Effects of Polyacrylamide (PAM) and Biopolymer on Erosion Control and Plant Growth

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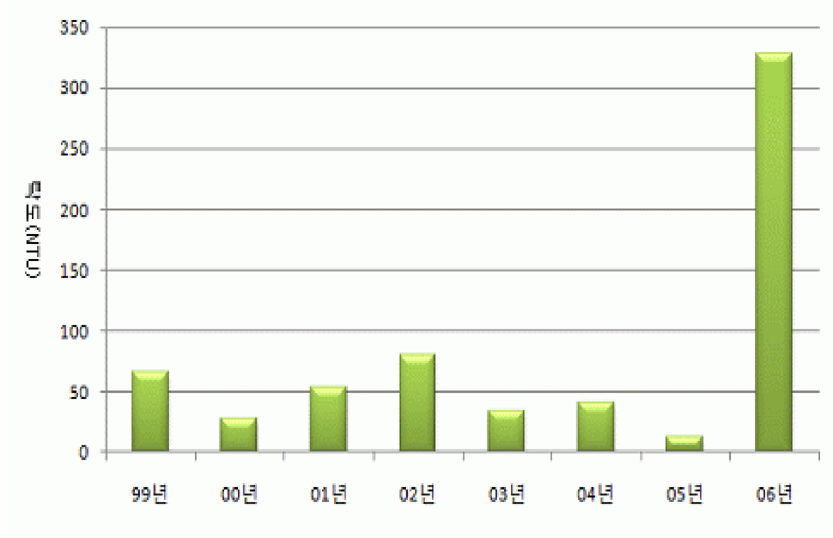
Introduction

- Highland is located at >600 m altitude and produces various crops at low temperature.
- Productive highland is very limited due to its steep slope and soil erosion.


Erosion problematic

- In Korea, annual soil loss estimated over 11 MT/ha.
- Soil erosion reduces crop productivity due to losses of soil organic matter and nutrients from a fertile topsoil.
- Soil erosion causes a nonpoint source pollution affecting water quality and aquatic system.


350
300
250
200
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탁도(NTU)
99년
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04년
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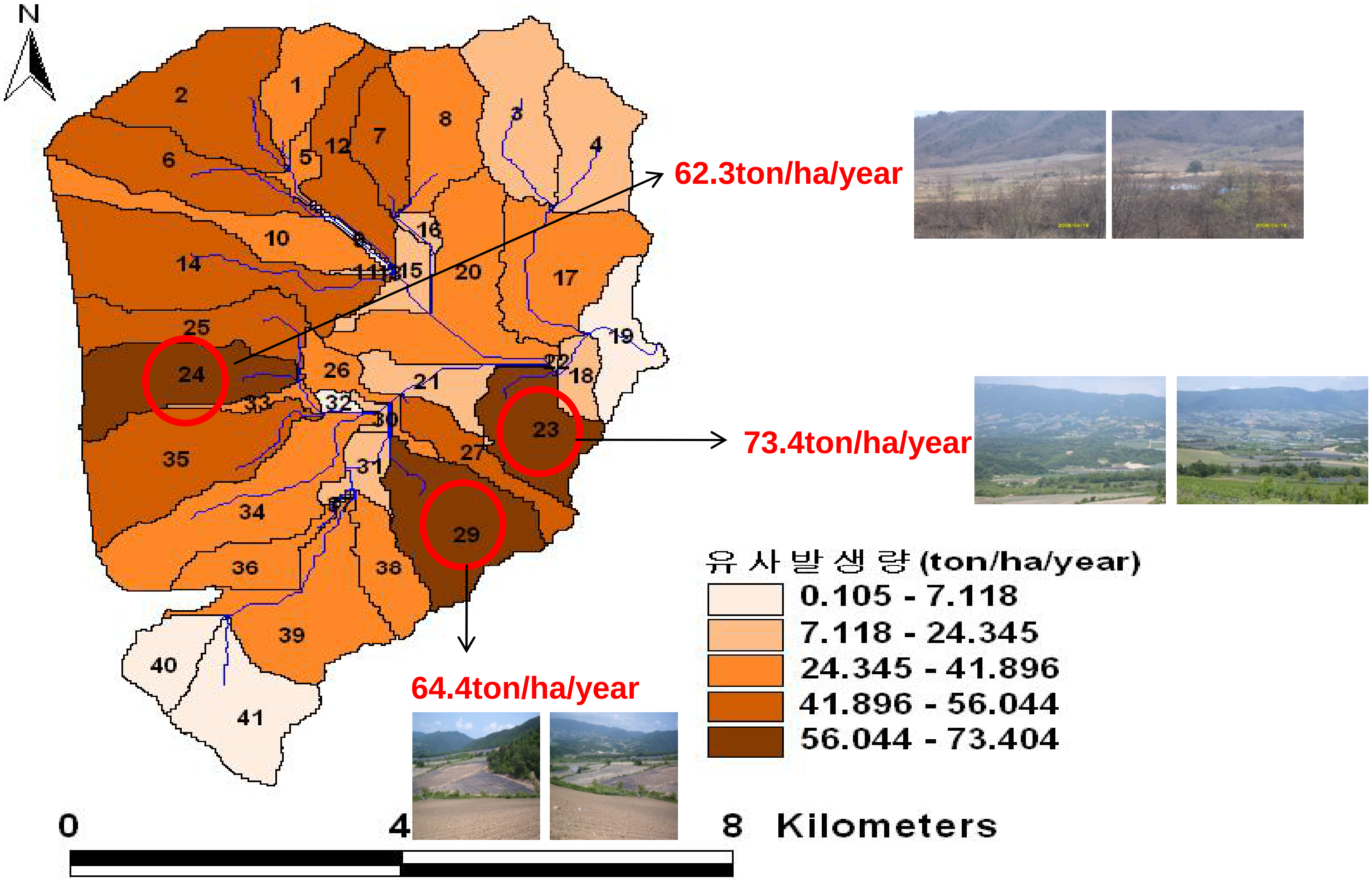
2008/05/02


N
62.3ton/ha/year
73.4ton/ha/year
64.4ton/ha/year
유 사 발 생 량 (ton/ha/year)
0.105 - 7.118
7.118 - 24.345
24.345 - 41.896
41.896 - 56.044
56.044 - 73.404
0 4 8 Kilometers

Erosion Control

- Anionic polyacrylamide (PAM) is emerging method to reduce soil erosion and runoff.

Effectiveness of PAM

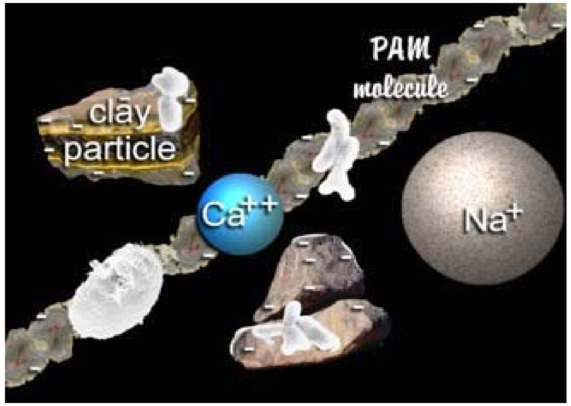
- PAM increases infiltration, thereby increasing plant germination, plant growth, and plant survival during drought.

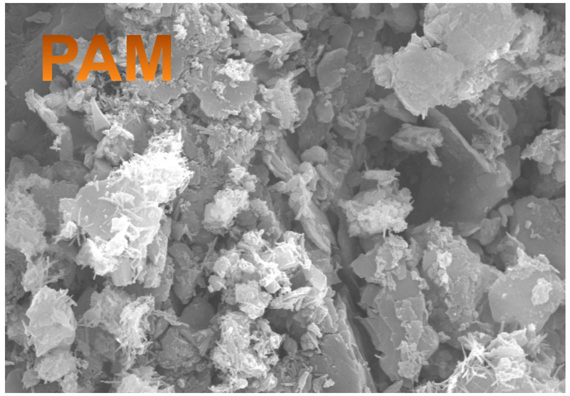
- PAM stabilizes soil aggregate, thereby reducing soil erosion and runoff.

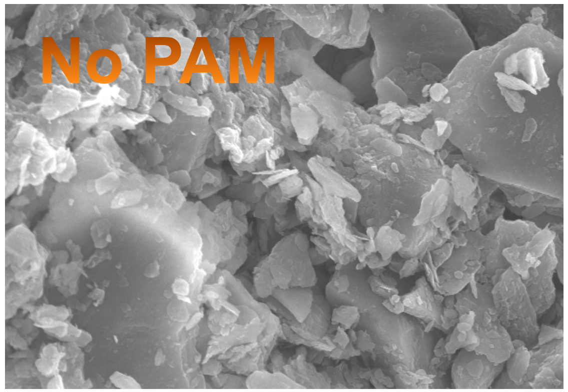
PAM's Mode of Action

- **For PAM in water with sufficient electrolytes, coulombic and van der Waals forces attract soil particles to anionic PAMs.**

- **Ca^{++} in water shrinks the double layer around soil particles and bridges between soil surfaces and PAM, enabling flocculation.**







Case Study I

Application of PAMs for Reducing Soil Erosion using Simulated Rainfall

Objective

- To investigate the effects of different PAMs for reducing soil erosion and turbidity.

Materials and Methods

➢ Properties of tested PAMs

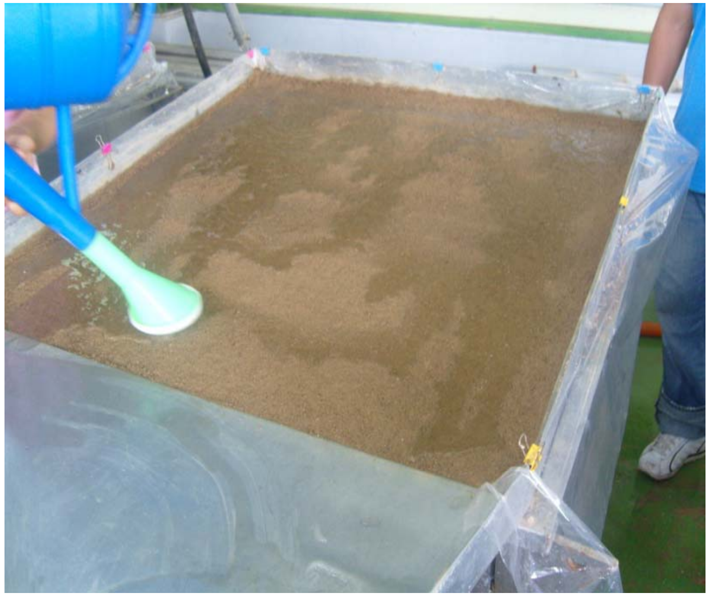
Item	Property						
	Yangfloc	Magnafloc 336	Soilfix G1	4611	SD 46312	9601 PULV	9901
Form	Granular power						
Color	White						
Odor	Little or no						
Solubility in water	Soluble						
Specific gravity	0.60 ~0.80	0.75	-	0.80	0.80	0.80	-
pH (0.5% solution)	6~8	6~9	6~9	4~9	4~9	4~9	5.5~7.5

Materials and Methods

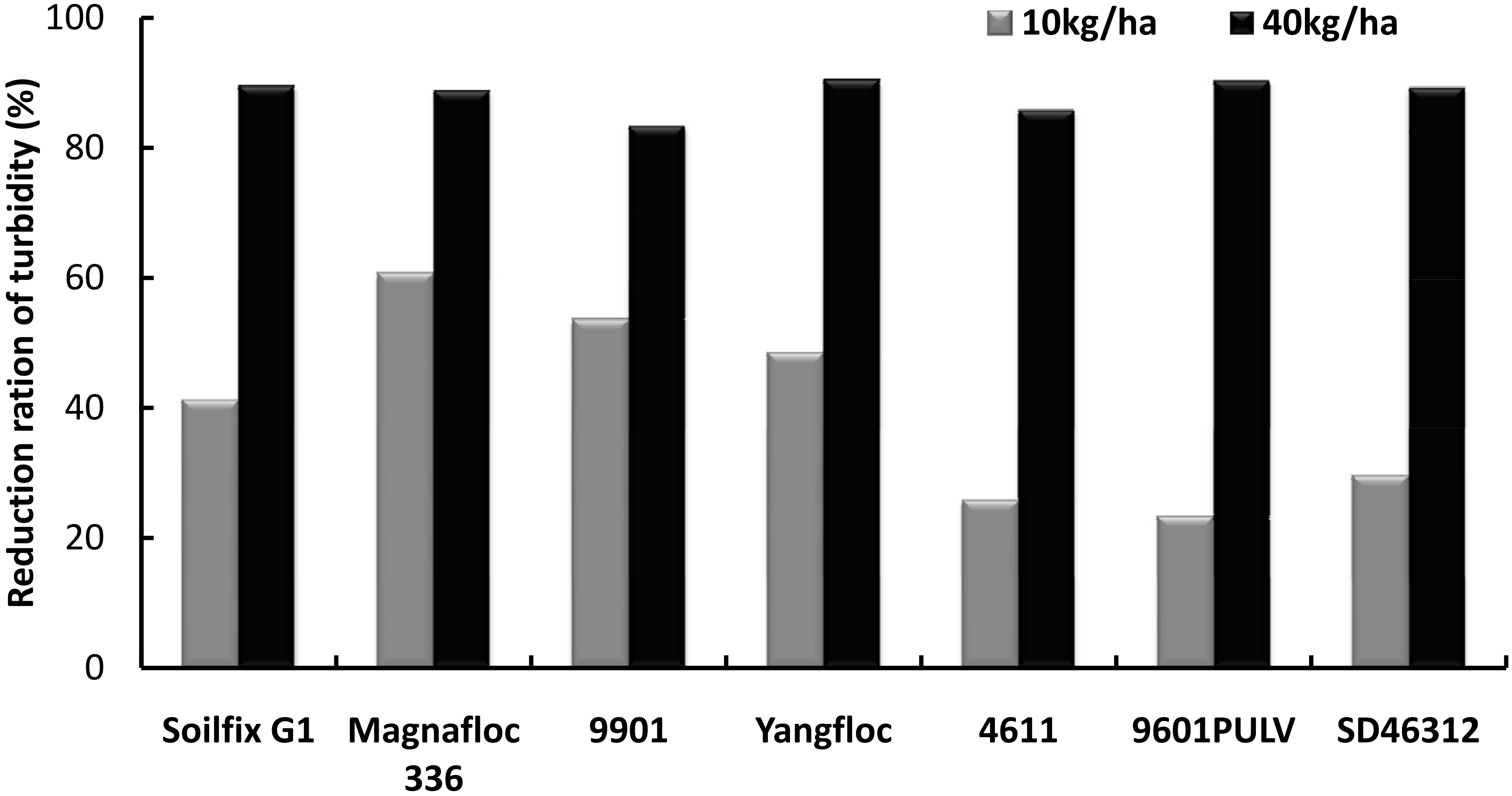
- Rainfall simulator was used to evaluate the application of PAMs at 10 and 20% slopes.
- Aqueous PAMs at 10 and 40 kg/ha were applied to the soil surface.
- After air drying, simulated rainfall was applied at an intensity of 30 mm/h.

Rainfall Simulator

Materials and Methods

Results & Discussion



Reductions in turbidity ranged 25~60% at 10 kg/ha and 83~91% at 40 kg/ha.

Results & Discussions

Treatments	Slope 10%		Slope 20%	
	Turbidity	Reduction (%)	Turbidity	Reduction (%)
Control	2310	0	4000	0
Soilfix G1	121	94.8	177	95.6
Magnafloc 336	91	96.0	108	97.3

Conclusion

- **Mean turbidity in runoff was reduced by 94.7 and 84.8% at 10 and 20% slopes with 40 kg/ha vs. CK .**
- **Magnafloc 336 was the best for reducing sediment loss, up to 60.6% and 25.2% at 10 kg/ha, and 90.3% and 92.7% at 40 kg/ha with 10% and 20% slopes.**
- **All PAMs significantly reduced sediment loss at 10% and 20% slopes.**

Case Study II

Reductions in Soil Erosion with PAM and Biopolymer

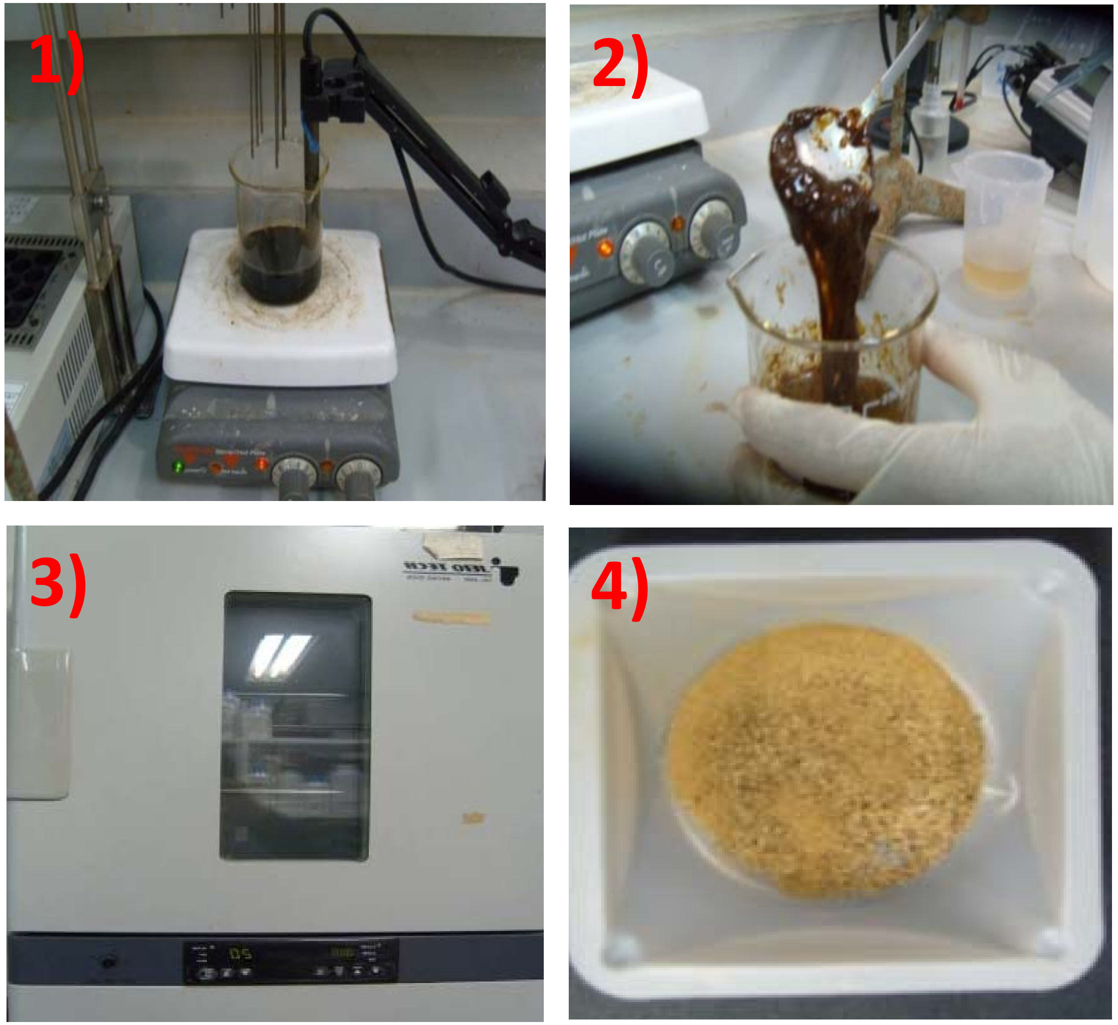
Objective

- To evaluate the effectiveness of a synthesized biopolymer for reducing soil erosion compared to PAM

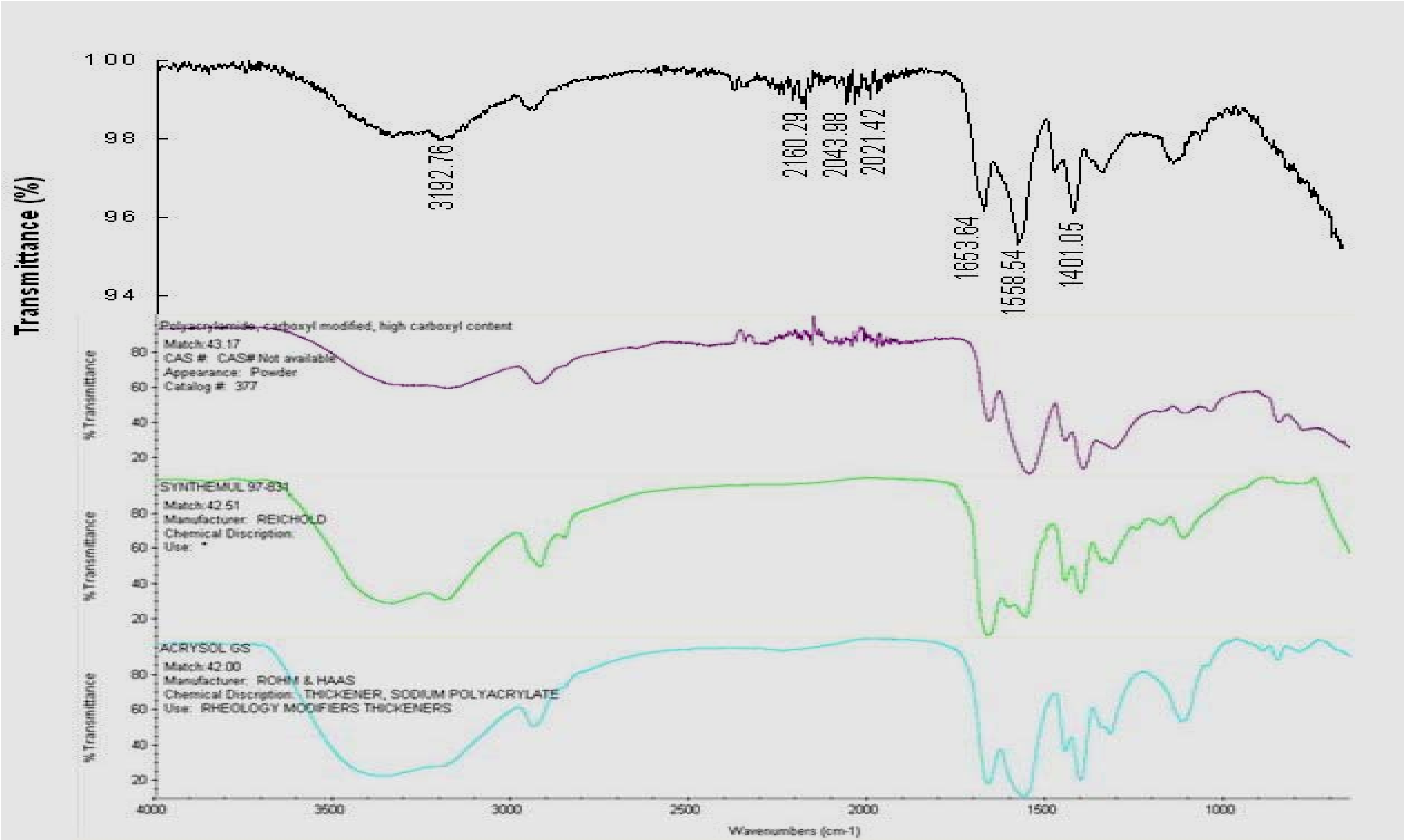
Materials and Methods

1,2) Biopolymer (LSAA) was synthesized from lignin, starch, acrylamide and acrylic acid.

3,4) LSAA was powdered after drying to a constant weight at 60°C.



Materials and Methods



Infrared spectrum of biopolymer (LSAA)

Materials and Methods

Properties of PAM and Biopolymer

Contents	TN (%)	TC (%)
Synthesized PAM (LSAA)	5.32	28.41
Magnafloc 336	13.23	40.15
Soilfix G1	16.28	42.22

Materials and Methods

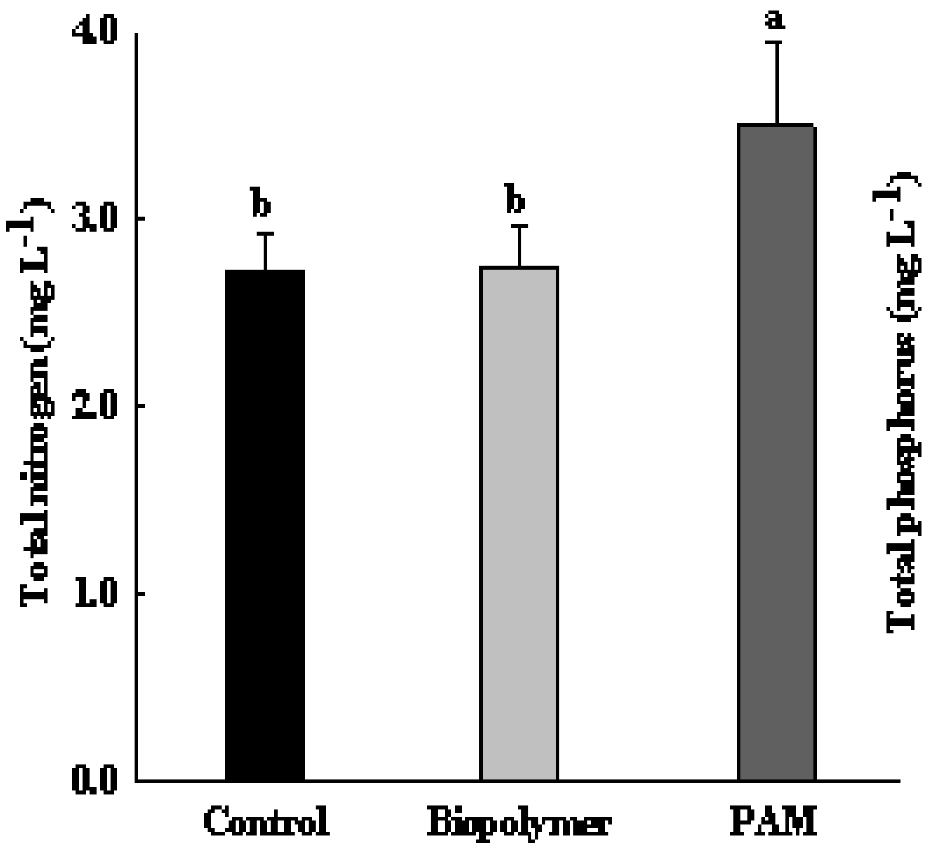
- PAM and LSAA at 200 kg/ha were applied to the soil surface at 36% slope.
- After a week incubation, simulated rainfall was applied at an intensity of 20 mm/h.
- The sediment load and water quality in runoff were analyzed.

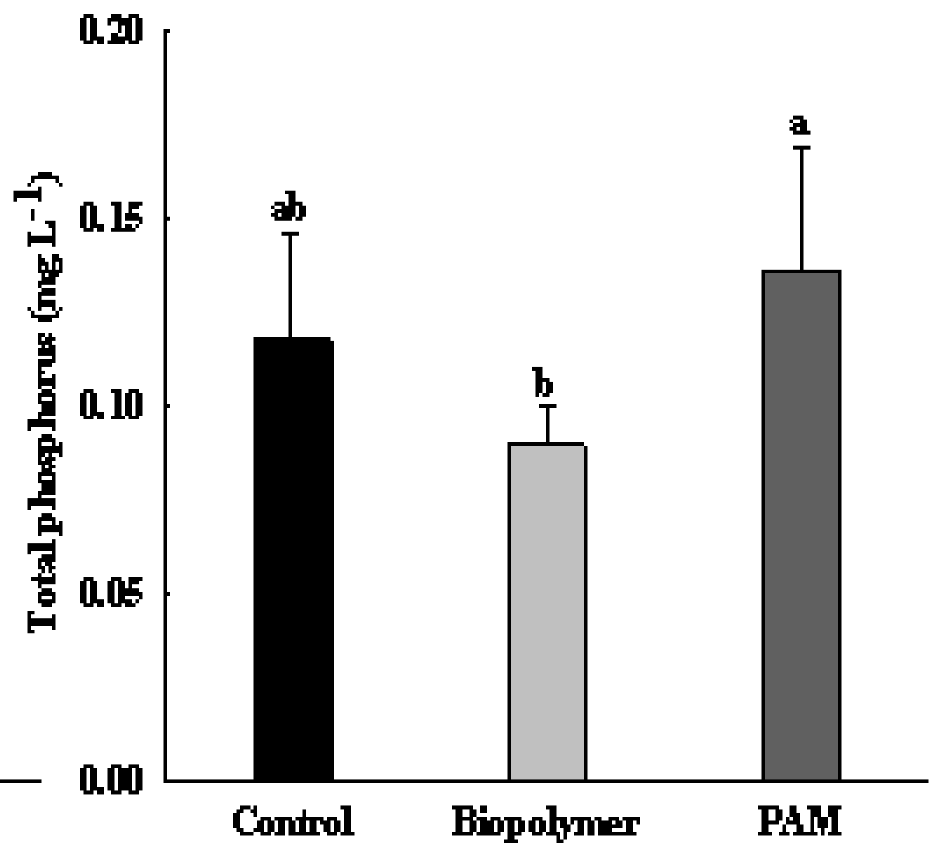
Results & Discussion

Soil loss and reduction ratio in runoff

Treatment	Soil loss (kg/ha)	Reduction ratio
Control	1187.0 a*	-
LSAA	27.1 b	97.8
PAM	56.6 b	95.5

Results & Discussion

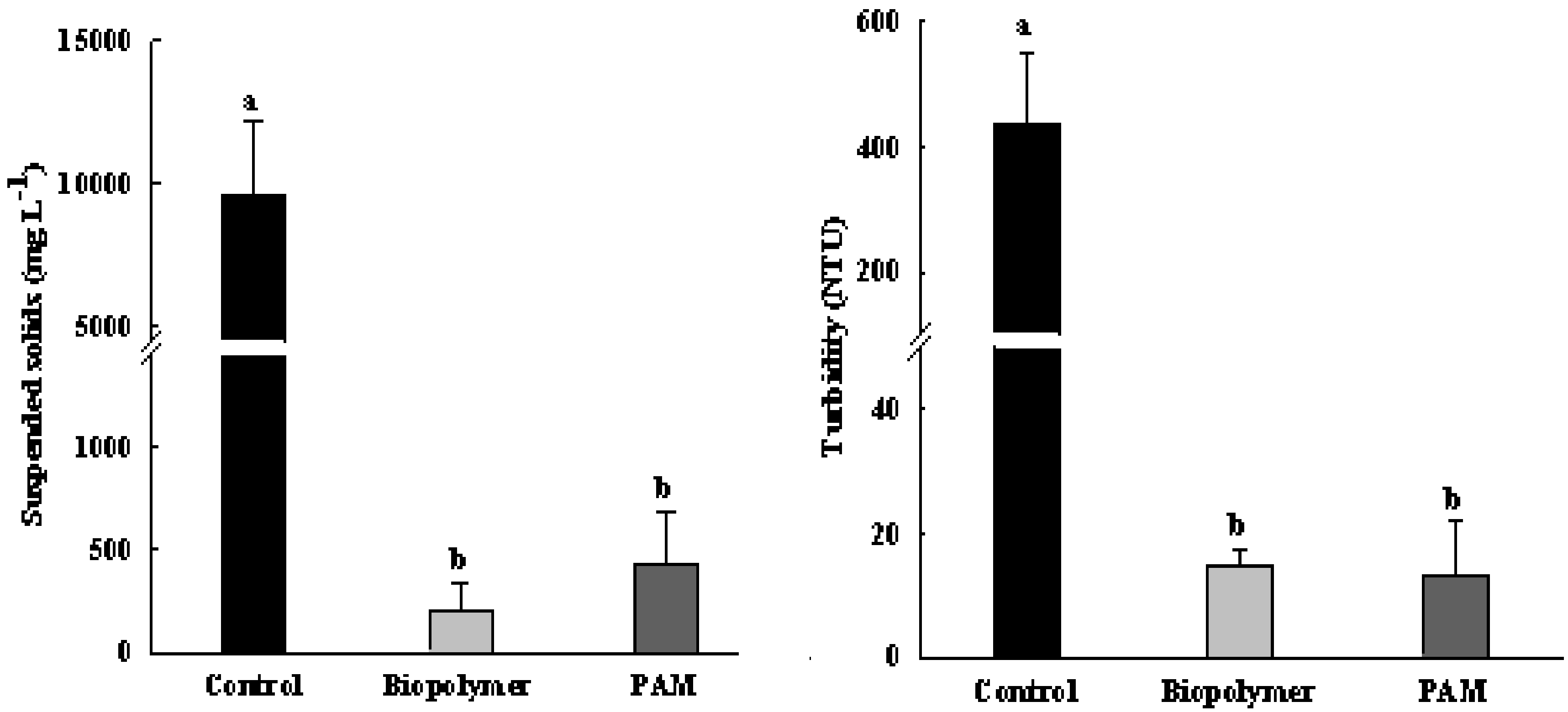




Total N in runoff was increased in PAM-treated soil.

Difference between LSAA and PAM was found in total P.

Results & Discussions



Suspended solids were reduced by 97.8 and 95.6% in LSAA- and PAM- treated soils compared to untreated zone, respectively.

Results & Discussions

Runoff from soils treated with PAM and LSAA compared to control.

Conclusion

- **Sediment with PAM and LSAA at 200 kg/ha reduced by 97.8% and 95.5% compared to the untreated soil.**
- **Total N (T-N) and total P (T-P) in runoff from LSAA-treated soil were similar to the untreated soil.**
- **PAM increased T-N and T-P in the runoff compared to the untreated soil.**
- **LSAA is an alternative to PAM for reducing soil loss, T-N, and T-P.**

Case Study III

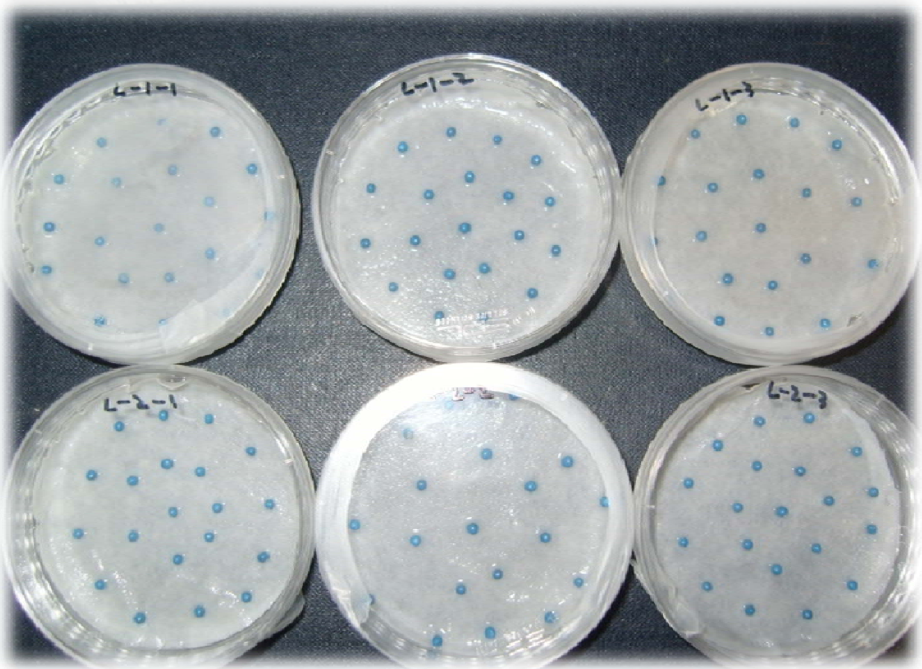
Effects of PAM and biopolymer on Chinese cabbage growth and soil properties

Objective

- To evaluate the effectiveness of PAM and biopolymer (LSAA) on soil properties and Chinese cabbage growth.

Materials and Methods

- **Aqueous PAMs and LSAA at 0.05% and 0.1% were evaluated using a Chinese cabbage (*Brassica campestris* L.) seed germination bioassay.**



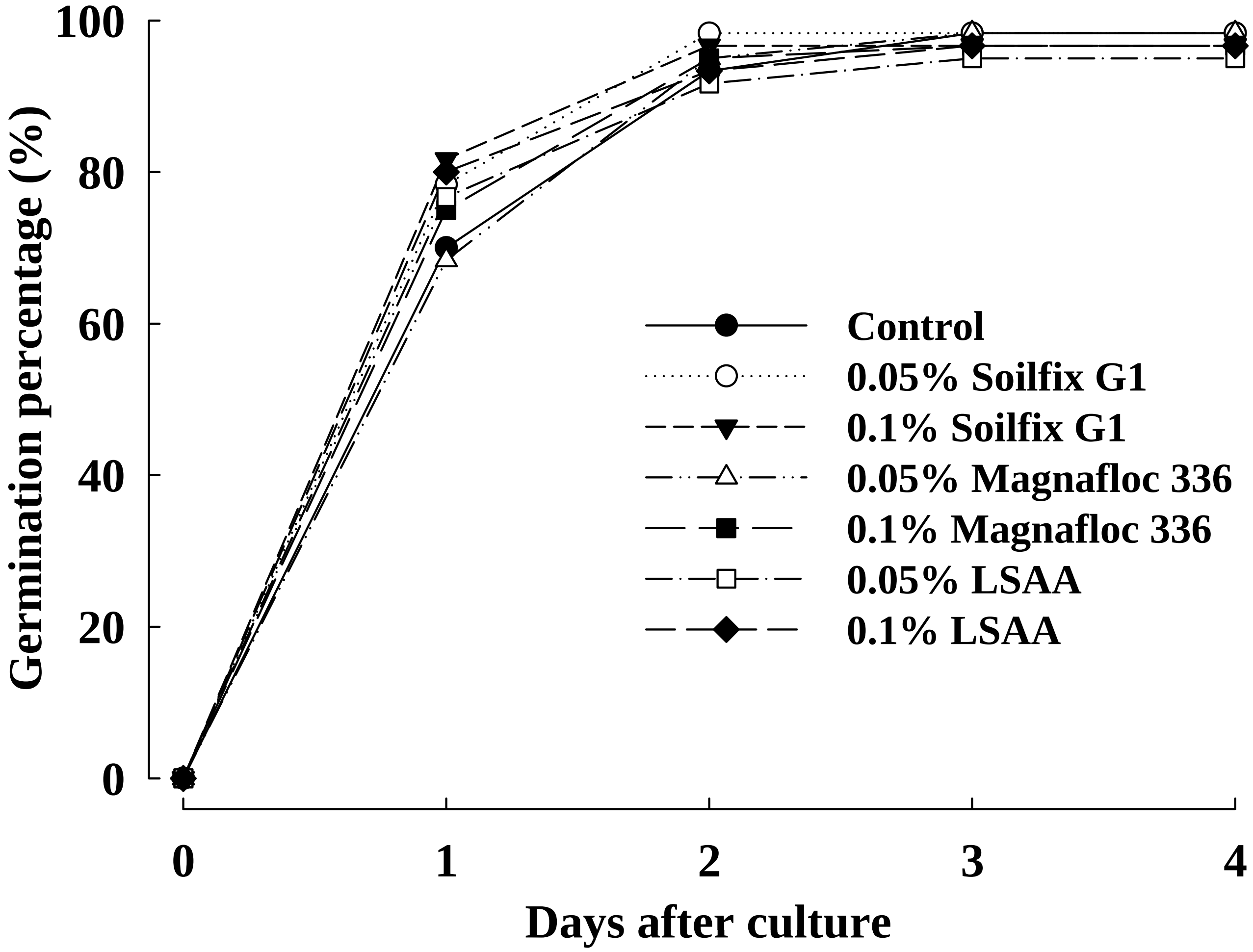
Materials and Methods

- Pot experiment was conducted in a rain shielding house.
- Chinese cabbage seedlings (30 days after sowing) were transplanted to 1/5,000a Wagner pots.
- Aqueous PAMs (Soilfix G1 and Magnafloc 336) and LSAA were applied at 0.35 g/pot.

Materials and Methods

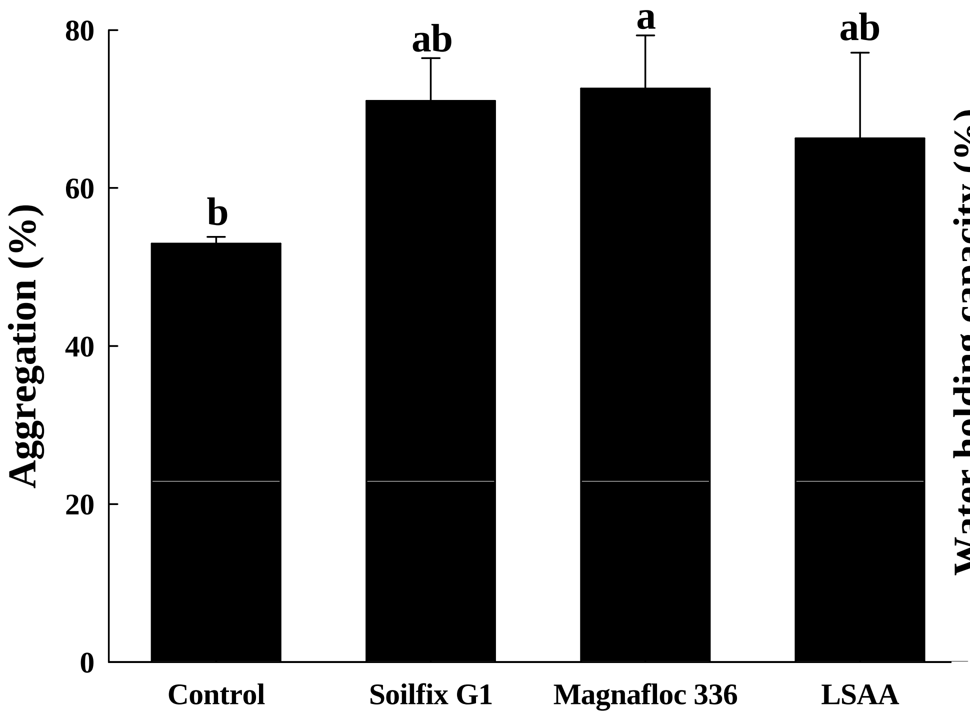
- **Plants were sampled eight weeks after transplantation .**
- **Plant biomass, leaf length, leaf width, and the number of leaves were determined.**

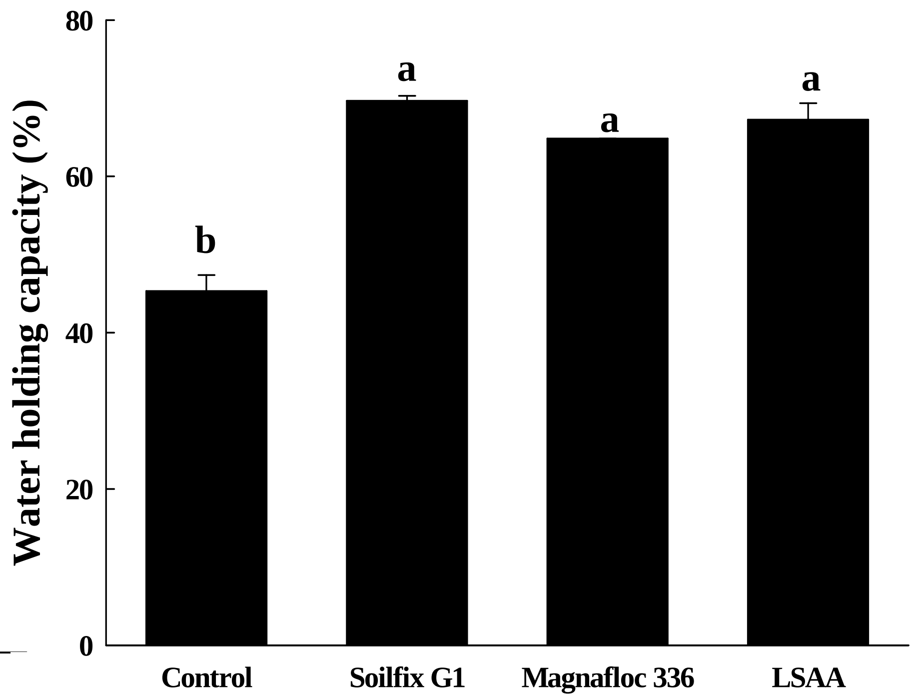
Results and Discussion

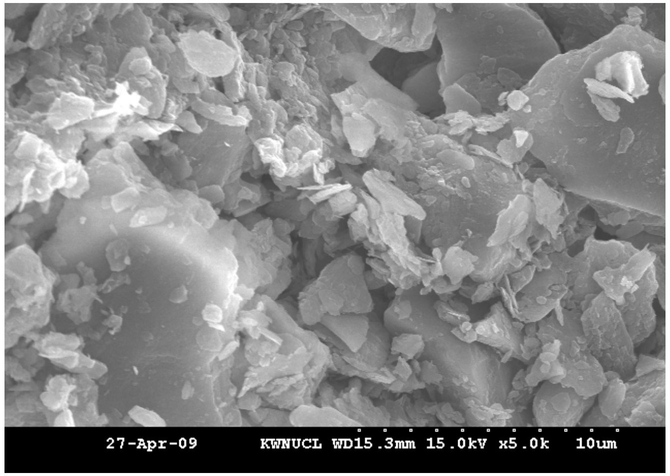


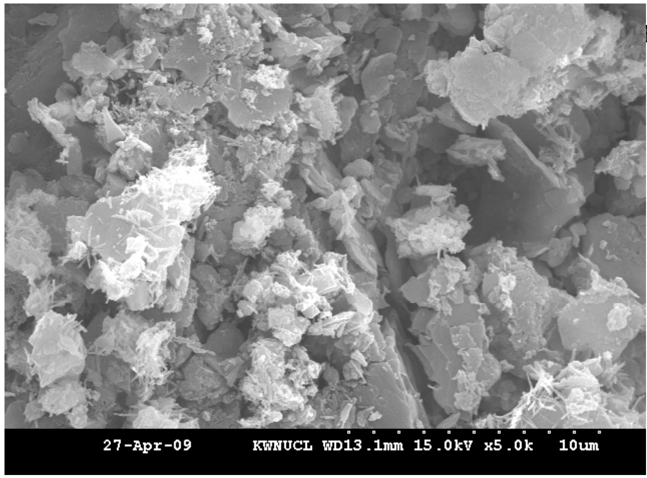
%Germination as affected by treatments

Results & Discussions



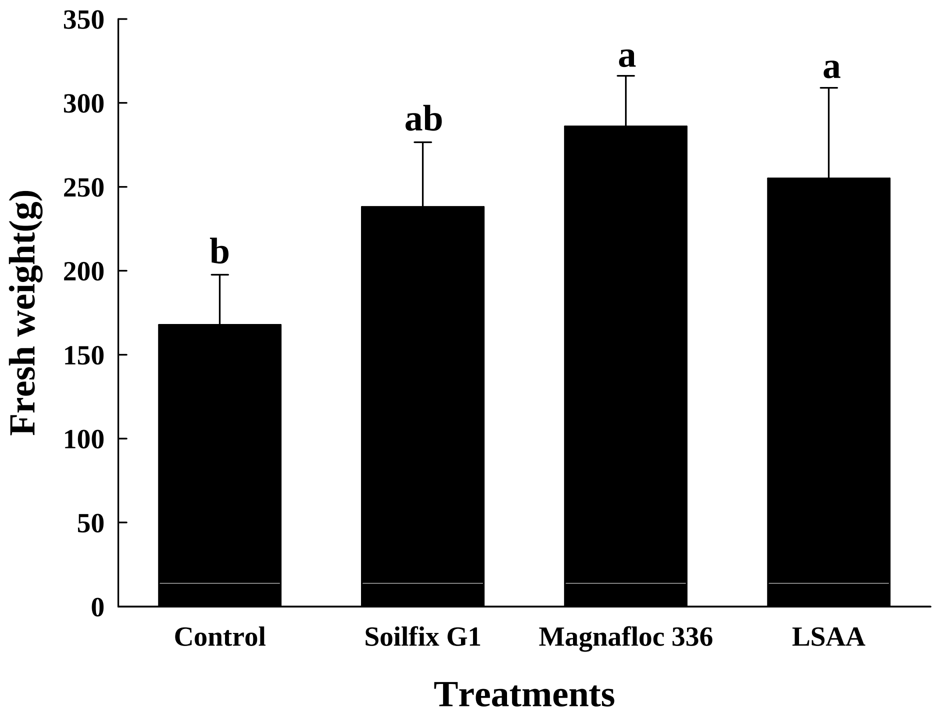


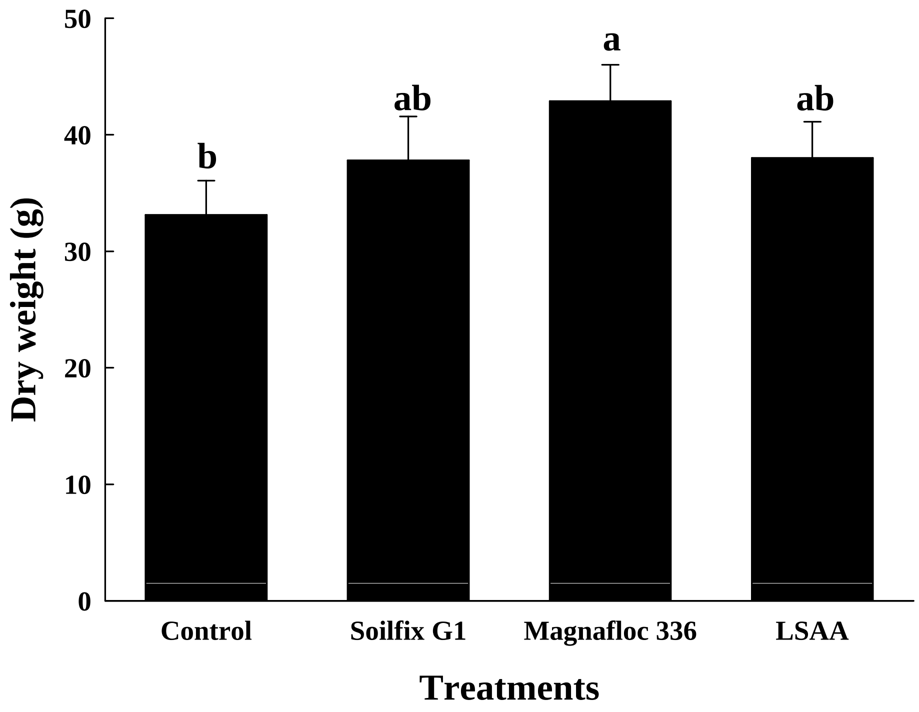




atments

Results & Discussions





Fresh and dry weights of Chinese cabbage

Conclusion

- **PAMs and LSAA at 0.5 and 1% increased cabbage seed germination by 95-98%.**
- **PAMs and LSAA increased plant biomass by 42-70% compared to the control.**
- **Soil aggregates were stabilized by 71, 73 and 66% with the Soilfix G1, Magnafloc 336 and LSAA.**

Case Study IV

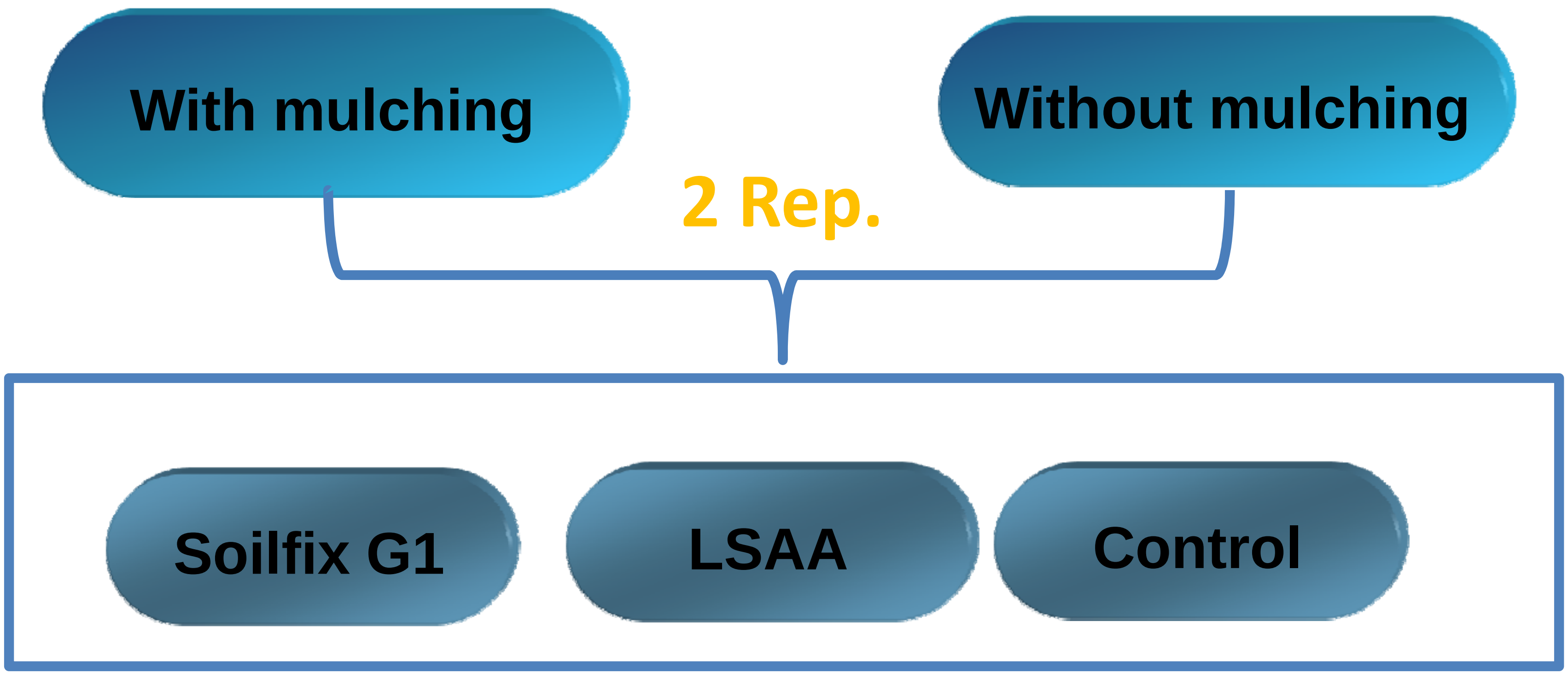
PAM and LSAA Efficacy on Erosion Control and Radish Growth in the Field

Objective

- To evaluate the effectiveness of PAM and LSAA on soil erosion control and radish growth in a field-scale experiment.

Materials and Methods

- PAM and LSAA at 40kg/ha were applied to the soil surface.
- Radish was cultivated with/without mulching.



Materials and Methods

Size: 18m × 3m
Slope: 15~20%
Altitude: 708m

Materials and Methods

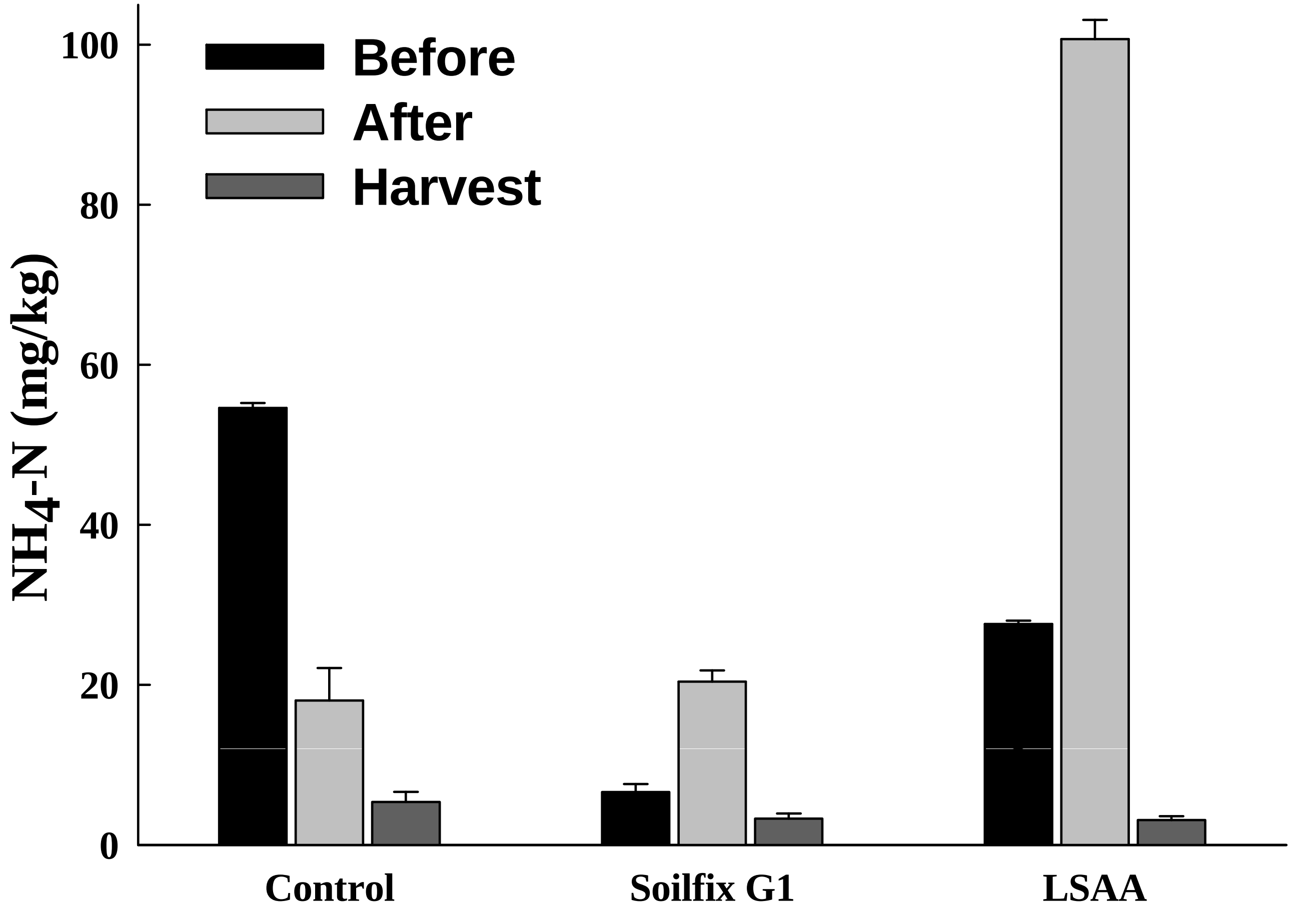
Regional rainfall duration and intensity

Samples		Rainfall			
#	Date	Duration	Amount (mm)	Main event (mm/day)	Maximum (mm/hr)
1st	09-7-10	07. 08~07. 09	227	25.2	41.5
2nd	09-7-16	07. 11~07. 15	353	70.6	39.0
3rd	09-7-26	07. 17~07. 26	154	15.4	23.5
4th	09-8-13	08. 07~08. 12	177	29.5	13.5

Results and Discussion

Sampling	Control	LSAA	Soilfix G1	Control	LSAA	Soilfix G1
	Sediment (kg/10a)			Water(ton/10a)		
1st	4616	3439	2329	194.3	205.0	199.6
2nd	3522	2400	2292	311.6	311.6	311.6
3rd	1873	1658	1116	87.6	82.3	77.0
4th	2028	1847	1376	135.6	125.0	119.6
Sum	12091	9344	7113	729.1	723.9	707.8

Results and Discussion



Concentrations of NO_3 and NH_4 in the soil

Conclusion

- **PAM and LSAA promoted the growth of radish, and reduced soil erosion.**
- **With mulching, Soilfix G1 and LSAA reduced sediment by 44.9 and 33.6%.**
- **Without mulching, Soilfix G1 and LSAA reduced sediment by 41.2 and 22.7%.**

Summary

- PAMs and LSAA stabilized soil aggregates, thereby reducing soil erosion and increasing the water-holding capacity.
- PAMs and LSAA enhanced the plant growth by increasing porosity and available water.
- LSAA can be an alternative to PAM.

Future Works

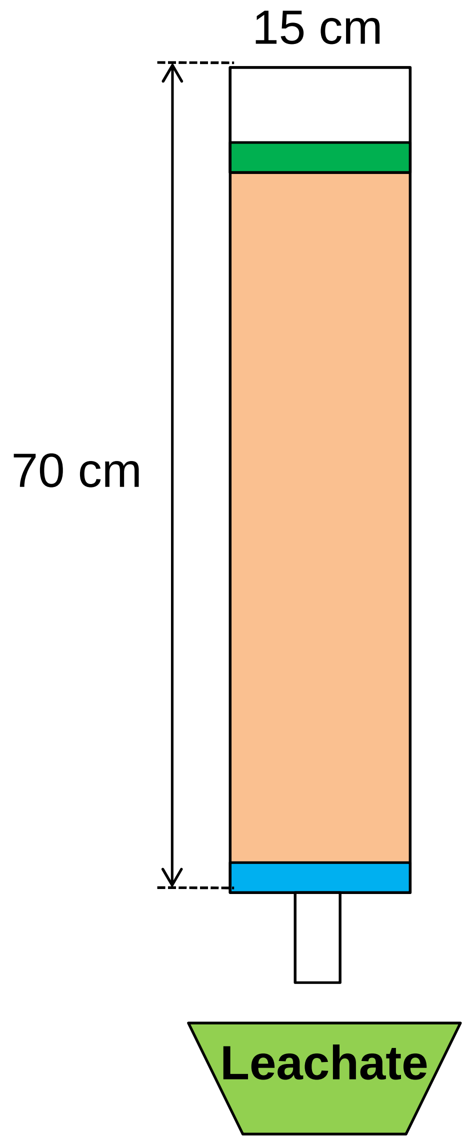
- **In Haean, compost (animal manure) with high DOC is applied to the soil at conventional farms.**
- **This practice may increase the potential for carbon loss due to soil erosion.**

Hypothesis

- Soil aggregate increases the retention capacity of organic substances (DOC) in the soil.
- PAM increases soil aggregate.
- PAM may reduce the loss of carbon (DOC) from soil.

Simulated rainfall column experiment

- **The amendments:**
  1. **Control (untreated soils).**
  2. **PAM at 10 kg/ha**
  3. **PAM at 40 kg/ha**
  4. **PAM at 10 kg/ha + compost**
  5. **PAM at 40 kg/ha + compost**
  6. **PAM at 10 kg/ha + 15N fertilizer**
  7. **PAM at 10 kg/ha + 15N fertilizer**



Measurements

Chemical

DOC, ^{14}C and ^{15}N

Physical

Soil surface seal (pore-size distribution & cumulative porosity) measurement using HRCT

Future Works

CT Analysis

All CT images were analyzed by dividing the sample into sub-regions.

Images were measured for voxel gray-scale using *ImageJ* ver. 1.34s