VETIVER GRASS FOR SUSTAINABLE AGRICULTURE ON ADVERSE SOILS AND CLIMATE IN SOUTH VIET NAM

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Abstract

Vetiver grass was successfully planted on some severely adverse soils in Vietnam, ranging from extreme acid sulfate, saline, acidic gray, sandy and alkali-sodic soils in arid area.

1. Productivity enhancement on sandy and saline sodic soil in semi arid condition

Agricultural production on the on sandy and alkali-sodic soils in semi-arid condition- annual rainfall is less than 300mm, is very limited due partly to the adverse soil conditions and partly to the lack of soil moisture. But once established under initial irrigation, vetiver grew exceptional well, with enormous biomass producing 12 tons and 25 tons/ha after 3 months on non saline sandy soils (96% sand) and alkali-sodic soils respectively. Its root went down to 70cm penetrating the sodic-petrocalcic horizon on saline-sodic soil, reaching sub surface moisture which the other plant can not do and soil pH and dissolved salt content were greatly reduced.

2. Embankment erosion control on extreme Acid Sulfate Soil

Vetiver grass was successfully used for embankment stabilisation and canal banks erosion control on extremely acidic conditions- very low pH (2.0-3.0) in dried condition, and very high in toxic element content (Al, Fe and SO_4^{2-}), where very few plants can survive, especially during dry season leading to severe and costly bank erosion problem.

3. Protection sea dike in sea water affected area

VS is being used to protect the outer batter of a sea dike built to protect shrimp ponds and farmlands. As the building materials were dredged on site so it is highly saline (EC (8- 11 mS/cm) and erodible, and affected by sea water intrusion. After 15 month, the dyke surface was well stabilised, soil loss was dramatically reduced, from 190mm to 27mm.

4. Embankment stabilisation and erosion control on acidic gray soil

VS was very successful in stabilizing to upper section of a concrete irrigation channel, especially where the weak structure building materials used. Twelve months after establishment, no more erosion occurred on the surface above the concrete and the cracks of concrete lining caused by seepage were also under control.

Keywords: Acid sulfate, saline, alkaline sodic, soil compaction

1.0 INTRODUCTION

Vetiver grass was successfully planted on some severely adverse soils in Vietnam such as sandy and alkaline-sodic soil in the semi-arid area of central Vietnam, extreme acid sulfate soils in the Mekong Delta, highly saline soil on the coastal zone, acidic gray soil in the eastern zone. Once established vetiver grass greatly improved irrigation and drainage canal bank stability and reduced bank erosion on extreme acid sulfate and saline dike system near the coast. Vetiver grass also improves soil fertility, fodder for livestock and effective in controlling wind erosion on sandy and sodic-saline soil in semi-arid condition in Vietnam.

2.0 PRODUCTIVITY ENHANCEMENT ON SANDY AND SALINE SODIC SOIL UNDER SEMI ARID CONDITIONS

A very peculiar climatic condition occurs in two provinces of central Vietnam, although they situated right on the coast, they experience a semi arid condition, with annual rainfall often less than 300mm, resulting in extreme shortage of fresh water for cropping and animal husbandry (Table 1). In addition the “soil” or more correctly the coastal dune is saline, alkaline, sodic with a compacted layer very close to the surface, it is also prone to wind erosion and water erosion when it rains, hence very sparse in vegetation and fodder for livestock. These factors give rise to extreme hardship and poverty to the local population.

2.1 Objectives and Site Details

A trial was established to determine:

- Whether vetiver can survive under these extremely harsh conditions:
    - Mean annual rainfall 300- 350mm,
    - Extremely hot and dry wind (40oC) in the summer
    - Mean evaporation 150mm
    - The sandy soil is almost pure sand, composed of 96% sand, 2% loam and 2% clay. It derives mostly from coastal dunes, with no structure, no organic matter, extremely low in fertility, neutral in pH (Table 2).
    - The saline alkaline soil with high pH (9-10), sandy loam in structure with a highly compacted layer (natric-petrocalcic horizon) about 70cm from the surface. The surface layer is highly saline due to capillary action (Table 3).
- Whether vetiver can improve the productivity of these soils.

Table 1: Some soil and climate data of the experimental site (2004-05)

2004	Rainfall (mm)	Evaporation (mm)	2005	Rainfall (mm)	Evaporation (mm)
Jan	-	158.1	Jan	-	142.5
Feb	-	176.5	Feb	-	178.8
Mar	-	171.0	Mar	1.2	174.1
Apr	10.1	190.6	Apr	2.4	192.3
May	65.5	142.2	May	16.0	153.0

Jun	162.7	153.3	Jun	22.0	103.6
Jul	35.2	112.1	Jul	53.2	158.1
Aug	11.3	115.5	Aug	27.0	161.6
Sep	18.8	136.8	Sep	137.6	117.0
Oct	40.7	146.9	Oct	94.8	115.7
Nov	0.4	-	Nov	-	-
Dec	0.8	-	Dec	-	-

Sandy soil in its original state and being used for grape growing

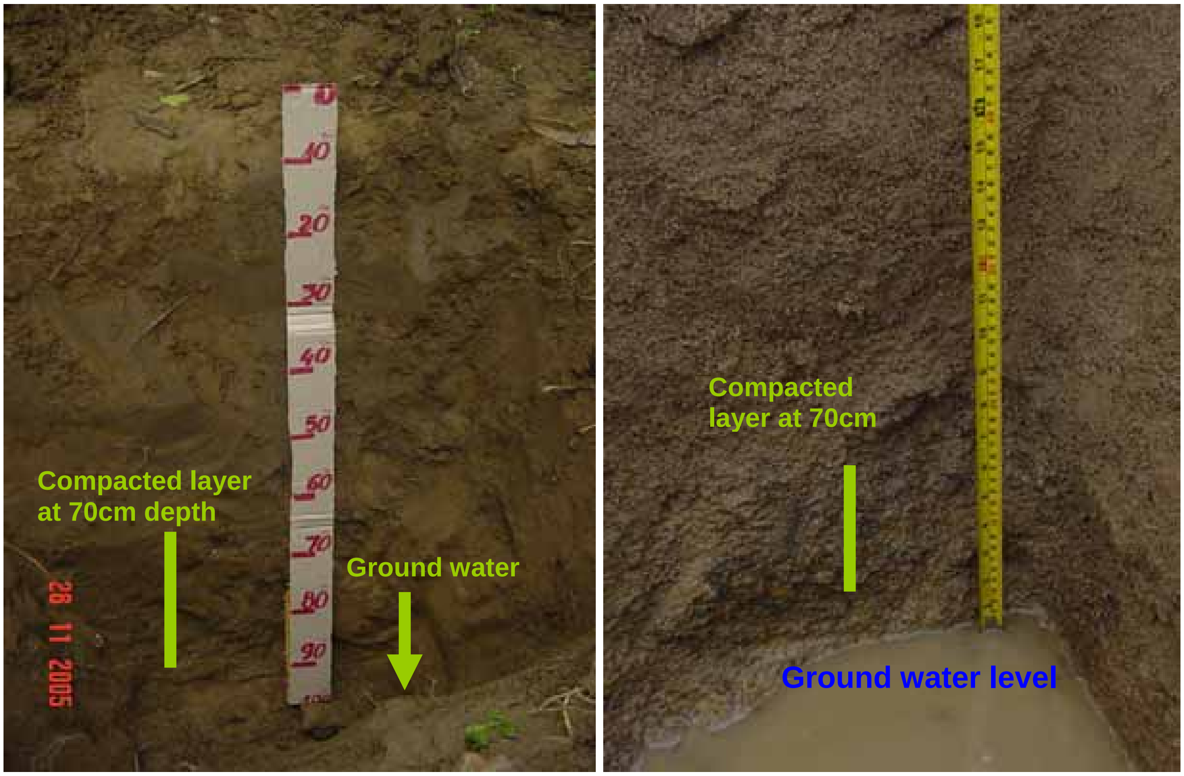
Table 2: Some chemical characteristics of the sandy soil

Soil Depth	pH		EC μs/cm	Org. matter	N	P	K	Ca^{2+}	Mg
	H_2O	KCl		%		mg/100g		1dl/100g	
Top soil (0-20cm)	7,45	6,51	101	0,185	0,04	2,719	3,52	0,76	0,4

Table 3: Some chemical characteristics of the original uncultivated saline alkaline soil

Depth (cm)	pH (1:1water)	ECmS/cm (1:2.5)	Exchangeable Cations (meq/100g)			
			Ca^{2+}	Mg^{2+}	K^+	Na^+
0-20	9.66	0.71	3.89	3.13	-	7.70
20-40	9.62	2.40	5.86	4.72	-	11.78
40-60	10.16	1.32	6.62	5.33	-	9.33
60-80	10.13	0.94	15.24	11.67	-	7.67
80-100	10.14	0.81	4.12	5.3	-	6.20

Ground water level is just below the compacted horizon at 70cm from surface.



2.2 Establishment and Yield

Under this extremely harsh environment, corn can be established with irrigation but seldom reach maturity because of water shortage. On the other hand Vetiver grew 2-3 times faster than on any other crops on this soil and climate and produce extremely high biomass as shown below.

Following planting vetiver was irrigated with 5 litres/5 plants and total rainfall over the 2 month growing period was only 80.2 mm. The followings are results three months after planting:

2.2.1 Sandy soil

- 80% of the bare root slips started growing 10 days after planting
- Fresh yield (harvested 20cm from ground level) after 60 days was 12t/ha, equivalent to 5t/ha dry matter yield.

2.2.2 Saline Alkaline Soil

- Very good establishment (100%) from bare root slips, plant started growing and tillering 10 days after planting
- Fresh yield (harvested 20cm from ground level) after 60 days was 25t/ha.

While vetiver root penetrated the compacted barrier to tap this ground water and flourished, corn and grape could not and died if not irrigated

2.3 Root Development

On both soil types, after 60 days vetiver roots reached down to 70 cm, and most remarkably they penetrated through the sodic-petrocalcic horizon on the saline sodic soil, where both crop and other native plant roots can not do.

The main reason for the large difference in growth between Vetiver and corn is the penetrating power, volume and depth of the vetiver root system.

Once the penetrating and massive Vetiver roots pierced through the compacted sodic-petrocalcic horizon it could tap into the underground water supply. In contrast the corn plant can not do this because of its poorer root system, and even if the corn root could reach the underground water supply, corn cannot tolerate the high pH and saline water. This would result in very poor establishment growth in the corn crop

2.4 Effect of Vetiver Planting on Soil Characteristics

A great improvement in soil fertility was noted only 3 months after vetiver planting, pH and soluble salt were greatly reduced. Soil pH reduced up to 2 units from surface layer down to 1m depth and dissolved salt content, especially sodium content was reduced more than half (Table 4), resulting in very large improvement in productivity of local crops such as corn and grapes. Whereas soil pH has hardly changed after 3 years of grape cultivation (Table 5).

Table 4: Changes in some chemical characteristics of the saline alkaline soil before and after vetiver planting

Depth	**pH**	**ECmS/cm**	**Exchangeable Cations (meq/100g)**			
Before vetiver planting						
(cm)	(1:1water)	(1:2.5)	Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}
0-20	9.72	0.96	19.8	1.32	4.65	2.53
20-40	9.67	0.47	4.28	0.88	0.38	4.81
40-60	9.82	0.46	2.2	0.2	0.31	7.18
60-80	10.10	0.88	2.0	0.56	0.75	1.35
80-100	10.12	1.07	2.4	0.16	0.84	5.05
Three months after vetiver planting						
0-20	8.02	0.42	9.6	8.06	-	0.40
20-40	7.87	0.45	3.0	2.45	-	0.75
40-60	7.62	0.27	1.88	2.63	-	0.39
60-80	6.90	0.37	1.66	2.92	-	0.70
80-100	7.84	0.31	2.28	2.69	-	0.21

Moreover, more yield enhancement was recorded when the green vetiver shoot and leaf was composted and used for corn and grape crops and vetiver biomass is also an excellent fodder source for livestock in this semi arid environment.

Biomass is used as mulch for the grape crop or fodder for livestock

Table 5: Some chemical characteristics of the saline alkaline soil after 3 years of grape cultivation.

Depth	pH	ECmS/cm	Exchangeable Cations (meq/100g)			
(cm)	(1:1water)	(1:2.5)	Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}
0-20	9.45	0.30	5.80	6.05	-	2.12
20-40	8.03	0.09	1.80	2.19	-	0.08
40-60	7.30	0.13	1.44	1.60	-	0.51
60-80	8.04	0.17	1.32	1.53	-	1.32
80-100	9.79	0.30	2.12	1.1	-	6.72

3.0 CANAL AND ROAD EMBANKMENT EROSION CONTROL ON EXTREME ACID SULFATE SOIL

To develop agriculture and aquaculture in the acid sulfate soil region, it is essential to build an effective and stable drainage and irrigation system for watering. In addition the acid sulfate zones are of low in topography and are flooded annually, causing extreme hardship to local population. The common feature of this region is to use local soil – high clay, low pH and high in toxic elements - to build infrastructure, hence very prone to soil erosion due to lack of vegetation covers. The main objective of this project is to establish vetiver grass to protect these infrastructures from erosion.

Although different in geographical distribution, the soils are all extreme acid sulfate, pH from 2.0-3.0 in the dry season and with high level of Al, Fe, SO_4^{2}. Due to the high clay content of the soil, it cracks on drying, resulting in large holes and letting water in, causing erosion in the rain and flood seasons. Because of these features, very few endemic plants can establish and survive during the dry season, including those considered locally as tolerant species (Table 6).

Table 6: Some chemical characteristics of the acid sulfate soil used for irrigation and drainage dike construction

pH (water)	**EC(mS/cm)**	**Al^{3+} (meq/100g)**	**Active Fe (ppm)**	**SO_4^{2-} (meq/100g)**
2.00 - 3.00	1-3.9	25-32	800-1200	6-7

Vetiver grass was used for embankment stabilisation and canal banks erosion control at 5 sites, located on extreme acid sulfate zone: one flood protection dike (protecting a flood-escaping community) in Tiền Giang province, three in Long An provinces and one on a section of a flood protection dike near Ho Chi Minh City.

There was no problem with establishment when polybags was used but all vetiver bare root slips died when planted directly to the fresh acid sulfate soil. However it could survive and grew normally on that soil with a small amount of lime, good topsoil or manure added to the furrows first. The survival rate was more than 80% and vetiver grew normally as planted on good soil.

The following results were recorded:

- Over period of four-months, once vetiver was established, soil loss by erosion was markedly reduced. On bare canal banks the soil loss was 400-750 tons/ha as compared with only 50-100 tons/ha on a channel embankment protected by vetiver.
- Soil loss was negligible after 12 months.
- When vetiver was trimmed to 20-30cm height and the shoots were used as much covering the bare area of the bank, the banks were completely stabilised.

Erosion on dike batters built with Acid Sulfate Soil

Before and after vetiver planting

Note the sediment trapped by vetiver hedge. Soil loss was reduced by 65-80%

4.0 PROTECTION SEA DIKE IN SEA WATER AFFECTED AREA -

At Go Cong Dong, Tien Giang province, vetiver was used to protect the outer batter of a sea dike system built to protect aquaculture ponds and farmlands. As in the acid sulfate soil region, the building materials were dredged on site so it is highly saline, sandy and erodible, endemic vegetation was negligible, mostly covered with samphires, a beach succulent in the rainy season (Table 7). Therefore the banks were easily eroded in the wet season and also their toe slopes were washed away by sea waves in high tides. A small trial section -1000m- of the dike was planted with 7 rows of vetiver, 3 on the top portion and 4 on the toe slope. Bare root slips and rice hull ash were used, watered if no rain fell during establishment period.

The following results were recorded:

- Very good survival, all green up after 7-10 days, especially those not affected by sea water.
- Solid hedges were obtained in rows those not affected by sea water. Soil is directly affected by sea water with neutral in pH (7-8), very high in EC (8- 11 mS/cm) and dissolved salts. Vetiver plant growth is excellent in rows above the inundated level, especially the first row from the surface of the dike.
- After 15 months, dike surface was completely stabilised, soil loss by erosion dramatically reduced, from 190mm to 27mm, due to the effect of vetiver grass itself and the thick cover of samphires, that is growing very well not only on the batter but also on the toe, where vetiver were planted.
- Where vetiver was not planted samphires only grew near the top of the dikes not at the toe. Where as on section with vetiver it grew from top to bottom of the dike.
- Dry matter yield of samphires on vetiver section was 447g/m^2, as compared with 283g/m^2 on areas with no vetiver.

Bank erosion due to poor vegetation covers (samphires). Mangrove on the top corner

Excellent establishment and growth, four months after planting

Two years after planting, note the good covers of samphires on the top of the dike

Contrast between unprotected and protected banks. Mangrove on the right corner

Table 7: Some chemical characteristics of the soil used to built the sea dike at Go Cong

Position	pH (water)	pH (KCl)	EC(mS/cm)	Org. cont. (%)
Dike bank	6.72	6.48	5.7	0.92
Dike toe	6.53	6.03	11.1	1.49

5.0 EMBANKMENT STABILIZATION AND EROSION CONTROL ON THE ACIDIC GRAY SOIL

The Dau Tieng irrigation scheme was established to supply water for the rich farm land along its route. The construction specification was to use material high in kaolinite clay so in term of fertility this material is sterile with pH around 5.0-5.5. The channel was paved with concrete lining, but with varying topography over its 100km length, on higher section only the floor and bank area 50cm above supply level were covered with concrete to reduce cost, leaving the higher section unprotected area and prone to extreme erosion. In addition, in low section of the channel, the surface and bank of the canal are also weak because of the soil poor physical characteristics.

A section of about 500m of this channel, near Ho Chi Minh City, where about 2-3m of the top portion of the bank was not covered with concrete, vetiver was planted on both sides, one row right on top of the concrete wall and 1 or 2 rows (1m apart) on the upper section depending on the slope length. With the addition of small amount of manure there was no problem with establishment on this sterile soil.

Once well established and after 12 months of growing, no more erosion occurred on the surface above the concrete. Water often collected on the depressions along the top of the dike, this water in addition to weakening the dike structure, causing severe erosion when seepage and runoff draining to the channel, resulting in cracks and eventual collapse of the concrete wall. This problem was irreparable in the past, but with vetiver planting, runoff and seepage were eliminated, the surface stay dry and the thick hedge retain the gravel used to maintain the dike surface and it was particularly remarkable that neither erosion nor cracks developed over the two years of the trial.

Three weeks after planting


Two and half years after planting, note some endemic plants re-established between hedges.


6.0 CONCLUSIONS

1. Vetiver grass grows extremely well in sandy and sodic alkaline soil along the coast even under semi arid conditions. Its penetrating root system pierced the petrocalcic horizon, reaching deep moisture reserve where other crop roots can not reach. Vetiver planting also improve soil fertility by reducing pH and soluble salt content of the soil to 1m deep, especially Ca and Na, and at the same time improved its organic content by its root and shoot.

2. Vetiver grass can be established on the extreme acid sulfate soils of the Mekong delta, but the planting medium has to be slightly modified by adding a small amount of top soil, manure or lime so that its roots can develop normally. Four months after establishment, dike erosion and slippage were reduced markedly and no further erosion after one year.

3. Vetiver grass grew well on a sea dike on the estuary of the Mekong River and 15 months after planting, erosion on the dike surface was reduced from 190mm to only 27mm. At the same time, vetiver planting promoted the growth of endemic species both on top of the dike and at its toe, which was often inundated during high tide period.

4. Vetiver grass is also very effective in controlling erosion on irrigation channel banks on poor gray clay. After 12 months no further erosion occurred, particularly on low and weak sections of the channel.

7.0 ACKNOWLEDGMENTS

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8.0 REFERENCES

Arun Prasad and DDPatra. Ameliorative potential of vetiver for reclamation of sodic soils.

Liyu Xu, S. Lu and P. Truong. Vetiver system for agriculture development. Paper presentation, IVC3, Guangzhou, China October 2003.

L.V. Du and P.N. Truong. Vetiver grass system for erosion control on severe acid sulfate soil in southern Vietnam. Paper presentation, IVC3, Guangzhou, China October 2003.

Tran tan Van, Elise Pinners, P. Truong. Coastal dune stabilization in Central Vietnam. Paper presentation, IVC3, Guangzhou, China October 2003.

Truong, P.N. Vetiver grass technology for land stabilization, erosion and water Bioengineering for erosion control and slope stabilization. Manila, Philippines, April 1999.

A Brief Introduction to the First Author

Mr Le Van Du is the Head of the Soil Science Division of the Agriculture Forestry University in Ho Chi Minh City, Vietnam. He is an active member of the Vietnam Vetiver Network and in the last 4 years he has been responsible for the R&D of VS under extreme conditions such as acidic, saline, sodic, alkaline soils.