plot is rectangular in shape with an area of 300 m^2 (15*20m). Collect growth data of ç. Site changes were evaluated after 6 months and 1 - 4 years after planting. Growth of *S. alba* on each type of site was measured with 30 trees in a sample plot of 100m2 (10*10 m); Each iteration of a site type is 10 trees. Sample plots are distributed in the center of the experimental plot. The influence of site type on the forest is assessed through survival rate (SR%), growth, quality, and stability of the planted forest after 4 years of planting. Research criteria are existing density (N, tree), ground diameter (D0, cm), top height (H, cm), canopy diameter (Cd, cm), biomass (B, kg), the quality or quality of the tree (good, medium, and bad).

Determination of soil and water element under the canopy

Clarifying the element of bare land before afforestation and land under the canopy of planted forests. *S. alba*plantations from 1 - 4 years old on each site type is determined from 3 soil profiles, where each profile represents 1 iteration. The profiles are arranged in the center of the experimental plots. Soil profile size is 70*150 cm (width, length). Soil samples were only collected in two layers 0 - 20cm and 20 - 50cm. Each layer of soil collects 0.5 - 1.0kg

The element of bare land and land under the plantation canopy were assessed through10 indicators:pH-H_2O, pH-KCl, humus (%), total nitrogen (N%), phosphorus (P_2O_5%), potassium (K_2O%),Al^{3+}(me/100g), Fe^{2+}(me/100 g),SO_4^{2-}(me/100 g),mechanized composition(% of clay, limon and sand,%).pH-H_2Oextracted by water, soil and water ratio 1:5, measured by pH meter, pH-KCl1N, soil ratio and KCl solution by ratio 1:5,measuredbypHmeteraccordingtoTCVN5979:2007 (Standards of Viet Nam, TCVN).Humuscontent was determined by the Walkley-Black method, oxidation by concentrated H_2SO_4mixture - $K_2Cr_2O_7$, titration by $FeSO_4$0.5 N according to TCVN-8726-2012, total nitrogen (%N) determined by Kjeldhall's method according to TCVN6645:2000, total phosphorus (%P2O5) inorganic soil sample by H_2SO_4 and $HClO_4$. Show color with phosphomolybdate with reducing agent ascorbic acid . UV Vis color measurement by spectrophotometer at wavelength 880nm according toTCVN8940:2011. Total potassium (%K_2O) in organizes soil samples by H_2SO_4 and $HClO_4$ and is measured by flame photo meter according to: TCVN8660:201.ThreetoxiccomponentsAl^{3+}, Fe^{2+} and SO_4^{2-}were measured by UV-V is colorimeters according to TCVN 4403: 2011,Fe^{2+}: according to TCVN 12202-8: 2018 and SO_4^{2-}according to

TCVN8727:2012.The mechanized composition of soil was determined by the composition (% clay, % Limon, and %sand)using the Robinson straw method according to TCVN8567:2010 Water sampling g method: pH: TCVN 5979: 2007, dissolvedoxygen(DO): TCVN 7325: 2016, salinity: TCVN 9167: 2012, Fe^{2+}: TCVN 6177: 1996, Al^{3+}Total: TCVN 6657: 2000,SO_4^{2-}: TCVN6656:2000.

The effect of forests on water element was only analyzed for *S. alba* plantations aged 1-4 years on site type II. This is the form of site type that ensures the best growth. Each subject collected 3 water samples. Analysis criteria were pH_{H2O}, dissolved oxygen content (DO, mg/l), salinity, ‰), Al^{3+}content (me/100g), Fe^{2+}content (me/100g) and SO_4^{2-} content (me/100g). The pH_{H2O} was determined by a pH meter. The DOcontent was determined by electrode measurement. Water salinity was measured with a salinity meter (refractometer). The three components Al^{3+}, Fe^{2+} and SO_4^{2-} were determined by colorimetry. All these indicators were measured on the 15th lunar day of every month; then averaged out the year. Water samples were analyzed at the soil and water environment laboratory of the Forestry Sciences Institute of South Vietnam.

Data processing methods

Growth analysis of S. alba plantations

Analyzing the growth of *S. alba plantations*: Data processing method for the growth of *S. alba* plantations. Calculate the survival rate (SR%) of *S. alba* plantations. Summary of measurement data D0 (ground diameter), H (top height), N (density) and Cd (Canopy diameter) by age (A = 6 months and 1 to 4 years) of *S. alba* plantations on three site types. Calculate the SCI index of *S. alba* plantations on three site types. Analyzing the level of competition between trees in *S. alba* plantations plantation forests. Analysis of wood reserves of *S. alba* plantations forests. Biomass analysis of *S. alba* plantations. Analyzing the stability of S. alba plantations on three site types. Identify suitable sites for planting *S. alba* plantations. Suitable sites are selected according to Max of (SR, D0, H, N, B).

Analyze the element of soil and water under the canopy of *S. alba* plantations plantation forests: Statistically describe the element of soil and water under the canopy of *S. alba* plantations plantation forests and bare soil. Compare the differences between soil and water properties according to forest age on three site types.

Analyzing the relationship between soil and water and the growth of *S. alba* plantations: Relationship between soil and water element (Nguyen Van Them, 2022) with the SCI index of *S. alba* plantations analyzed by coefficient Spearman's rank correlation.

Analysis of soil and water element under the canopy of S. alba plantations

Determine the statistics describing the element of soil and water under the canopy of *S. alba* plantationsand bare land. Then compare the differences between soil and water element by plantations age across three sites.

Analysis of the relationship between soil and water with the growth of S. alba plantations

The relationship between soil and water element (Nguyen Van Them, 2022) and the SCI index of *S. alba* plantations was analyzed according to Spearman's grade correlation coefficient.

Analyze the relationship between S. alba plantations of soil and water

The relationship between *S. alba*plantations forests and soil element is described by the model (1).

$SCI=f(N, P,K,Al,Fe,SO_4)$ (1)

The relationship between *S. alba*plantations and water element is described by the model (2).

$SCI =f(salinity, Al, Fe, SO_4)$ (2)

The role of each soil and water characteristic in *S. alba* plantationsgrowth was assessed according to the regression coefficient. The order of role contribution from large to small was determined through the absolute value of the normalized regression coefficient.

All descriptive statistical calculations, hypothesis testing and graphing were performed using Excel software and STATGRAPHICS Centurion version XV.I

3. Research Findings And Discussions

Growth of *S. alba plantations* on different sites

Growth in diameter and height

Statistical element of the diameter and height of *S. alba* plantations *on* the three-site type are summarized in Tables 1 - 5.

Table1.*Diameter growth of S. alba plantations on three site types.*

A (year)	D_{0Bq} (cm)	Min	Max	±SEE	CV%	N (tree/ha	Survival rate N (%)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	
Site type I							
6 months	0.9	0.8	1.1	0.10	10.7	3.082	93.39
1	1.8	1.5	2.0	0.16	8.9	2.987	90.52
2	2.6	2.1	3.2	0.36	13.5	2.914	88.30
3	4.5	4.3	4.6	0.13	2.8	2.864	86.79
4	7.0	6.7	7.3	0.21	2.9	2.828	85.70
Site type II							
6 months	1.0	0.8	1.1	0.10	10.5	3.145	95.30
1	2.0	1.7	2.2	0.16	8.0	3.059	92.70
2	2.9	2.3	3.4	0.31	10.9	2.987	90.52
3	7.2	6.7	7.6	0.36	5.0	2.914	88.30
4	10.7	10.2	11.1	0.32	3.0	2.871	87.00
Site type III							
6 months	0.9	0.8	1.1	0.11	11.4	2.492	75.52
1	1.5	1.2	1.7	0.17	11.4	2.386	72.30
2	2.4	1.8	2.9	0.34	14.1	2.264	68.61
3	3.3	3.1	3.6	0.15	4.7	2.053	62.21
4	6.3	6.1	6.4	0.15	2.4	1.993	60.39

Table2.*The height growth of S. alba plantationson three site type.*

A (year)	H (cm)	Min	Max	±SEE	CV%
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Site type I					
6 months	57.4	48	66	5.4	9.5
1	96.0	92	99	2.1	2.2
2	123.0	115	131	4.7	3.8
3	154.8	152	158	2.1	1.4
4	284.7	275	294	6.1	2.1
Site type II					
6 months	59.3	56	63	2.1	3.5
1	102.1	62	106	5.2	5.1
2	136.8	129	145	4.7	3.5
3	179.7	177	183	2.0	1.1
4	326.8	317	336	5.9	1.8
Site type III					
6 months	57.8	48	66	5.6	9.6
first	89.3	86	93	2.5	2.8
2	112.6	105	121	4.7	4.2
3	134.8	130	140	3.2	2.3
4	211.4	174	240	22.4	10.6

Analysis of the growth process of the *S. alba* plantations in the period of 4 years (Table 3 to 5) shows two quantities ZD_0 and ΔD_0 (what do these variables mean? – you should perhaps provide a definition in the Table legend or as a Table footnote) on the three-site type all increased with age. Compared with the average ZD_0 and D_0 on site type III (1.5 cm and 1.3 cm respectively), these two quantities on site type I (1.7 cm and 1.5 cm respectively) are larger respectively 15.4% and 19.5%. Similarly, these two quantities on site type II (2.7 cm and 2.0 cm respectively) are 83.1% and 60.3% larger, respectively. The two quantities ZH and ΔH on the three-site type also increase with age. Compared with the average ZH and H on site type III (47.8 cm and 60.2 cm respectively), these two quantities on site type I (63.5 cm and 67.9 cm respectively) are 32 .7% and 12.9%. Similarly, these two

quantities on site type II (73.9cm and 75.2cm respectively) are 54.5% and 25.0% larger, respectively. In general, the plantations of S. alba plantations on site type II grow faster than on site type I and III.

Table3.*Growth in diameter and height of S. alba plantations on site type I.*

A (year)	Diameter growth				Height growth			
	D_0 (cm)	ZD_0	D_0	Pd(%)	H (cm)	ZH	H	Ph(%)
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
1	1.3	1.3	1.3	100.0	74.0	74.0	74.0	100.0
2	3.0	1.7	1.5	55.5	137.1	63.1	68.5	46.0
3	4.8	1.8	1.6	37.8	196.6	59.5	65.5	30.3
4	6.7	1.9	1.7	28.6	253.9	57.3	63.5	22.6
Average		1.7	1.5			63.5	67.9	

Table4.*Growth in diameter and height of the S. alba plantations on site type II.*

A (year)	Diameter growth				Height growth			
	D_0 (cm)	ZD_0	D_0	Pd(%)	H (cm)	ZH	H	Ph(%)
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
1	1.3	1.3	1.3	100.0	77.0	77.0	77.0	100.0
2	3.8	2.4	1.9	64.7	150.9	73.9	75.4	49.0
3	6.9	3.2	2.3	45.6	223.6	72.7	74.5	32.5
4	10.7	3.7	2.7	35.1	295.6	72.0	73.9	24.4
Average		2.7	2.0			73.9	75.2	

Table5.*Growth in diameter and height of the S. alba plantations on site type III.*

A (year)	Diameter growth				Height growth			
	D_0 (cm)	ZD_0	D_0	Pd (%)	H (cm)	ZH	H	Ph(%)
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
1	1.1	1.1	1.1	100.0	78.5	78.5	78.5	100.0
2	2.5	1.4	1.2	57.5	122.6	44.0	61.3	35.9
3	4.1	1.6	1.4	39.4	159.0	36.5	53.0	22.9
4	5.8	1.7	1.5	29.9	191.3	32.3	47.8	16.9
Average		1.5	1.3			47.8	60.2	

Growth of canopy diameter and canopy length of S. alba plantations

The averagecanopy diameter of the *S. alba* plantations at the age of 1 - 4 years was the lowest on the site type III (respectively 0.51; 0.65; 0.78 and 1.22m), the highest on the site type II (0.70; 0.93; 1.13 and 2.23m, respectively). The average canopy length at the age of 1 - 4 years is lowest on-site type I (0.60; 0.76; 0.91 and 1.43m respectively), the highest on-site type II corresponding to 0.80; 1.07; 1.41 and 2.57m). In general, Dcanopyand Lcanopy of the *S. alba* plantations at the age of 4 on 3 different site type (corresponding to F = 4 1.9 with P <0.0 1; F = 38.1 with $P < 0.01$).

Complexity and competitivenessindex of S. alba plantations

The SCI and CCI scores of the *S. alba* plantations varied with age and site type. On site typeI, the SCI index increased from 5.2 at the age 1 year to 56.4 at age 4years,on site typeII from 6.2 at the age 1 y to 100.4 at age 4 y, andon-site typeIII, from3.2 at the age y1 to 26.5 at age 4 years. At age 4 years, the SCI index of *S. alba* plantations on site typeII (100.4) was 1.8 timesand 3.9 timeslarger than on site types I and III, respectively,. At the age of 4 years, the canopy area of the *S. alba* plantationson site types I, II and III were 0.68 times, 1.12 times and 2.30 times in the ground area, respectively.

Wood and biomass reserves of S. alba plantations

Wood and biomass reservesof *S. alba* plantationson three site type are shown in Tables 6 to 11.

Table6.*Growth of timber reserves in the S. alba plantations on site typeI*

A (year)	M (m^3/ha)	ZM (m^3/ha/year)	ΔM (m^3/ha/year)	PM%
(1)	*(2)*	*(3)*	*(4)*	*(5)*
1	0.01	0.01	0.01	100.0
2	0.61	0.60	0.31	98.6
3	4.09	3.48	1.36	85.0
4	12.72	8.63	3.18	67.8

Table7.*Growth of timber reserves in the S. alba plantations on site typeII.*

A (year)	M (m^3 /ha)	ZM (m^3 /ha/year)	ΔM (m^3 /ha/year)	PM%
(1)	*(2)*	*(3)*	*(4)*	*(5)*
1	0.01	0.01	0.01	100.0
2	1.94	1.92	0.97	99.4
3	13.93	11.99	4.64	86.1
4	40.56	26.63	10.14	65.7

Table8.*Growth of timber reserves for S. albaplantationson site type III.*

A (year)	M (m^3 /ha)	ZM (m^3 /ha/year)	ΔM (m^3 /ha/year)	PM%
(1)	*(2)*	*(3)*	*(4)*	*(5)*
1	0.01	0.01	0.01	100.0
2	0.10	0.09	0.05	89.5
3	1.79	1.70	0.60	94.7
4	9.48	7.69	2.37	81.1

Table9.*Biomass of S. alba plantations on site typeI.*

A (year)	Biomass components (tonne/ha)				
	Bstem(0,0)	B stem	B branch	B leave	B (branh&leaf)
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
1	0.42	0.38	0.02	0.01	0.04
2	1.06	0.91	0.10	0.05	0.16
3	4.13	3.31	0.52	0.30	0.82
4	13.89	10.65	1.91	1.34	3.25

Table10.*Biomass of S. alba plantationson site typeII.*

A (year)	Biomass components (tonne/ha)				
	Bstem (0,0)	B stem	B branch	B leave	B (branh&leaf)
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
1	0.57	0.51	0.04	0.02	0.06
2	1.41	1.19	0.15	0.08	0.22
3	15.44	11.80	2.13	1.51	3.64
4	50.58	37.43	7.22	5.94	13.15

Table11.*Biomass of S. alba plantationson site typeIII.*

A (year)	Biomass components (tonne/ha)				
	Bstem (0,0)	B stem	B branch	B leave	B (branh&leaf)
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
1	0.18	0.17	0.00	0.00	0.01
2	0.71	0.59	0.08	0.04	0.12
3	1.67	1.36	0.21	0.11	0.32
4	9.89	7.60	1.38	0.92	2.30

The timber reserves of the *S. alba* plantationsvariedmarkedlywith age andsite type. Compared with the timber volume of the *S. alba* plantationsonsite typeIII (100%), times larger, respectively. In general, the timber reserves of the *S. alba*plantations are highest on-site typeII and lowest on-site typeIII.

On site typeI, total biomassincreased from 0.42 ton per hectare at age 1 to 13.89 ton per hectare at age 4. T in site typeII, total biomassincreased from 0.57 ton per hectareat the age of 1 to 50.58 ton per hectareat the age of 4 . T on site typeIII, total biomassincreased from 0.18 ton per hectareat the age of 1 to 9.89 ton per hectareat the age of 4 .

Stock in the biomass of *S. alba* plantations received the highest value in site typeII, the lowest in site typeIII. Compared with the above 4-year-old conifer plantations on site typeIII, carbon storage in biomass and CO_2 absorption capacity of *S. alba*plantations s on site typeI and II is 1.4 times greater, and 5.1 times.

The influence of the site type on the stability of the *S. alba* plantations

The stability of the plantations of *S. alba* is assessed through the H/D ratio and the quality of the trees. The shape of the trunk of the white cypress tree on the three-site type tends to decrease with age. The ratio of H/D at all ages is less than 0.80, showing that *S. alba* plantationsis developing stably. The trees that form the plantations of the *S. alba* plantations from 1 to 4 years old are clearly differentiated

in terms of quality. In general, the percentage of 4-years-old conifers of good and medium quality was highest on site typeII (90.1%), the lowest in site typeIII (70.9%).

Element of the soil under the canopy of plantations S. alba plantations

The element of soil under the canopy of 1to 4year-old*S. alba* plantations on three site type are summarized in Tables 12 to 14.

Table12.*Changes in soil element under the canopy of S. alba plantations from 1 to 4 years old on-site type I.*

Soil characteristics	Age (years)				
	Bare land	1	2	3	4
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
pH $_{H2O}$	5.9	6.1	6.3	6.5	6.5
pH $_{KCL}$	5.8	5.9	5.7	5.9	6.0
Humus (%)	1.20	1.79	2.05	2.18	2.44
Nitrogen (%)	0.056	0.099	0.113	0.110	0.122
Phosphorus (%)	0.050	0.082	0.081	0.073	0.091
Potassium (%)	0.129	0.181	0.221	0.215	0.262
Al^{3+} (me/100g)	1.68	1.27	1.17	0.97	1.02
Fe^{2+} (me/100g)	113.7	92.0	79.6	66.6	51.6
SO_4^{2-}(me/100g)	0.099	0.081	0.070	0.061	0.067
Clay (%)	12.8	14.3	15.5	14.3	18.0
Limon (%)	8.0	9.7	10.0	7.0	8.1
Sand (%)	79.2	76.0	74.5	78.7	73.9

Table13.*Changes in soil properties under the canopy of S. alba plantationsfrom 1 to 4 years old on-site type II.*

Soil characteristics	Age (years)				
	Bare land	1	2	3	4
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
pH $_{H2O}$	6.1	6.6	6.8	6.8	6.5
pH $_{KCL}$	5.9	6.0	5.9	6.0	5.9
Humus (%)	1.20	0.72	0.96	1.04	1.09
Nitrogen (%)	0.056	0.064	0.074	0.101	0.123
Phosphorus (%)	0.050	0.065	0.065	0.069	0.078
Potassium (%)	0.129	0.142	0.182	0.195	0.234
Al^{3+} (me/100g)	1.681	0.539	0.749	0.775	0.562
Fe^{2+} (me/100g)	113.7	65.3	65.5	60.6	45.5
SO_4^{2-}(me/100g)	0.097	0.059	0.051	0.042	0.045
Clay (%)	12.8	12.7	12.0	12.5	12.5
Limon (%)	8.0	7.4	7.7	5.8	5.5
Sand (%)	79.3	79.9	80.4	81.7	82.0

Table14.*Changes in soil element under the canopy of S. alba plantationsfrom 1 to 4 years old on-site type III*

Soil characteristics	Age (years)				
	Bare land	1	2	3	4
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
pH $_{H2O}$	6.1	6.3	6.5	6.5	6.8
pH $_{KCL}$	5.9	6.0	5.9	6.0	6.0
Humus (%)	1.20	1.43	1.69	1.94	2.28
Nitrogen (%)	0.056	0.083	0.094	0.088	0.178
Phosphorus (%)	0.051	0.080	0.079	0.083	0.092
Potassium (%)	0.129	0.182	0.220	0.233	0.256
Al^{3+} (me/100g)	1.681	0.787	0.852	0.677	0.835
Fe^{2+} (me/100g)	113.7	112.0	79.9	86.9	73.6
SO_4^{2-}(me/100g)	0.099	0.084	0.070	0.074	0.062
Clay (%)	14.3	15.4	16.6	17.2	18.0
Limon (%)	6.4	6.9	7.1	5.3	5.5
Sand (%)	79.3	77.8	76.4	77.5	75.9

The data in Table 12 show that 6 soil elementson site type I increased with the increase in age of *S. alba* plantations, namely $pH_{H2O,}$ humus content, nitrogen, phosphorus, potassium, and percentage lighting. On the contrary, 5 elementsthat decrease gradually with the increase of age of the plantations are Al^{3+}, Fe^{2+}, SO_4^{2-},ratio of Limon (%) and sand. Thevalue pH- KCL tends to be stable, only fluctuating in the range of 5.8 - 6.0. At the age of 4, compared with bare soil, 6 elements(pH_{H2O}, humus content, nitrogen, phosphorus, potassium, and percentage of clay) of the soil under the forest

canopy increased by 10.2 %, 103, respectively. 3%, 117.9%, 82.0%, 103.1% and 40.6%. In contrast, 4 properties (Al^{3+}, Fe^{2+}, SO_4^{2-},percentage of sand) was lower than 39.3%, 54.6 %, 32.3% and 6.7% respectively.

The data in Table 13 show that 4 elements(pH-H_2O, nitrogen, phosphorus, potassium) of soil on site type II increased markedly with the increase of age of *S. alba* plantations. In contrast, 5 elements(humus content, Al^{3+}, Fe^{2+}, SO_4^{2-},Limon (%)) decreased markedly with the increase in age of the *S. alba* plantations. The value pH-KCLtends to be stable, fluctuating in the range of 5.9 - 6.0. At the age of 4, compared with bare soil, the 4 elements(pH_{H2O}, nitrogen, phosphorus, potassium) of the soil under the canopy of the forest increased by 6.6%, 119.6%, 56.0% and respectively. 81.4%. In contrast, 4 properties (Al^{3+}, Fe^{2+}, SO_4^{2-}, Limon (%) was lower than 66.6%, 60.0 %, 53.6% and 31.3% respectively.

The data in Table 14 show that 6 elements(pH_{H2O}, humus, nitrogen, phosphorus, potassium, and clay content) of soil on site type III increased markedly with the increase of forest age. Plant white coriander. In contrast, 4 properties (Al^{3+}, Fe^{2+}, SO_4^{2-} ,limon (%) decreased markedly with the increase in age of the *S. alba* plantations. The value pH-KCLtends to be stable, only fluctuates in the range of 5.9 - 6.0. At the age of 4, compared with bare soil, the 6 elements(pH_{H2O}, humus, nitrogen, phosphorus, potassium, and clay) of the soil under the canopy of the forest increased by 11.5 %, 90.0%, respectively. 217.9%, 80.4%, 98.4% and 25.9%. In contrast, 4 properties (Al^{3+}, Fe^{2+}, SO_4^{2-} ,Limon (%)) was lower than 50.3%,35.3%, 37.4% and 14.1% respectively.

Statistical analyzes show that 9soil properties (pH-H_2O , pH-KCL , humus , phosphorus , Fe^{2+}, SO_4^{2-} , proportion of clay, flesh and sand)under the canopy of the *S. alba* plantationsfrom 1 to 4 years old on three distinct site type ($P < 0.05$). In contrast, the components (N, K and Al)were not significantly different ($P > 0.05$).

The relationship between soil element and growth of S. alba plantations

The growth of the plantations of *S. alba*significantly affects the soil properties on the three-site type(Tables 15 – 17).

Table15.*Relationship between soil and growth of S. alba plantationson site typeI*

Soil characteristics	r	P_α	K (sample)
(1)	*(2)*	*(3)*	*(4)*
pH_{H2O}	0.483	0.007	30
pH_{KCL}	0.560	0.001	30
Humus (%)	0.829	0.000	30
Nitrogen (%)	0.676	0.000	30
Phosphorus (%)	0.546	0.002	30
Potassium (%)	0.808	0.000	30
Al^{3+} (me/100g)	-0.204	0.279	30
Fe^{2+} (me/100g)	-0.855	0.000	30
SO_4^{2-}(me/100g)	-0.638	0.000	30
Clay (%)	0.661	0.000	30
Limon (%)	-0.552	0.002	30
Sand (%)	-0.355	0.054	30

Table16.*Relationship between soil and growth of S. alba plantations on site typeII.*

Soil characteristics	r	P_α	K (sample)
(1)	*(2)*	*(3)*	*(4)*
pH_{H2O}	0.277	0.138	30
pH_{KCL}	-0.006	0.976	30
Humus (%)	0.046	0.808	30
Nitrogen (%)	0.688	0.000	30
Phosphorus (%)	0.649	0.000	30
Potassium (%)	0.796	0.000	30
Al^{3+} (me/100g)	-0.406	0.026	30
Fe^{2+} (me/100g)	-0.752	0.000	30
SO_4^{2-}(me/100g)	-0.686	0.000	30
Clay (%)	-0.042	0.825	30
Limon (%)	-0.665	0.000	30
Sand (%)	0.418	0.021	30

Table17.*Relationship between soil and growth of S. alba plantationson site typeIII.*

Soil characteristics	r	P_{α}	K (sample)
(1)	*(2)*	*(3)*	*(4)*
pH_{H2O}	0.501	0.005	30
pH_{KCL}	0.145	0.444	30
Humus (%)	0.760	0.000	30
Nitrogen (%)	0.515	0.004	30
Phosphorus (%)	0.620	0.000	30
Potassium (%)	0.767	0.000	30
Al^{3+} (me/100g)	-0.240	0.202	30
Fe^{2+} (me/100g)	-0.754	0.000	30
SO_4^{2-}(me/100g)	-0.676	0.000	30
Clay (%)	0.714	0.000	30
Limon (%)	-0.370	0.044	30
Sand (%)	-0.266	0.156	30

On site type I, 7elements(pH_{H2O}, pH_{KCL}, humus content, N, P, K and clay ratio) had a clear positive relationship ($P < 0.01$) with the SCI of the site. *S. alba* plantations. In contrast, 4elements (Fe^{2+} content, SO_4^{2-} and Limon (%) were negatively related with ($P < 0.01$) with the SCI index of the Whitewood plantations. On site type II, 4 element of soil (N, P, K and ration of clay) have a positive relationship ($P < 0.01$), while four element (Al^{3+}, Fe^{2+}, SO_4^{2-} and limon (%) has a negative relationship with ($P < 0.01$) with the SCI index of the plantations of *S. alba* plantationson site type III, seven element of soil (pH_{H2O}, pH_{KCL}, humus, N, P, K, and clay (%) in the soil) have a positive relationship ($P < 0.01$), while the remaining five element of soil (Al^{3+}, Fe^{2+}, SO_4^{2-},ratio of limon (%) and sand) has a negative relationship with ($P < 0.01$) with the SCI index of *S. alba* plantations.

Regression analyzes show that the soil properties can be approximated based on the age of the mangrove plantations. The estimation functions exist at a very high significance level ($P < 0.01$) and the coefficient of determination (r^2) ranges from 74 to 99%. On site type I, 6 soil element (humus content, N, P, K, Fe^{2+}, SO_4^{2-}) under the canopy of *S. alba* plantationscan be estimated according to the function 3.1 – 3.6 (Table 18). On site type II, 6 soil properties (N, P, K, Al^{3+},Fe^{2+}, SO_4^{2-}) under the canopy of *S. alba* plantationscan be estimated according to the function 3.7 – 3.12 (Table 19). On site type III, 6 element of soil (humus content, N, P, K, Fe^{2+}, SO_4^{2-}) under the canopy of *S. alba* plantations can be estimated according to the function 13 – 18 (Table 20).

Table18.*Estimating functions of soil element by age of S. alba plantations on site typeI.*

No	Function	
1	$Humus = (1.10024 + 0.228186*\sqrt{A})^2$	3.1
2	$N = \sqrt{0.00359117 + 0.00565127*\sqrt{A}}$	3.2
3	$P = 1/(18.7432 - 3.98414*\sqrt{A})$	3.3
4	$K = \exp(-2.04343 + 0.337414*\sqrt{A})$	3.4
5	$Fe^{2+} = (10.5822 - 0.839019*A)^2$	3.5
6	$SO_4^{2-} = \sqrt{0.00957254 - 0.00299218*\sqrt{A}}$	3.6

Table19.*Estimating functions of soil element by age of S. alba plantationson site typeII.*

No	Function	
1	$N = \sqrt{0.00306812 + 0.00075658*A^2}$	3.7
2	$P = 1/(19.6885 - 3.31256*\sqrt{A})$	3.8
3	$K = \exp(-2.0598 + 0.150819*A)$	3.9
4	$Al^{3+} = \sqrt{2.37241 - 1.18256*\sqrt{A}}$	3.10
5	$Fe^{2+} = (10.4608 - 1.77942*\sqrt{A})^2$	3.11
6	$SO_4^{2-} = \exp(-2.37032 - 0.416317*\sqrt{A})$	3.12

Table20.*Functions for estimating soil properties according to age of S. alba plantationson site typeIII*

No	Function	
1	$Humus = (1.0936 + 0.102606*A)^2$	3.13
2	$N = \sqrt{0.00358122 + 0.00288369*\sqrt{A}}$	3.14
3	$P = \sqrt{0.00286209 + 0.00264951*\sqrt{A}}$	3.15
4	$K = (0.358129 + 0.0736772*\sqrt{A})^2$	3.16
5	$Fe^{2+} = (10.7029 - 0.542894*A)^2$	3.17
6	$SO_4^{2-} = \sqrt{0.00975687 - 0.002881*\sqrt{A}}$	3.18

The relationshipbetweenwaterwith of the *S. alba* plantations *Element of water under the canopy of S. alba plantations*

The value of pH_{H2O} content varies very slightly with the age of the *S. alba* plantationson site type II, ranging from 6.3 to 6.4 with CV < 2.5%. Similarly, the DO. Componentalso varies very slightly with the age of the *S. alba* plantations, ranging from 5.4 on bare land to 5.5 under the canopy of the *S. alba* plantations; average 5.4 with CV = 2.6%. Compared with bare land (100%), the salinity of water under the canopy of the *S. alba* plantations from 1 to 4 years old is lower, respectively, by 6.6%, 12.6%, 14.9% and 17.7%; Al^{3+} content was lower, respectively, 5.9%, 16.1%, 28.2 % and 29.5%; Fe^{2+} content was lower, respectively, 4.1%, 12.6%, 22.4 % and 24.2%; SO_4^{2-} content was lower than 25.3%, 42.2%, 46.1% and 50.0%, respectively.

Relations* betweenwaterwith *the growth of S. alba plantations

The growth of the *S. alba* plantationssignificantly affects the element of the water(Table 21). The increase in the age of the plantations of the White spp. led to an increase in $pH_{H2O,}$ DO content, salinity, Al^{3+}, Fe^{2+} and SO_4^{2-}. However, the change in the SCI index of the plantations of the *S. alba* plantations a only resulted in a marked decrease in salinity (r = -0.982; $P < 0.01$), Al^{3+} content(r = -*0.977;P < 0.01*), Fe^{2+} content ($r = -0.951$; P< 0.01) and SO_4^{2-} ($r = -0.932$; $P < 0.01$). Regression analysis showed that the salt, Al^{3+}, Fe^{2+} and SO_4^{2-} contents could be estimated according to the age of the *S. alba*plantations (Table 22). These 4-component estimators exist at a very high significance level ($P < 0.01$) and the coefficients of determination ($r^{2)}$ range from 96% to 98%.

Table21.*Relationship between water andS. alba plantations.*

Soil characteristics	r	P_{α}	K (sample)
(1)	(2)	(3)	(4)
pH_{H2O}	-0.061	0.828	15
DO (mg/l)	-0.141	0.617	15
Salinity (‰)	-0.982	0.000	15
Al^{3+} (me/100g)	-0.977	0.000	15
Fe^{2+} (me/100g)	-0.951	0.000	15
SO_4^{2-}(me/100g)	-0.935	0.000	15

Table22.*Model for estimating water element according to age of S. alba plantationson site typeII.*

No	Function	
1	Salinity = $\sqrt{515.384 - 84.321*\sqrt{A}}$)	3.19
2	Al^{3+} = 0.2962 - 0.024*A	3.20
3	Fe^{2+} = 0.2054 - 0.0136*A	3.21
4	SO_4^{2-}= (0.225664 - 0.0334785* $\sqrt{A}$) ^{2}	3.22

The relationship between S. alba plantations andtheelement of soil and water

The relationshipbetweenthe S. alba plantations and the elementof soil

The results of SCI index of *S. alba* plantationson site type II have a relationship with 6 soil elements(N, P, K, Al, Fe, SO_4). The regression analysis shows that the SCI index only has a close relationship (R^2 = 56.8%) with 5 factors (N, P, K, Al, Fe)

SCI = 1.49875 + 35.2979*N + 30.9501*P + 150.295*K + 3.62515*Al - 0.266977*Fe - 7.7071*(N*P*K*Al*Fe) (Function 23)

R^2 = 56.8%; SEE = ±13.1

The SCI index of *S. alba* plantationsdepends the most on Fe content (Standardized Regression Coefficient |-0.843|); next is aluminum content (Standardized regression coefficient |0.341|); The lowest is the P content (Standardized regression coefficient |-0.008|.

The relationshipbetweenthe S. alba plantations and the elementof water

The results of SCI index of *S. alba* plantationsare closely related to 4 elementsof water (Salinity, Al, Fe, SO_4). The regression analysis shows that the change of SCI index of *S. alba plantations* s according to 4 factors (N, P, K, Al, Fe) has the form as Function 24.

SCI = 417,239 - 8,8789*Saline -372,895*Al - 839,412*Fe + 646,916*SO_4 + 387,745*(Saline*Al*Fe*SO_4) (Function24)

R^2 = 66.3%; SEE = ±25.3.

The change in the SCI index of the white coniferous forest depends the most on Fe content (*Standardized Regression Coefficient* |-1,416|); next is salinity (*Standardized regression coefficient* |-1,276|); The lowest is Al content (*Standardized regression coefficient*|0.704|.

Proposal to apply research results

Choose the type site for *S. alba* plantations

The growth of *S. alba* plantations is the highest in site type II.

The technique of *S. alba* plantations

S. alba plantations can be planted from 6-month-old seedlings. Seedlings need to be nursed in polyethylene with the size of 25 * 30cm. The seedlings broughtplanted aregood growing trees , straight stems and free from pests and diseases ; where the root diameter (D_0) and height (H) are greater than 0.5cm and 50cm respectively. Seedlings are planted in rows. The rows of white pine are planted in the direction at right angles to the riverbank and the sea. The initial planting density was 3,300 trees per hectare (1.5*2.0m). In order to help the seedlings after planting not to fall when encountering waves and strong winds , each tree is fixed by 3 bamboo poles with a diameter of 2-3cm and a height of 100-150cm. The stakes are inserted 40 – 60 cm deep; then the seedling is tied to the stake at two-third of the stems. Around the experimental plot is protected by a fencebamboo to reduce of strong waves and prevent of moss.

Planting *S. alba* plantationsto protect the environment along estuaries and sea

The estuary and coastal land can be improved by planting mangroves. In order to improve and protect the estuary and coastal environment of ThuaThien Hue province, the thesis proposes to plant *S. alba* plantations. This forest type is only well adapted to site type I and II. Techniques for planting and protection *S.alba*canopy closed, no thinning and no pruning. The strong growth of trunks and branches in *S. alba* plantations s has the effect of preventing large waves from crashing into structures along rivers and the sea. In addition, the plantations of *S. alba.* also have the effect of improving soil and water properties, increasing soil sedimentation.

4. CONCLUDE

S. alba plantations are well adapted to the sites in the coastal area of ThuaThien Hue province. They grow best on-site type II, then site type I and site type III. Site type II is the most suitable planted *S. alba.*

The element of the soil under the canopy of *S. alba* plantations are clearly different from those without afforestation. There is an increase value of pH-H_2O, humus content, nitrogen content, phosphorus content, potassium content and clay rate in the soil layer from 0-50cm when afforestation occurs. At the same time, there is a very clear decrease in the content of Al^{3+}, Fe^{2+} and SO_4^{2-}, the ratio of limon and sand in the soil layer from 0 - 50cm.

Growth of *S. alba* plantations depends closely on the element of water. Water factors improve with the age of the plantation, decreasing salinity, Al^{3+}, Fe^{2+} and SO_4^{2-} content. Increased growth will reduce the content of salinity, Al^{3+} and Fe^{2+} in water leading to the reduction of heavy metals in water. On the contrary, as growth increases with age, SO_4^{2-} content also increases in the water environment.

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