

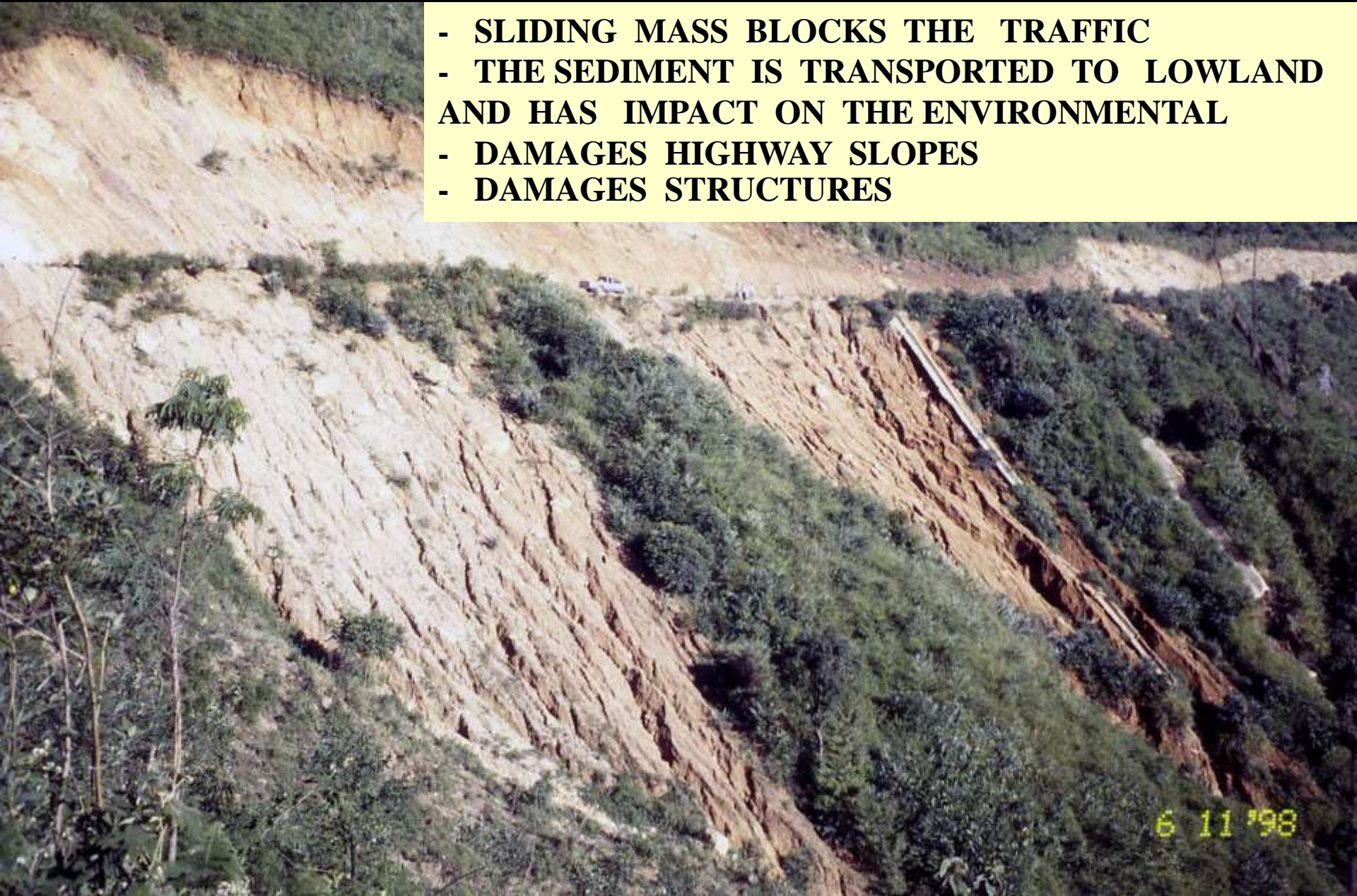


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Department of Highways Thailand

**SUSTAINABLE VETIVER SYSTEM IN EROSION CONTROL
AND STABILIZATION FOR HIGHWAYS SLOPE IN
THAILAND**

1.1) EROSION PROBLEMS IN HIGHWAY CONSTRUCTION AND MAINTENANCE

- SLIDING MASS BLOCKS THE TRAFFIC
- THE SEDIMENT IS TRANSPORTED TO LOWLAND AND HAS IMPACT ON THE ENVIRONMENTAL
- DAMAGES HIGHWAY SLOPES
- DAMAGES STRUCTURES



1.1) EROSION PROBLEMS

1.1.1) EROSION ON BACK SLOPE (CUT SLOPE)



- SLIDING MASS BLOCK THE TRAFFIC
- SEDIMENTS FILL UP SIDE DITCH AND BLOCK WATER FLOW
- WATER FLOW ACROSS THE ROAD , ERODE AND DAMAGES EMBANKMENT SLOPE

1.1) EROSION PROBLEMS

1.1.2 EROSION ON SIDESLOPE (FILL SLOPE)



SHALLOW-SEATED FAILURUE

STRONG EROSION (LACK OF ADEQUATE PREVENTIVE) INDUCED TO SHALLOW MASS MOVEMENT OF SOILS (SHALLOW-SEATED FAILURE)

1.1) EROSION PROBLEMS

1.1.3) EROSION AT THE END OF SURFACE DRAINAGE SYSTEMS



1.1) EROSION PROBLEMS

1.1.4) STREAM BANK EROSION



EROSION AT THE TOE OF EMBANKMENT SLOPE ALONG THE STREAM CHANNEL WAY



"นามิกรรมา"

โครงการปลูกต้นไม้เฉลิมพระเกียรติ... (Text describing the project's purpose and history, mentioning the King's 60th birthday and the goal of planting 100 million trees.)

เส้นทางนี้...ไม่เคยสิ้นสุด

โครงการปลูกต้นไม้เฉลิมพระเกียรติ... (Text describing the project's impact and the role of the Highway Department in promoting environmental protection.)



โครงการพัฒนาและรณรงค์การใช้หญ้าแฝกอันเนื่องมาจากพระราชดำริ กรมทางหลวง

2. การนำร่องรักษาทางหลวง

3. โครงการศึกษาทดลอง ปรับปรุงพัฒนาประสิทธิภาพ

1.2) BACKGROUND OF THE VETIVER GRASSING PROJECT OF THE HIGHWAYS DEPARTMENT, THAILAND

1.2) BACKGROUND OF THE VETIVER GRASSING PROJECT OF THE HIGHWAYS DEPARTMENT, THAILAND

1.2.1 VETIVER SYSTEM FOR HIGHWAY CONSTRUCTION PROJECT.

**VS FOR EROSION CONTROL AND STABILIZED ON DEEP
CUT AND HIGH FILL SLOPE**



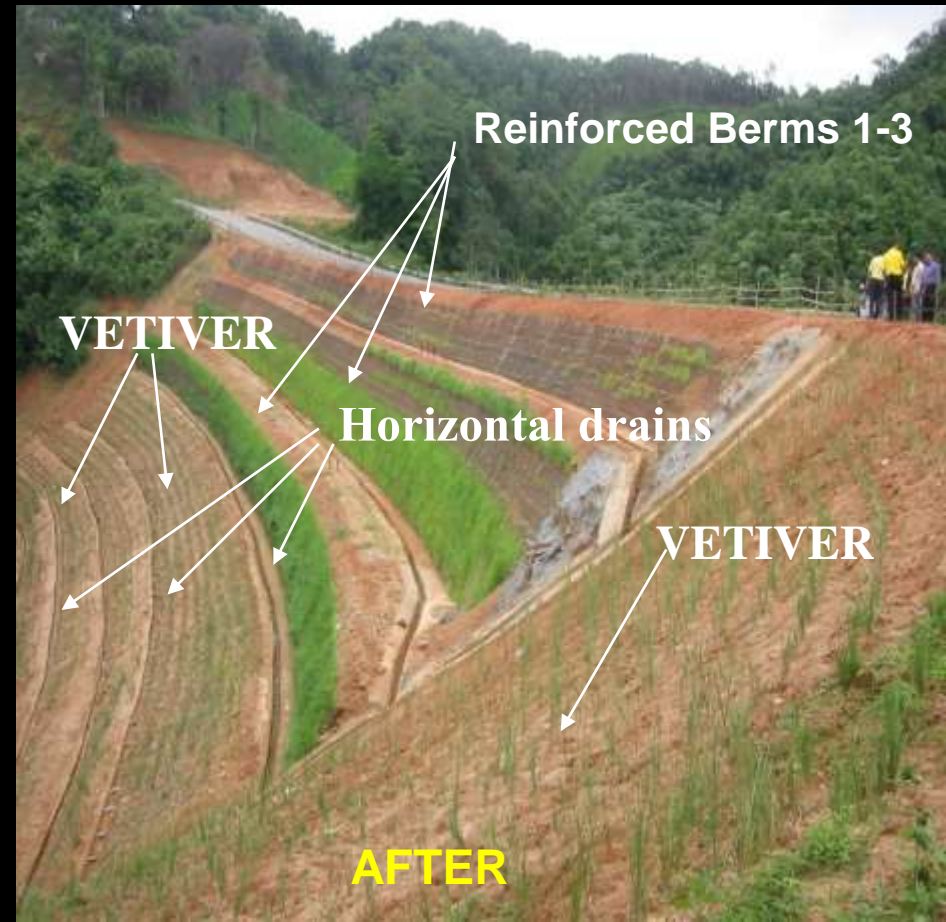
1.2) BACKGROUND OF THE VETIVER GRASSING PROJECT OF THE HIGHWAYS DEPARTMENT, THAILAND

1.2.2 VETIVER SYSTEM FOR HIGHWAY MAINTENANCE



1.2) BACKGROUND OF THE VETIVER GRASSING PROJECT OF THE HIGHWAYS DEPARTMENT, THAILAND

1.2.3 VETIVER SYSTEM FOR HIGHWAY MAINTENANCE IN REHABILITATION OF COLLAPSED EMBANKMENT SLOPES



2) SLOPE EROSION CONTROL AND STABILIZATION MECHANISM BY VETIVER

LIVING SOIL NAIL

(2 – 3 M.)



LIVING WALL



UNDERGROUND CURTAIN

- Average tensile strength of 75 MPa.(0.7-0.8 mm. root dia.)
- Improve the shear strength of soil ~30 %

VETIVER CONTRIBUTING TO EROSION CONTROL AND STABILITY OF SLOPE BY :

- 1) SLOW DOWN RUNOFF**
- 2) ROOT REINFORCEMENT**
- 3) EVAPOTRANSPIRATION**

REDUCE RUNOFF ~ 70%



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3) APPLICATION OF THE VETIVER SYSTEM IN EROSION CONTROL AND STABILIZATION OF HIGHWAY SLOPES

3.1) THE PATTERN OF VETIVER GRASSING ON HIGHWAY SLOPE

3.1.1) ON SLOPES WHERE EROSION IS NOT SEVERE



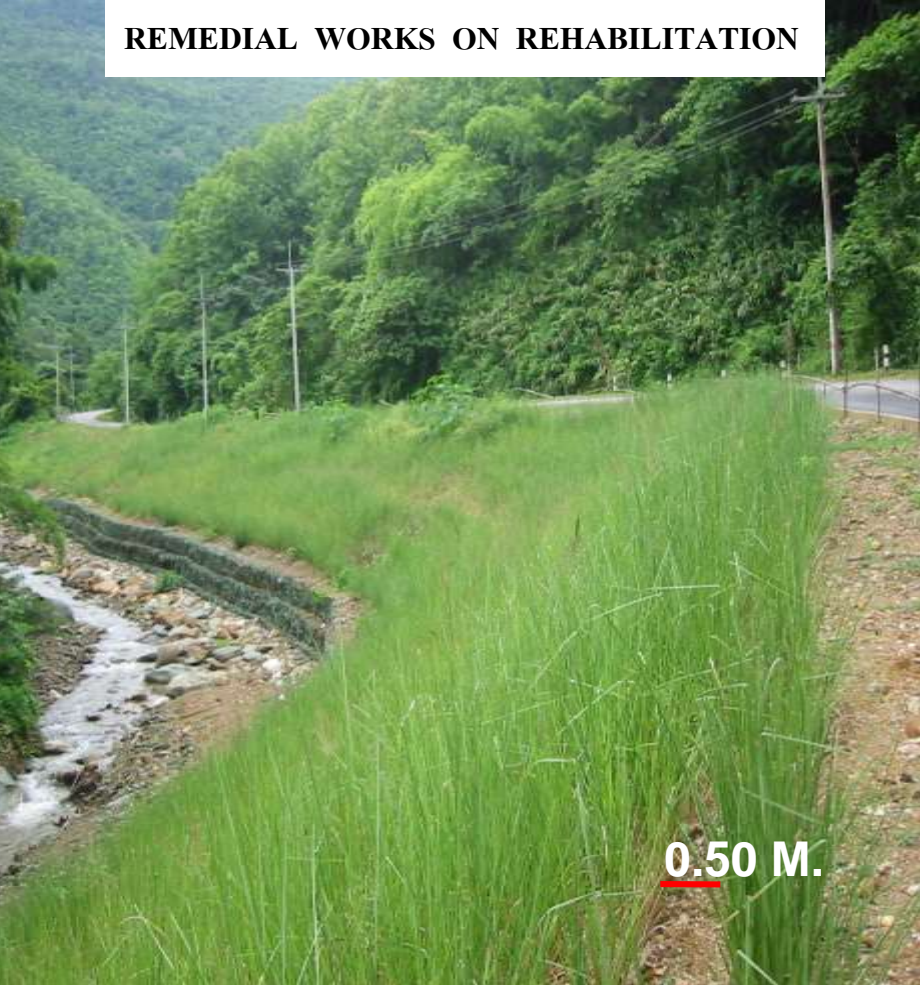
- PLANTING THE VETIVER IN LARGE SCALE AREA FOR
GENERAL PREVENTIVE PURPOSE

-THE SPACING BETWEEN THE PLANTING ROWS CAN BE 1 METER APART AND 10 CMS. BETWEEN THE CLUMPS.

3) APPLICATION OF THE VETIVER SYSTEM IN EROSION CONTROL AND STABILIZATION OF HIGHWAY SLOPES

3.1.2) ON SLOPES WHERE EROSION IS SEVERE

REMEDIAL WORKS ON REHABILITATION



-STRONGLY ERODING SITES OR COLLAPSED SLOPES



0.50 M.

THE SPACING BETWEEN THE PLANTING ROWS IS 0.5 METER APART AND 5 TO 10 CMS. BETWEEN THE CLUMPS

3) APPLICATION OF THE VETIVER SYSTEM IN EROSION CONTROL AND STABILIZATION OF HIGHWAY SLOPES

3.2) THE BENEFITS OF VETIVER GRASSING FOR HIGHWAY SLOPE ARE IN 6 FORMATIONS

FIRST APPLICATION



VS IS APPLIED FOR HIGHWAY BACK SLOPE (CUT SLOPE)

SECOND APPLICATION

HIGHWAY



VS IS APPLIED FOR HIGHWAY SIDE SLOPE (FILL SLOPE)



THIRD APPLICATION

GABION WALL



**VS IS APPLIED FOR STREAM BANK ALONG THE ROADWAY FOR RIVER
EROSION PROTECTION**

**IN THIS APPLICATION VETIVER IS PLANTING ON THE SLOPE FACE
OVER THE ROCK FILL OR GABION WALL**

FOURTH APPLICATION



VETIVER

VS IS APPLIED FOR HIGHWAY DITCH LINING

FIFTH APPLICATION

VS IS APPLIED ON SHOULDER SLOPE FOR EROSION CONTROL AT STEEP GRADIENT SECTION.



SIXTH APPLICATION

GABION WALL



VS WITH SLOPE PROTECTION WORKS

- VS IS ASSOCIATED WITH GABION WALL AND SURFACE DRAINAGE SYSTEMS

4) SITUATION AND PROBLEMS IN THE VETIVER GRASS PROJECTS OF THE HIGHWAYS DEPT. THAILAND

4.1) UNSUSTAINABILITY OF VETIVER SYSTEM



**VIGOROUS
LOCAL WEEDS**

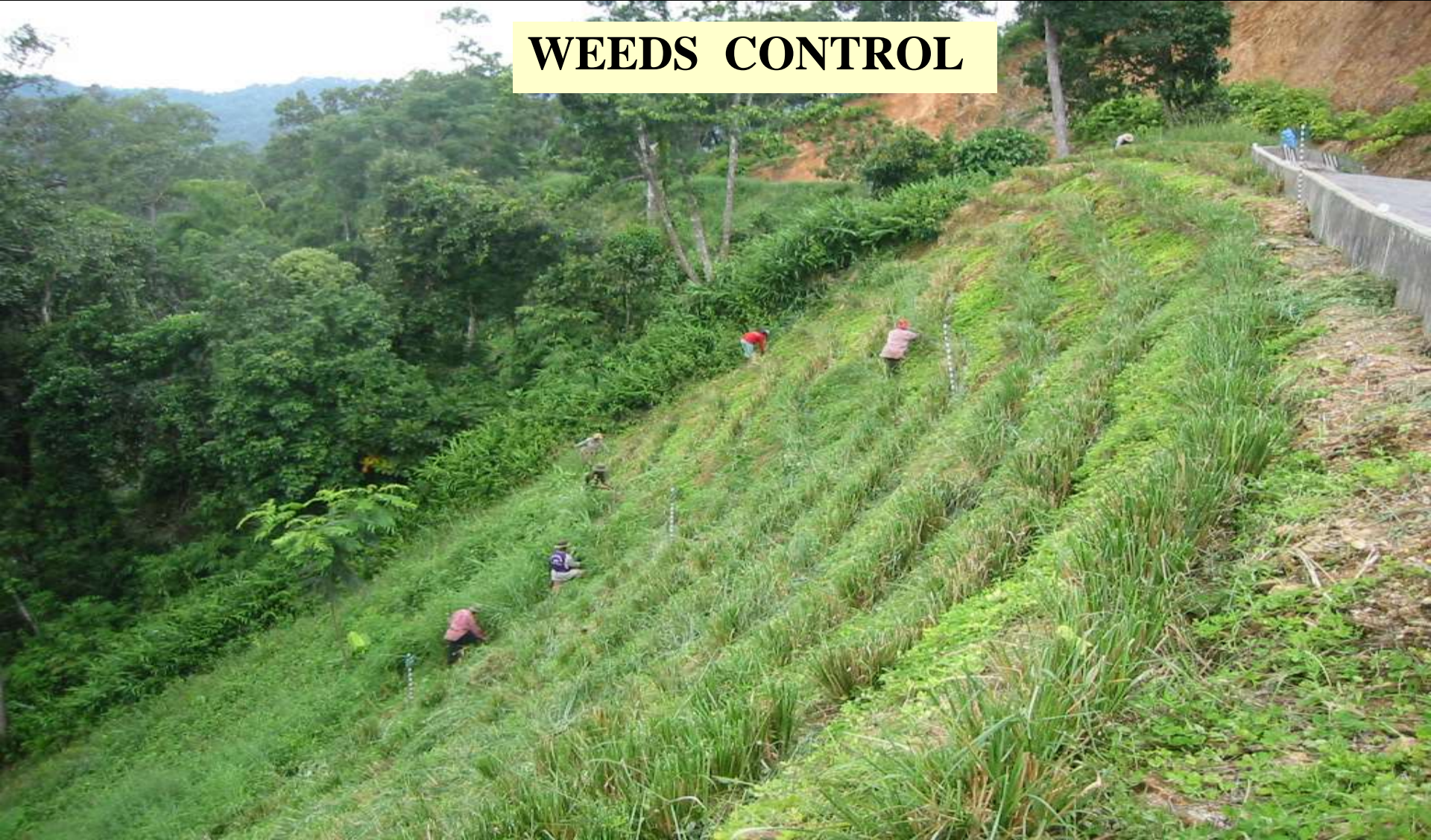
POORLY DEVELOPED VETIVER

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4) SITUATION AND PROBLEMS IN THE VETIVER GRASS PROJECTS

4.2) MAINTENANCE FOR 1-2 YEARS AFTER PLANTING

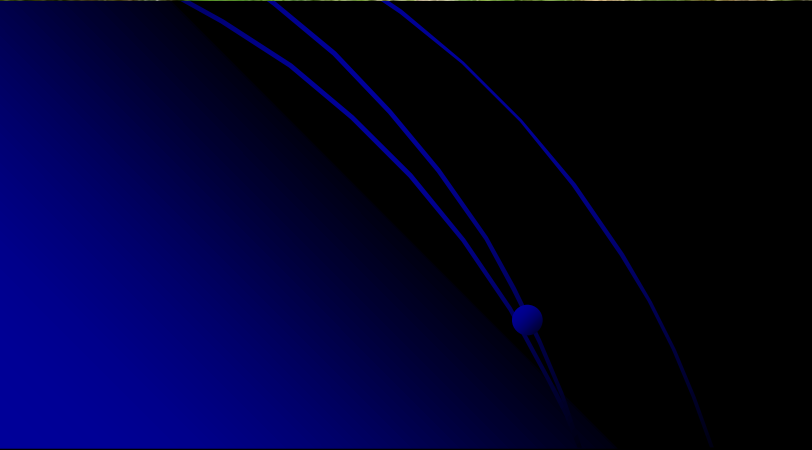
WEEDS CONTROL



4) SITUATION AND PROBLEMS IN THE VETIVER GRASS PROJECTS

MAINTENANCE FOR 1-2 YEARS AFTER PLANTING (FERTILIZATION)

FERTILIZATION



4.3) EXPERIMENTAL STUDY (HIGHWAYS ROUTE NO. 3272 KANCHANABURI PROVINCE, THAILAND: 2003 – 2006)

4 .3.1) TO STUDY THE OPTIMUM PLANTING TECHNIQUES AND MAINTENANCE COST




EXPERIMENTAL DESIGN

S1 = SOIL FERTILITY IMPROVEMENT AND MAINTENANCE FOR 2 YEARS

S2 = SOIL FERTILITY IMPROVEMENT

S3 = CONTROL



8+250-8+178 Rt
S3-PO-D 05

**POORLY DEVELOPED
VETIVER (SURVIVAL
RATE 20 - 30 %)**

EXPERIMENTAL PLOT (S3): VETIVER PLANTING FOR 2 YEARS (AUGUST,04 - JULY, 06)

4.3) EXPERIMENTAL STUDY

4.3.2) TO STUDY THE EFFICIENCY OF *ARACHIS* 'PINTOI' TO CONTROL WEEDS

VETIVER INTERPLANTING WITH *Arachis pintoi* (LEGUMINOUS PLANTS)



5) SUSTAINABLE VETIVER SYSTEM

5.1 OPTIMUM PLANTING TECHNIQUES

5.1.1 SUITABLE VETIVER TILLERS

NURSERY VETIVER SLIPS IN POLY-BAGGED FOR 45-60 DAYS TO PRODUCE ACTIVE TILLERS



5) SUSTAINABLE VETIVER SYSTEM

5.1 OPTIMUM PLANTING TECHNIQUES

5.1.1 SUITABLE VETIVER TILLERS

ACTIVE TILLERS AT AGE OF 45-60 DAYS MUST BE PLANTED



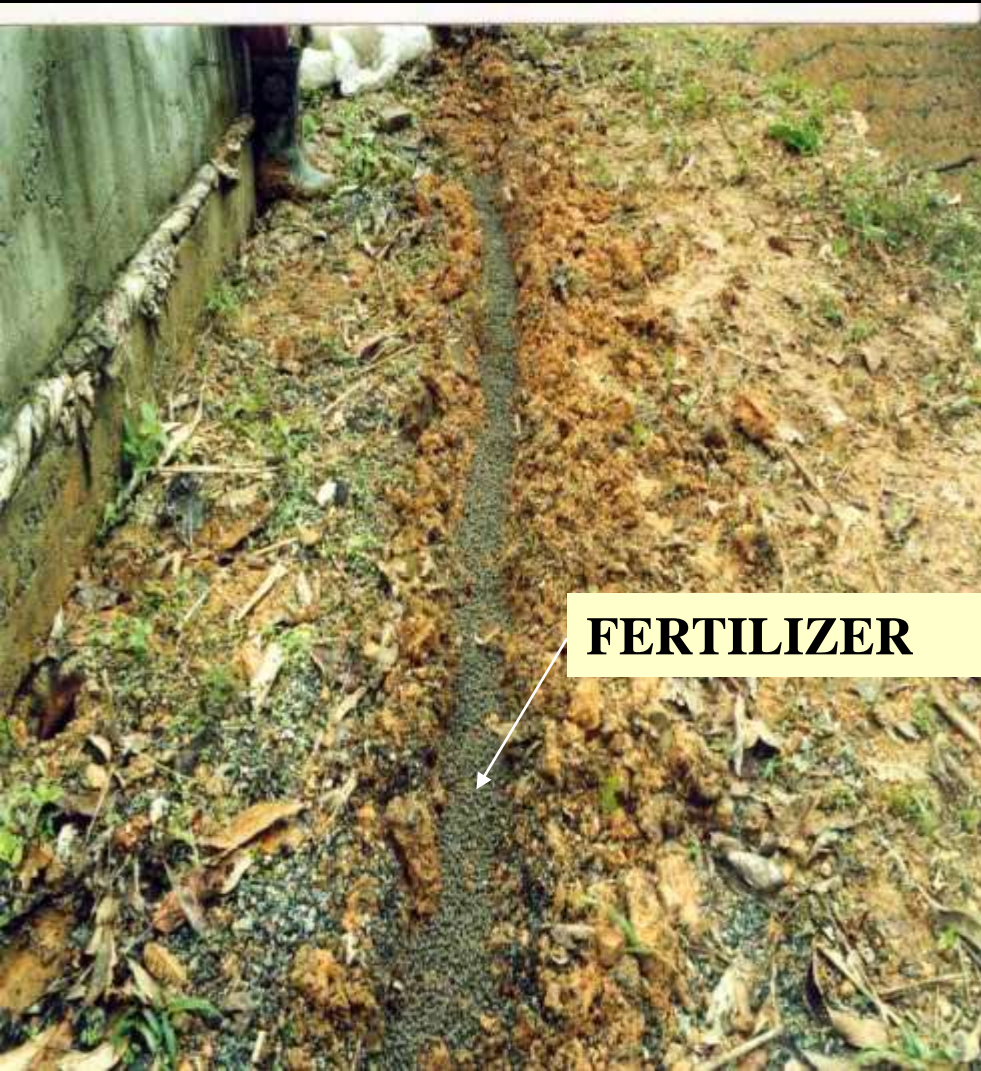
**ACTIVE
TILLER**

**UNGROWTH
ORIGINAL
SHOOT**

5) SUSTAINABLE VETIVER SYSTEM

5.1 OPTIMUM PLANTING TECHNIQUES

5.1.2 SOIL FERTILITY IMPROVEMENT: FERTILIZE THE SOIL WITH BASAL APPLICATION OF CHICKEN MANURE OR FARMYARD MANURE MIXED WITH CHEMICAL FERTLIZERS



5) SUSTAINABLE VETIVER SYSTEM

5.1 OPTIMUM PLANTING TECHNIQUES

5.1.3 PLANTING DURING SUITABLE PERIOD (AT LEAST 2 MONTHS FOR VETIVER GROWING IN RAINY SEASON)

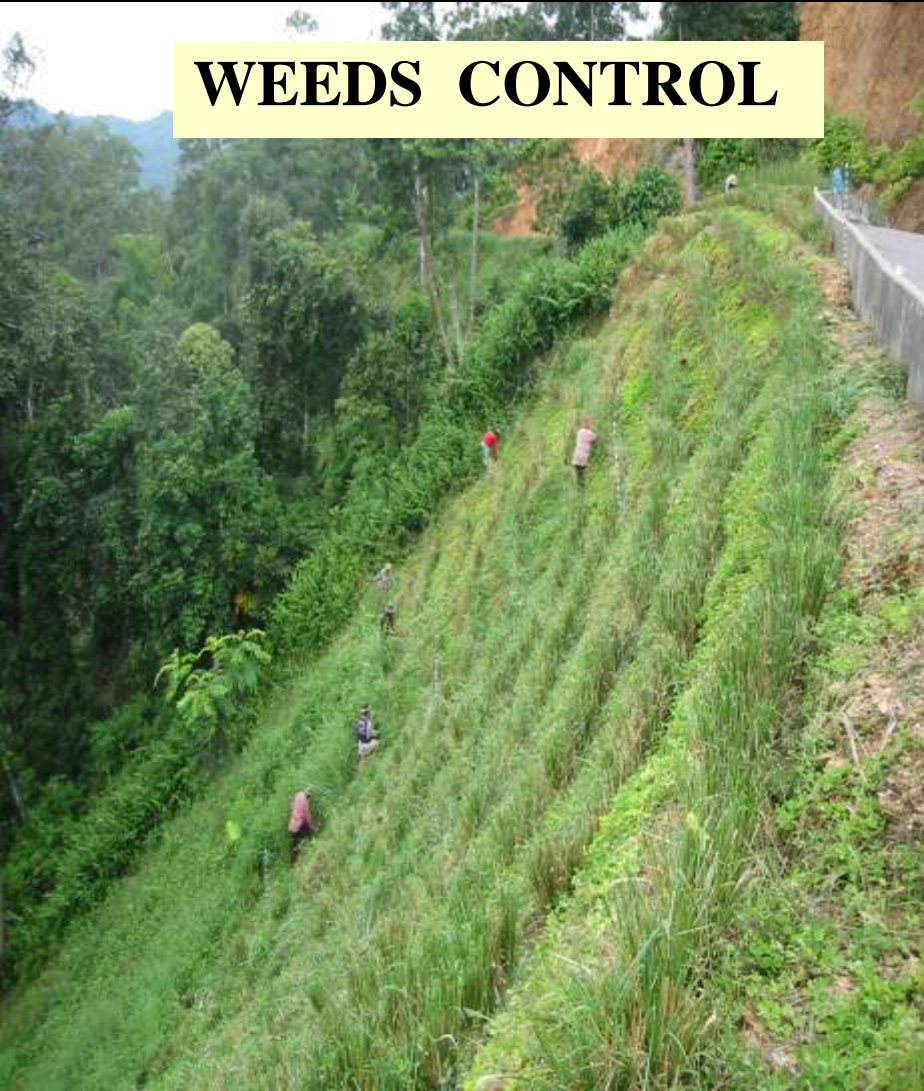


ACTIVE TILLERS AT AGE 45-60 DAYS (IN POLY-BAG)

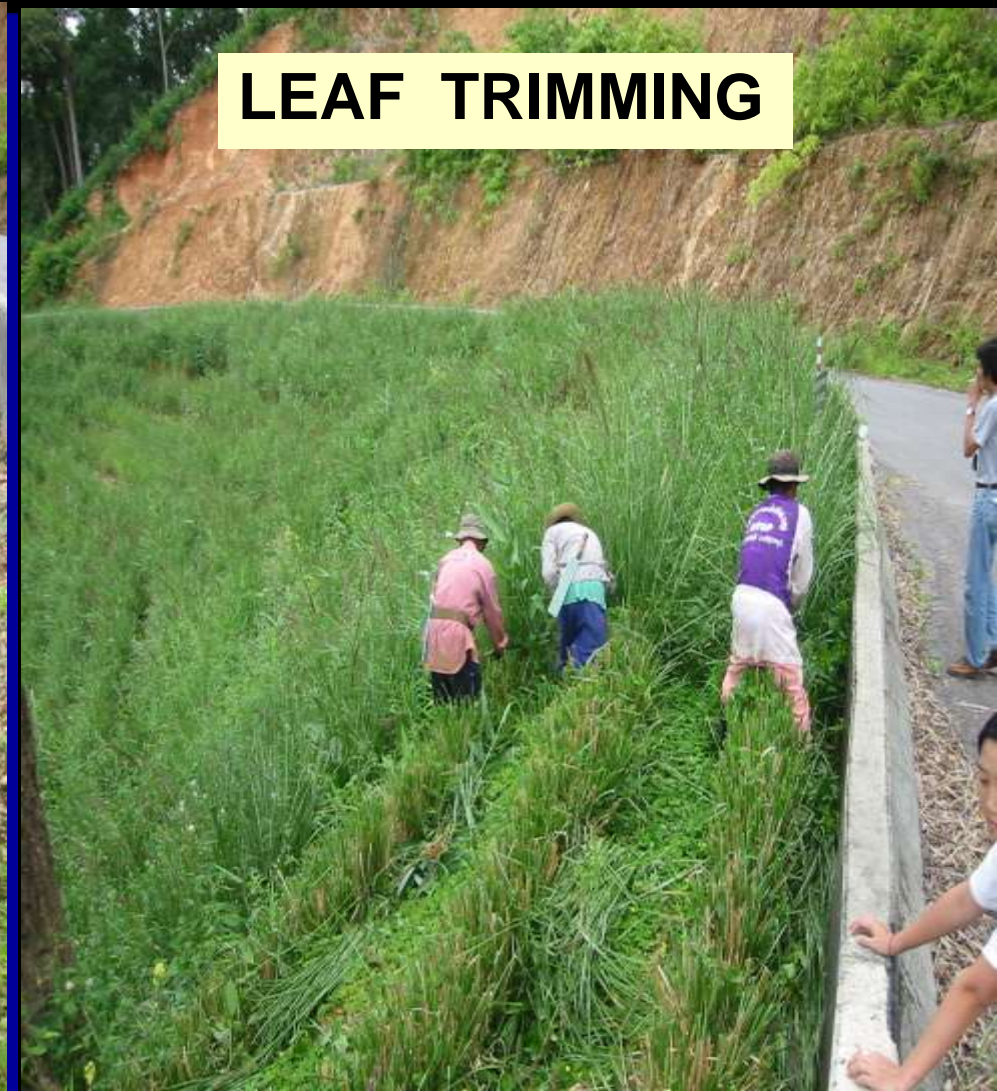
5.1) OPTIMUM PLANTING TECHNIQUES

5.1.4) MAINTENANCE OF WEED AND FERTILIZATION ARE NECESSARY FOR 1-2 YEARS AFTER PLANTING

WEEDS CONTROL



LEAF TRIMMING

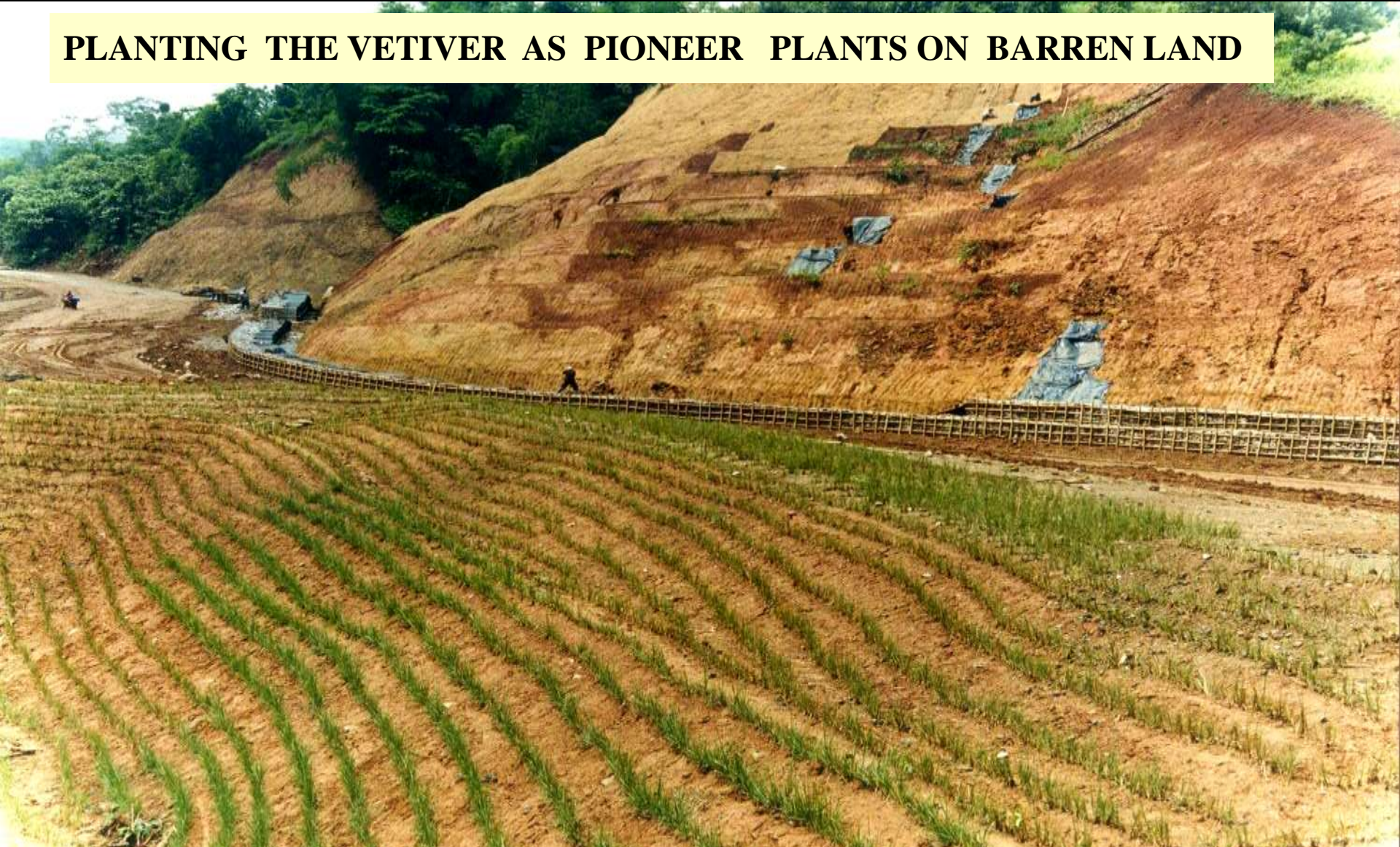


5) SUSTAINABLE VETIVER SYSTEM

5.1 OPTIMUM PLANTING TECHNIQUES

5.1.5 THE EFFECT OF LAND SURFACE

PLANTING THE VETIVER AS PIONEER PLANTS ON BARREN LAND



5) SUSTAINABLE VETIVER SYSTEM

5.1 OPTIMUM PLANTING TECHNIQUES

5.1.6) EFFECT OF SLOPE INCLINATION ON THE GROWTH DEVELOPMENT



45 degrees

70 degrees

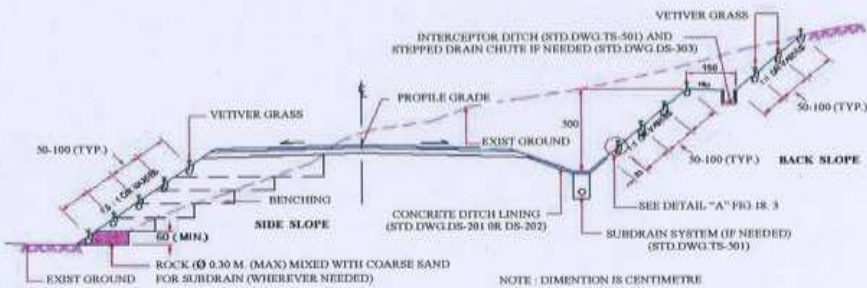


VETIVER SLIPS CAN DEVELOPS A COMPLETELY DENSE HEDGEROW THAT TO BE EFFECTIVE FUNCTION ABLE AFTER 3-4 MONTHS

5) SUSTAINABLE VETIVER SYSTEM

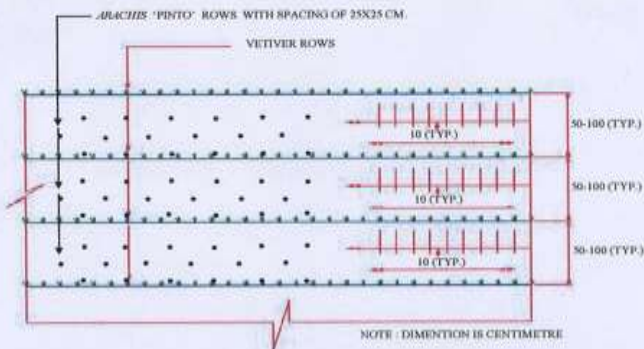
5.2 DRAWING: VETIVER GRASS PLANTING FOR HIGHWAYS SLOPE PROTECTION, SP-205 / 2 (2006)

Fig.18 Standard Drawing "Vetiver grass planting for highways slope protection" (2006)



- Spacing of vetiver grass rows varies from 50-100 cm. and in clump 10 cm. which depend on severe erosion problems on soils.
- Drainage system i.e. interceptor ditch, drain chute, subdrains are also necessary.

Fig.18.1 Cross-section : Vetiver grassing on back slope and side slope



- For not serious cases, planting in rows is 1.00 m. apart and in clump 10 cm spacing.
- For serious cases, planting in rows is 50 cm. apart and in clump 10 cm spacing.
- For minimal maintenance of weeds and fertilization, *Arachis 'Pinto'* is planted between the rows of vetiver.

Fig. 18.2 Plan : Vetiver grassing on back slope and side slope

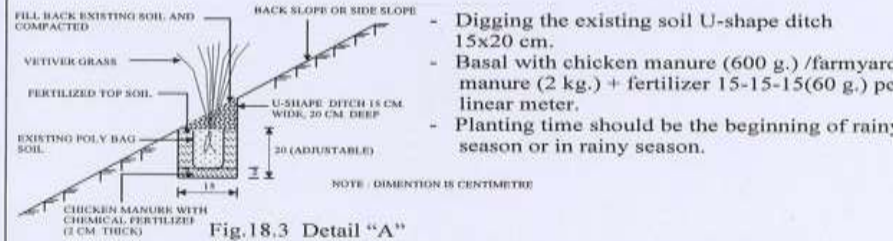
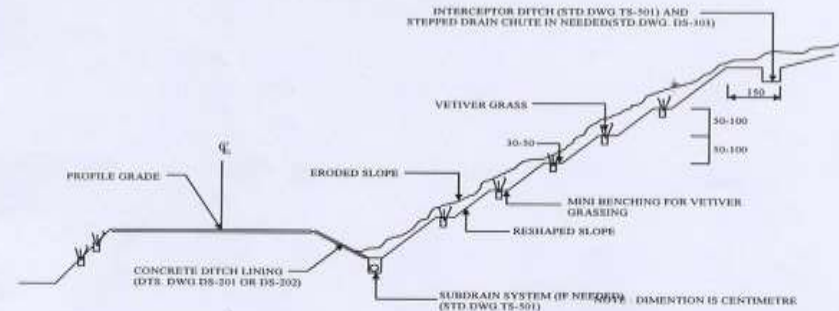


Fig.18.3 Detail "A"

- Digging the existing soil U-shape ditch 15x20 cm.
- Basal with chicken manure (600 g.) /farmyard manure (2 kg.) + fertilizer 15-15-15(60 g.) per linear meter.
- Planting time should be the beginning of rainy season or in rainy season.



- Reshape the eroded back slope
- Make mini benching 30-50 cm. wide, 50-100 cm. height
- Plant the vetiver grass on the bench
- Together with drainage systems

Fig. 18.4 Cross-section : Vetiver grassing on existing eroded back slope

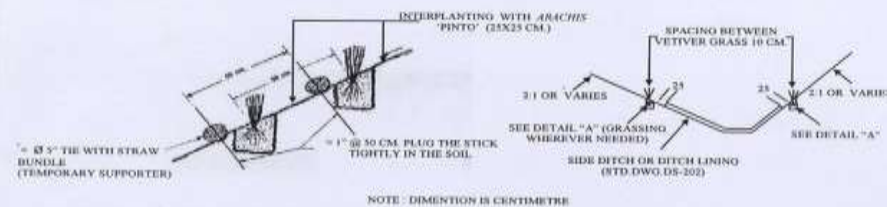


Fig. 18.5 Vetiver grassing on high erodible area and side ditch.

DRAWING BASED ON TECHNOLOGY IMPROVEMENTS : VETIVER GRASS PLANTING FOR HIGHWAYS SLOPE PROTECTION, SP- 205 / 2 (2006)

- 1) THE SPECIFICATION OF VETIVER TILLER**
- 2) GROUND PREPARATION AND HOLE DIGGING**
- 3) SOIL FERTILITY IMPROVEMENT**
- 4) PATTERN OF VETIVER GRASSING**
- 5) SUITABLE PERIOD FOR PLANTING**
- 6) PLANT CARING**
- 7) MAINTENANCE AFTER PLANTING**
- 8) MINIMAL MAINTENANCE (THE VETIVER IN COMBINATION WITH *ARACHIS 'PINTOI'*)**
- 9) VETIVER GRASSING ON DEEP CUT AND HIGH FILL SLOPES**

5) SUSTAINABLE VETIVER SYSTEM

5.3 UNIT RATES OF VETIVER GRASSING FOR HIGHWAY SLOPE PROTECTION

A) GROUND PREPARATION COST	0.10 BAHT/ TILLER
B) MATERIALS COSTS	1.10 BAHT/ TILLER
<ul style="list-style-type: none">- MATERIALS FOR MULTIPLICATION IN PLASTIC BAGS- COST OF VETIVER TILLER- MATERIALS FOR BASAL APPLICATION- MATERIAL FOR MAINTENANCE	
C) LABOUR COSTS	1.50 BAHT/ TILLER
<ul style="list-style-type: none">- LABOUR COST OF NURSERY FOR 60 DAYS- LABOUR COST FOR PLANTING AT THE TARGET AREA	
D) TRANSPORTATION COSTS	0.55 BAHT/ TILLER
<ul style="list-style-type: none">- IN CASE OF BARE ROOT SLIPS- IN CASE OF TILLER IN PLASTIC BAG- FROM NURSERY TO TARGET AREA	
E) MAINTENANCE COST AFTER PLANTING	0.50 BAHT/ TILLER
F) MISCELLANEOUS COST	0.25 BAHT/ TILLER
TOTAL COST	4.00 BAHT/TILLER

5) SUSTAINABLE VETIVER SYSTEM

5.4 MIXED PLANTING WITH SUITABLE PLANT (*Arachis pintoi*)



DECEMBER, 2005



Arachis pinto

- Arachis pinto* :LEGUMINOSAE (CREEPING FORAGE PEANUT)**
**-1) VERY DENSE MAT-FORMING PERENNIAL (HIGH EFFICENCY ON
BLOCKING OR CONTROLING WEEDS)**
-- 2) BIOLOGICAL NITROGEN FIXATION (TO FERTILE SOIL)



‘ PINTOI ‘ IS A CREEPER THAT GROWS CLOSELY TO THE GROUND SURFACE AND SHADE TOLERANT CAN GROW WITH TALL GRASS AS VETIVER



COVERING 40 - 60 % OF AREA WITHIN 5 MONTHS

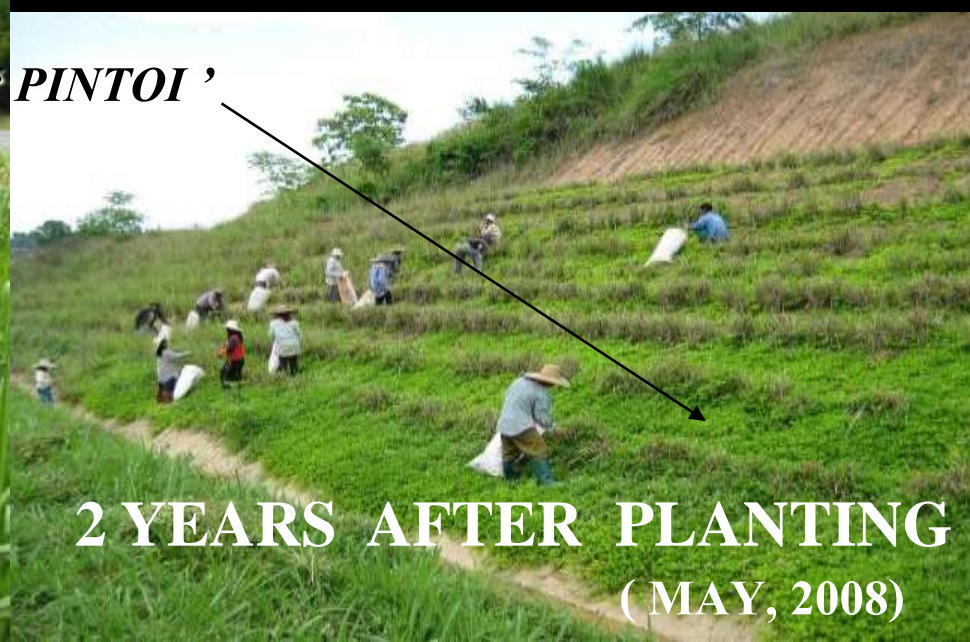


VETIVER

Arachis 'Pinto'

COVERING 80 - 90 % OF AREA WITHIN 8 - 12 MONTHS

**THE EFFICIENCY OF
ARACHIS 'PINTOI' TO
CONTROL WEEDS ON
ROUTE NO. 107 (Km. 10.150 –
Km. 10.450)**



6) EFFICIENCY OF EROSION CONTROL AND STABILIZATION OF HIGHWAY SLOPES

6.1 PROTECT THE SOIL AGAINST EROSION AND SHALLOW-SEATED FAILURE



BEFORE STABILIZED BY VETIVER



AFTER STABILIZED BY VETIVER FOR 2 YEARS

6) EFFICIENCY OF EROSION CONTROL AND STABILIZATION OF HIGHWAY SLOPES

6.2 SLOPE OF HIGH WATERTABLE STABILIZED AGAINST EARTHFLOWS BY VETIVER

Landslide / Earthflows



6) EFFICIENCY OF EROSION CONTROL AND

STABILIZATION OF HIGHWAY SLOPES

6.2 SLOPE OF HIGH WATERTABLE STABILIZED AGAINST EARTHFLOWS BY VETIVER

KM. 78.600

SEEPAGE ZONE

WATERTABLE

VETIVER

: Landslide / Earthflows on highway cut slope of high groundwater table and seepages (Route No. 107 : KM. 78+500 – KM. 78+600).

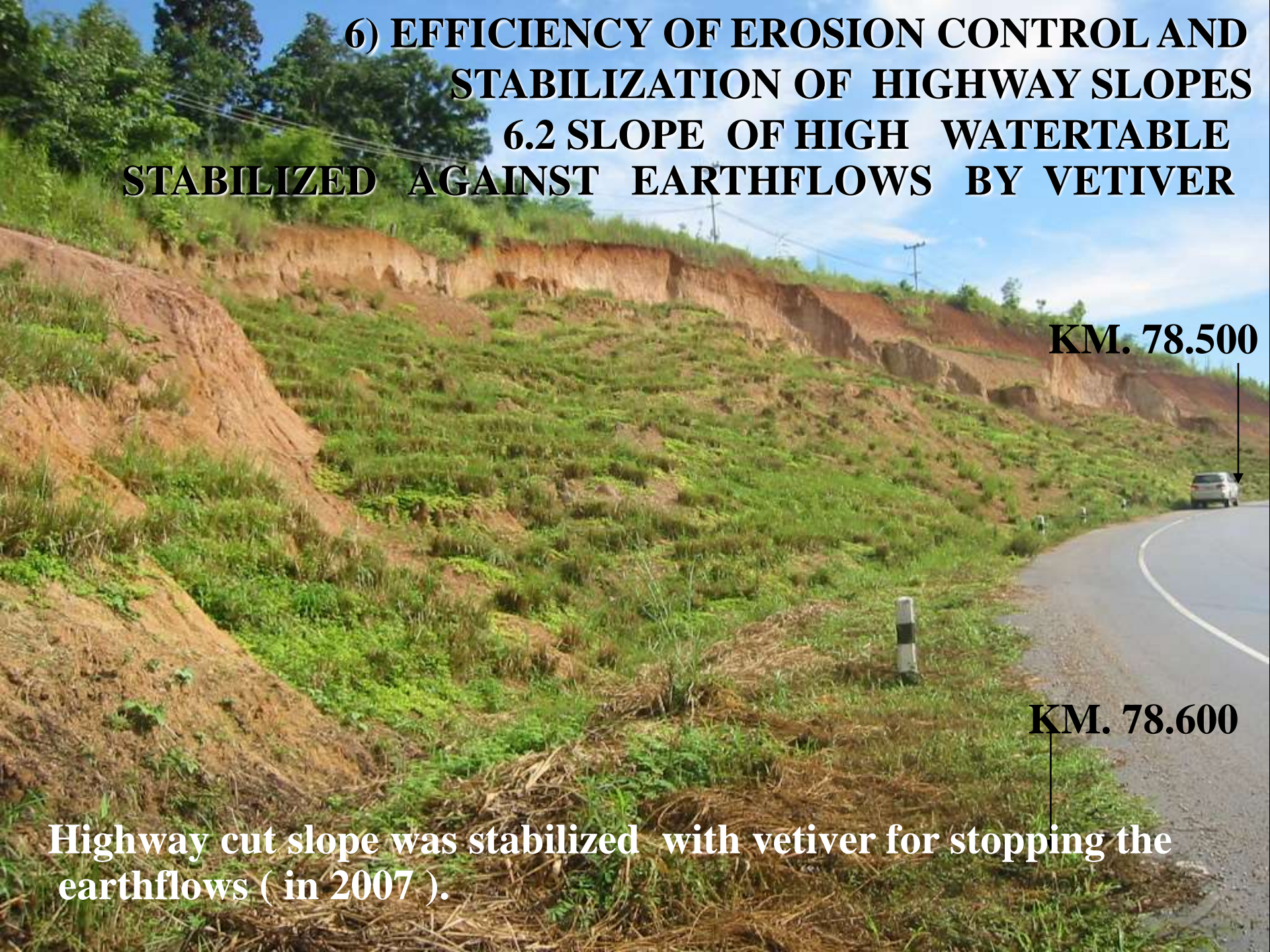
In 2006, the slope was stabilized with vetiver for stopping the earthflows .

**6) EFFICIENCY OF EROSION CONTROL AND
STABILIZATION OF HIGHWAY SLOPES
6.2 SLOPE OF HIGH WATERTABLE
STABILIZED AGAINST EARTHFLAWS BY VETIVER**

KM. 78.500

KM. 78.600

Highway cut slope was stabilized with vetiver for stopping the earthflows (in 2007).

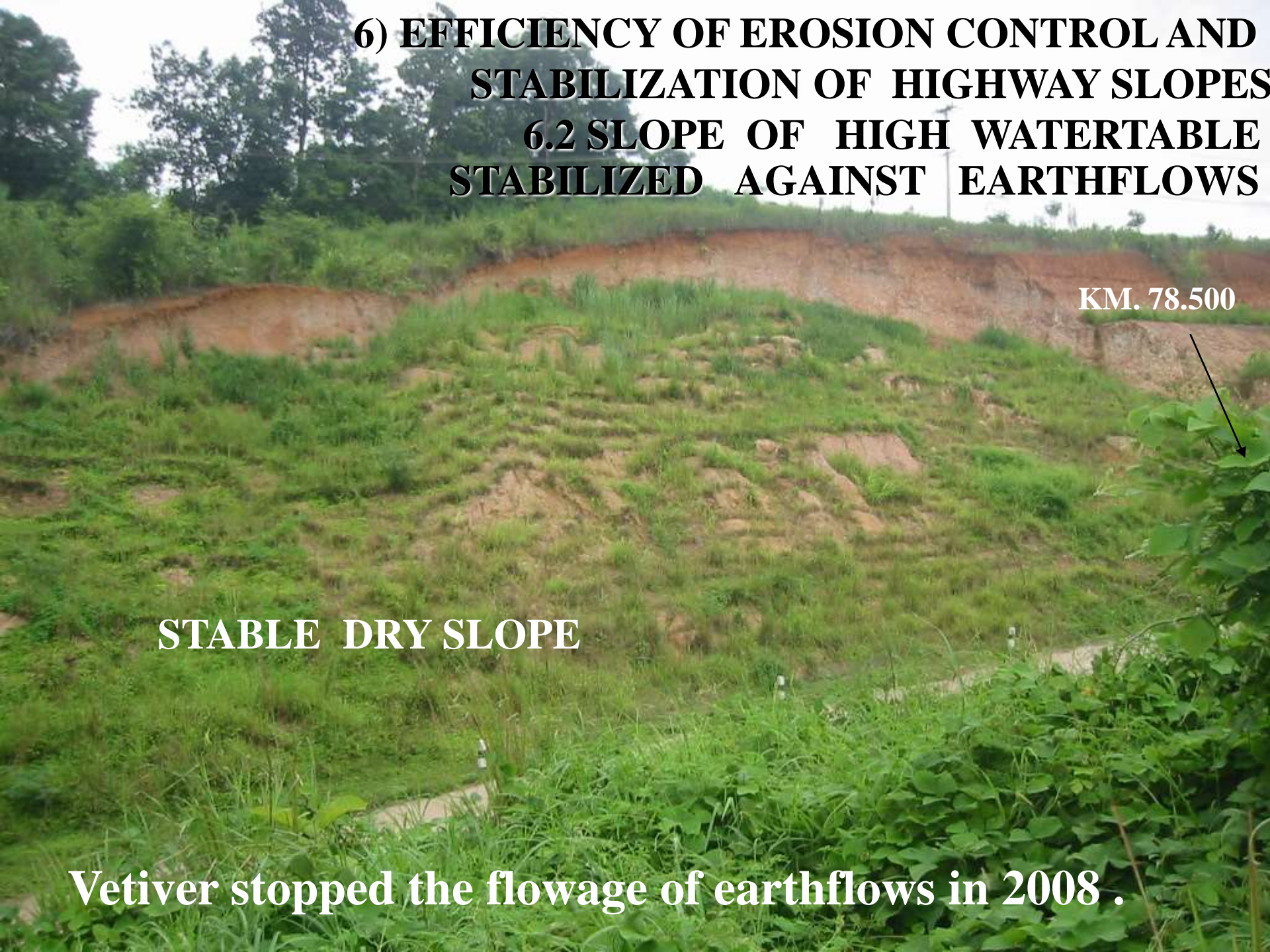


**6) EFFICIENCY OF EROSION CONTROL AND
STABILIZATION OF HIGHWAY SLOPES
6.2 SLOPE OF HIGH WATERTABLE
STABILIZED AGAINST EARTHFLAWS**

KM. 78.500

STABLE DRY SLOPE

Vetiver stopped the flowage of earthflows in 2008 .



VETIVER PLANTING AREA



NON-PLANTING VETIVER AREA

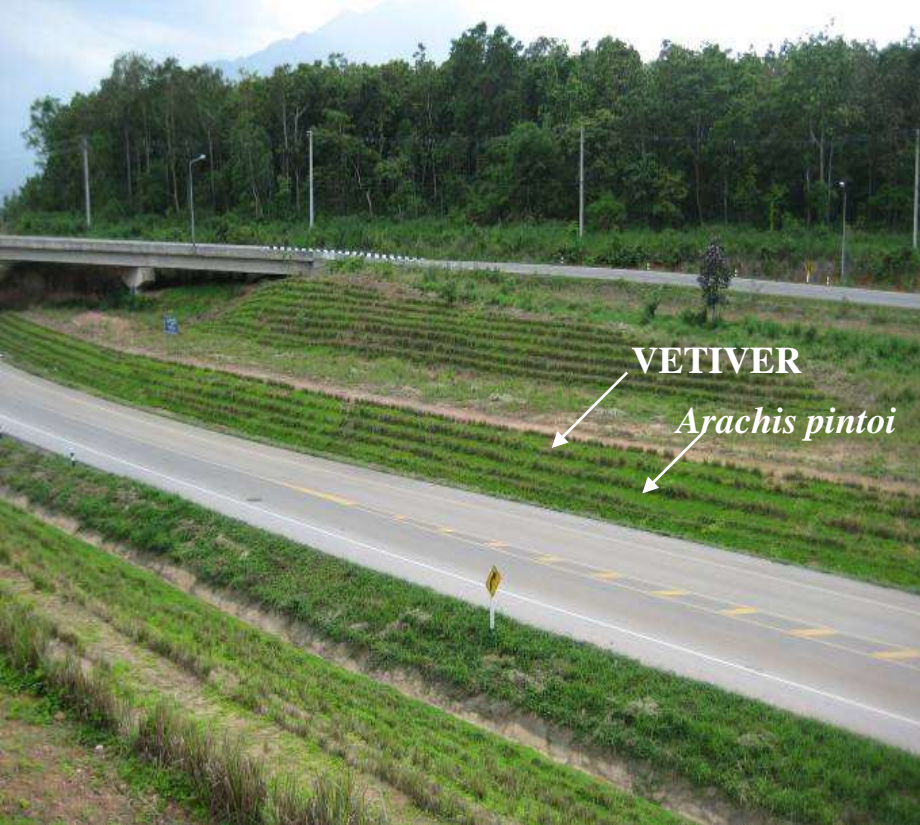


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7) CONCLUSIONS

7.1 OPTIMUM PLANTING TECHNIQUES

7.2 PLANTING THE VETIVER AS PIONEER PLANT ON BARREN LAND.



7.3 ARACHIS 'PINTO' HAS EFFICIENCY TO CONTROL WEEDS.

7) CONCLUSIONS

7.4 VETIVER STABILIZED THE SOIL SLOPES NOT ONLY ROOT REINFORCEMENT BUT BY GETTING SOIL TO DRY BY EVAPOTRANSPIRATION .

7.5 VS IS AN EFFECTIVE MEASURES FOR EROSION CONTROL AND STABILIZATION AGAINST EROSION, SHALLOW-SEATED FAILURE AND EARTHFLAWS (SLOW MOVEMENT OF SATURATED SOILS).



7.6) VS IS MULTI- TECHNOLOGY



VETIVER

VETIVER

MSE WALL

VETIVER

VETIVER SYSTEM WAS APPLIED WITH MSE WALL ON
HIGHWAY CONSTRUCTION PROJECT ROUTE NO. 11

08/09/2011



THANK YOU