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Evaluating the Reduction Effect of Nonpoint Source Pollution Loads from Upland Crop Areas by Rice Straw Covering Using SWAT

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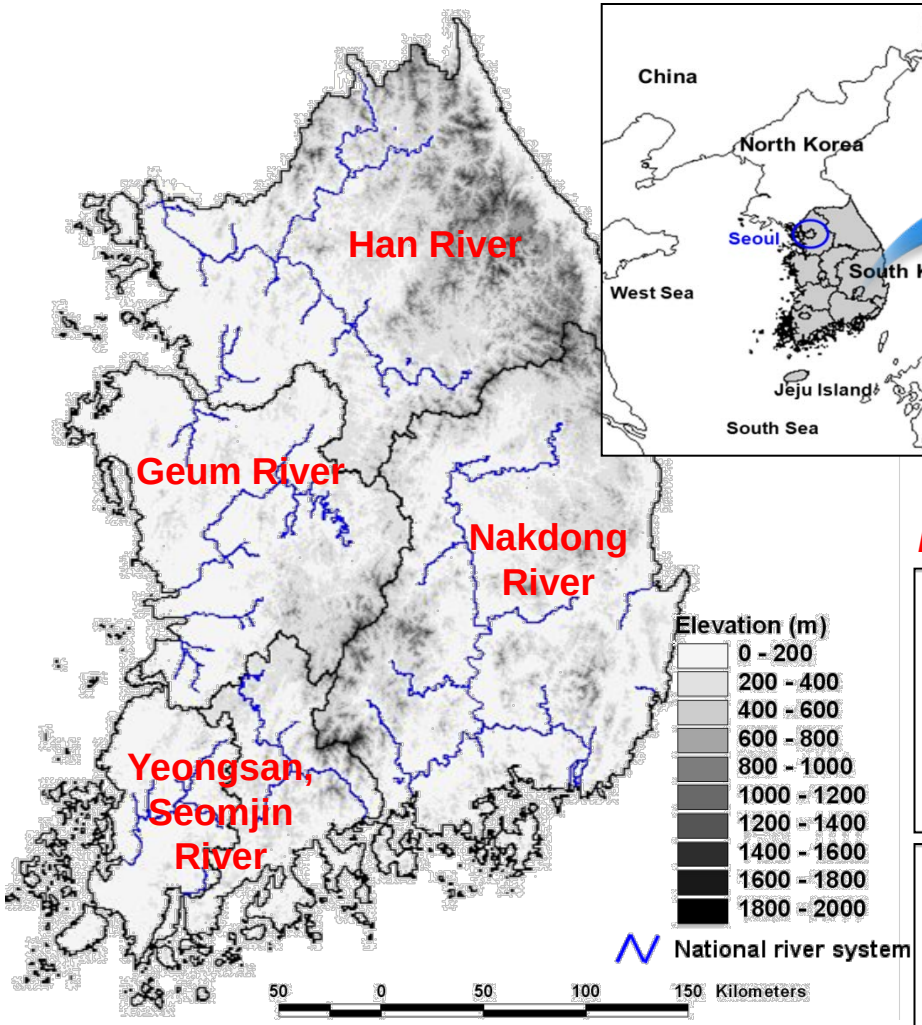
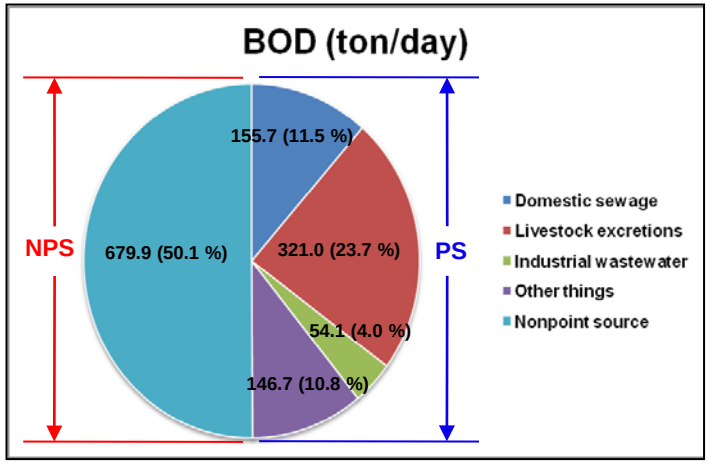
- Concluding remarks

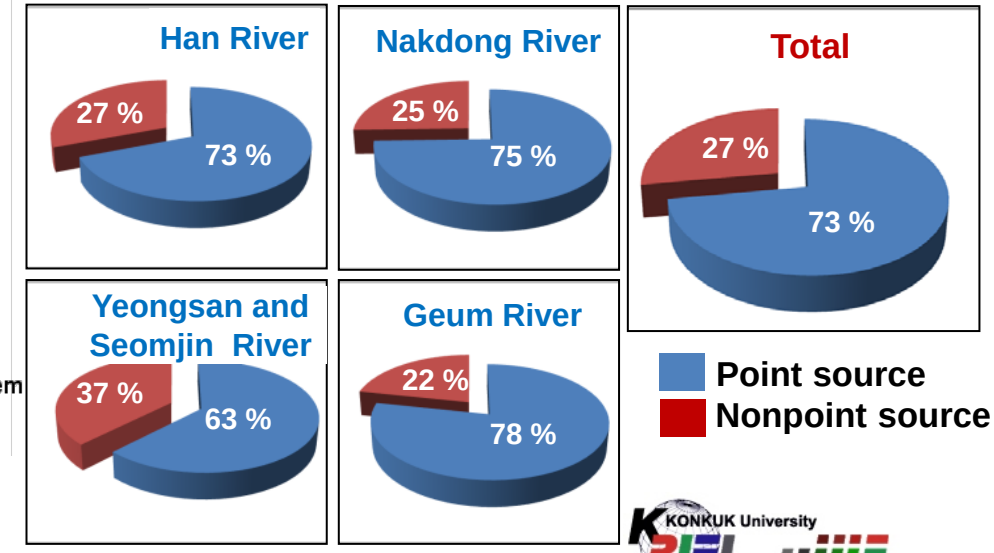
The state of NPS pollution (South Korea)



BOD loads (South Korea, 2007)



Pollution loads (Four major river, 2007)



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Introduction

- *This study has been supported by the Ministry of Environment since 2010.*
- *The main is field experiments, and the modeling & policy making hold 20 % each.*
- *Korean government is now operating the TMDL (Total Maximum Daily Load) to local government. With the yearly evaluation results, the central government controls the development and gives some incentive to rural community.*
- *Till 1970s, the straw-thatched house was found in rural areas. After the rural community movement (Saemaeul), the roof was changed to tile. By the intensified cattle breeding, the feed was changed to assorted grains.*

Introduction

- ***The solution of agricultural non-point source (NPS) pollution is a big issue in our country as it contributes big portions for the aquatic water quality.***
- ***The T-N and T-P loadings from upland crop areas in South Korea cover more than 30 % among the total pollutants.***
  - ✓ ***Especially, the NPS loads from June to August (Monsoon period) are highly discharged.***
- ***A catchment-scale identification of NPS pollution loads is helpful to support the economic planning of BMPs (Best Management Practices) at the right time and right place.***
  - ✓ ***NPS pollution is the rainfall-runoff process, which tends to be a complex non-linear, time-varying, and spatially distributed process in agricultural watersheds.***
  - ✓ ***Environmental hydrologic models such as SWAT and HSPF are very useful for effective evaluation of BMPs impact.***
- ***The purpose of this study is to assess the reduction effect of NPS pollution loads from catchment upland crop areas by applying the rice straw covering scenario through SWAT modeling.***

Study schematic

Total 12 events (2011 June to October)

Total 14 events (pre:20, post:12)

Meteorological Data	Spatial Data	Watershed monitoring	Experimental plot
Precipitation(sub-hourly), Temperature, Wind Speed, Solar Radiation, Relative Humidity	DEM(30m), Land Use(1m), Soil type (1:25,000)	Streamflow SS, T-N, T-P	Rice straw covering (1,276.6 m^2)

1.21 km^2

SWAT Model setup

Sat. hydraulic conductivity

Apply BMP scenario to upland crop areas

Upland crop: 0.067 km^2 (5.6%)

Evaluation of NPS loads reduction effects at catchment outlet

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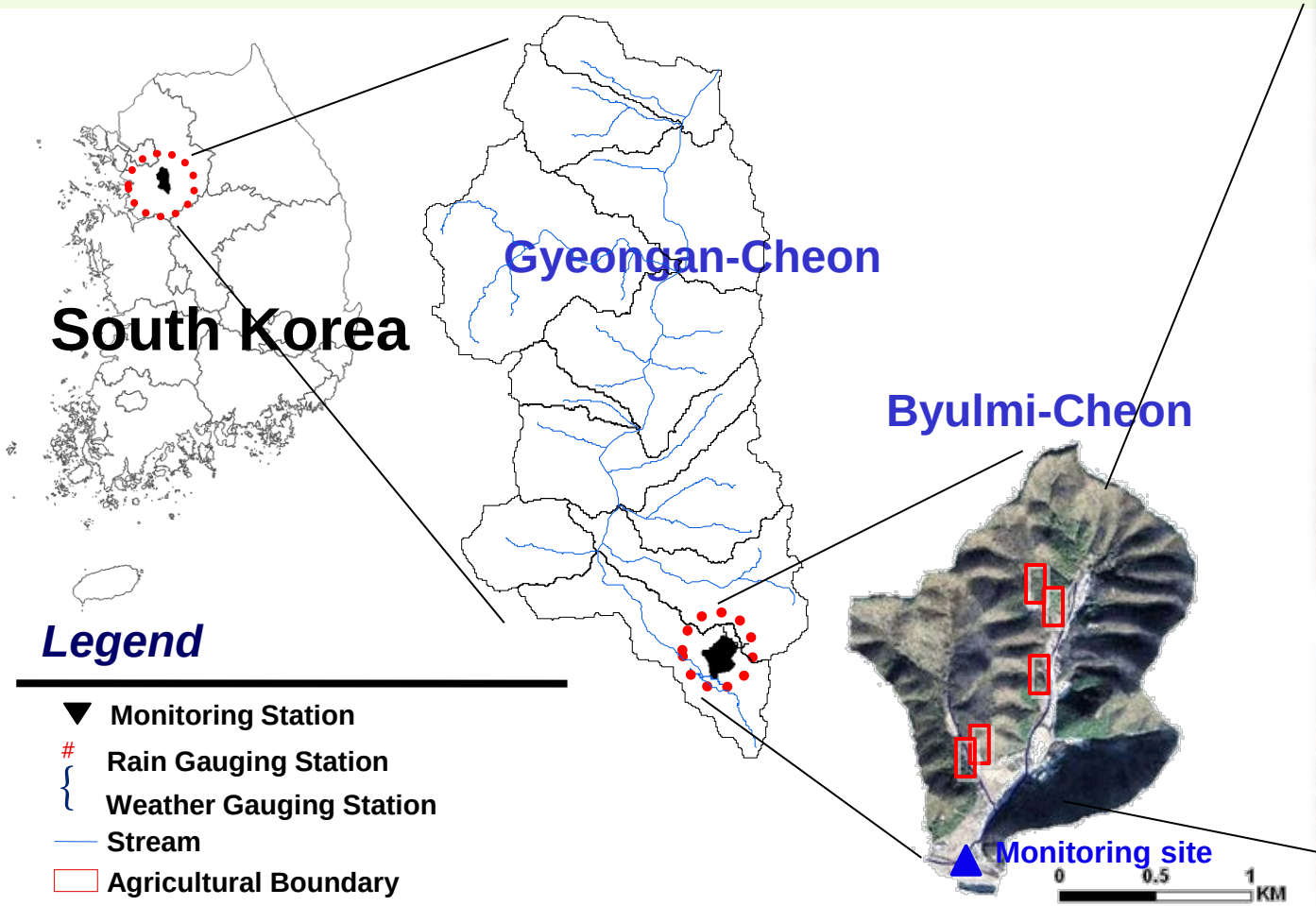
Study area



Legend

- Monitoring Station
- Rain Gauging Station
- Weather Gauging Station
- Stream
- Agricultural Boundary
- Watershed Boundary
- Study Area

Location

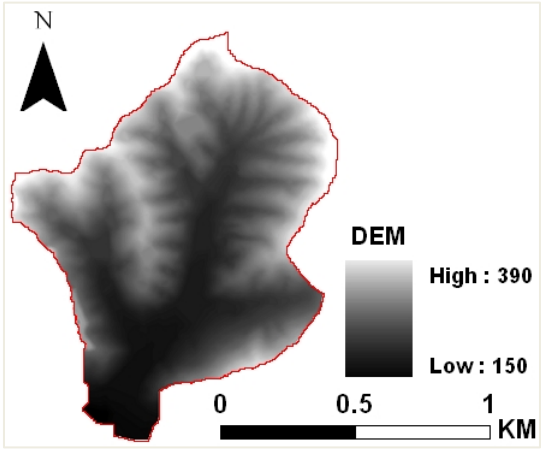
Latitude 37° 11´ to 37° 12´

Longitude 127° 15´ to 127° 16´

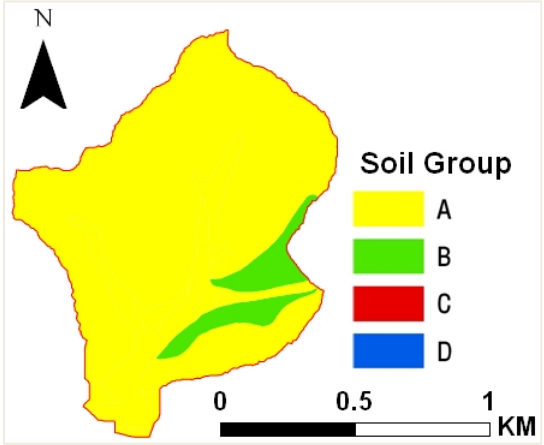
Catchment Area: 1.21 km^2

Catchment Data

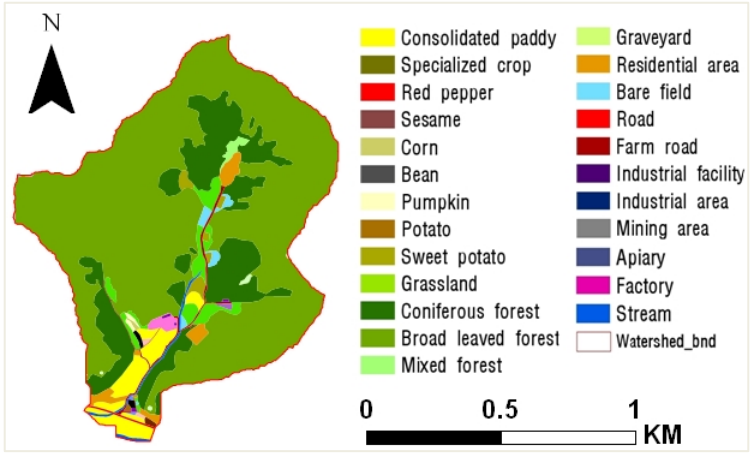
- ✓ *DEM 1:5,000*
- ✓ *Soil: 1:25,000*
- ✓ *Landuse: QuickBird (1st May 2006)*



DEM 2m



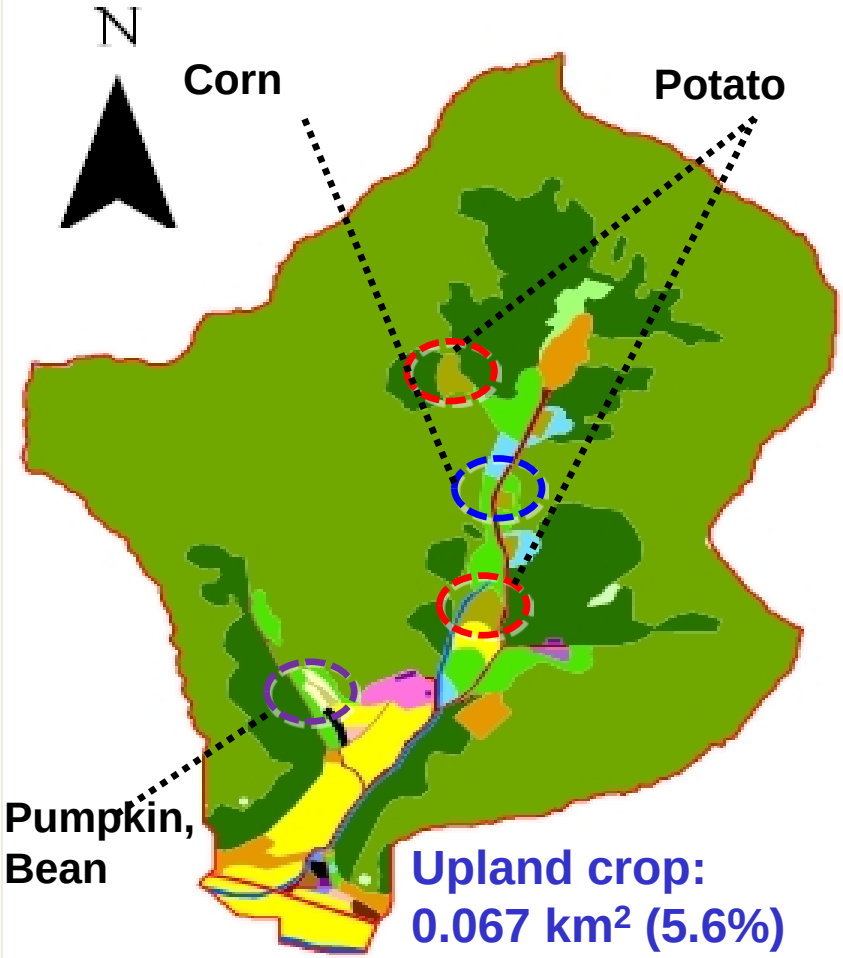
Soil



Landuse (QuickBird)

Catchment Data

❖ Land use (24 categories)



- Consolidated paddy
- Specialized crop
- Red pepper
- Sesame
- Corn
- Bean
- Pumpkin
- Potato
- Sweet potato
- Grassland
- Coniferous forest
- Broad leaved forest
- Mixed forest
- Graveyard
- Residential area
- Bare field
- Road
- Farm road
- Industrial facility
- Industrial area
- Mining area
- Apiary
- Factory
- Stream
- Watershed_bnd

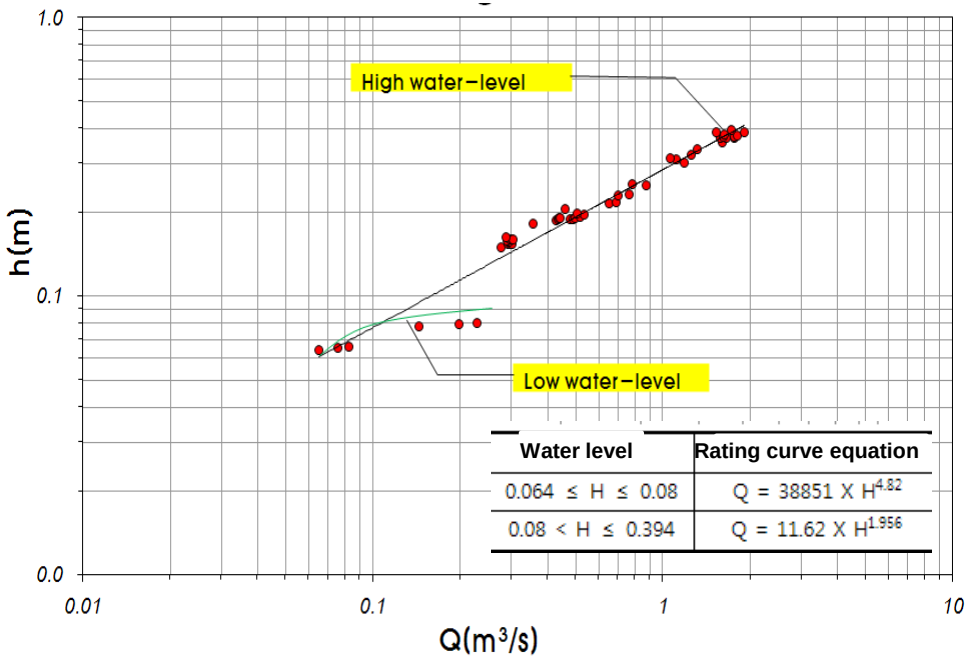
0 0.5 1 KM

Catchment data

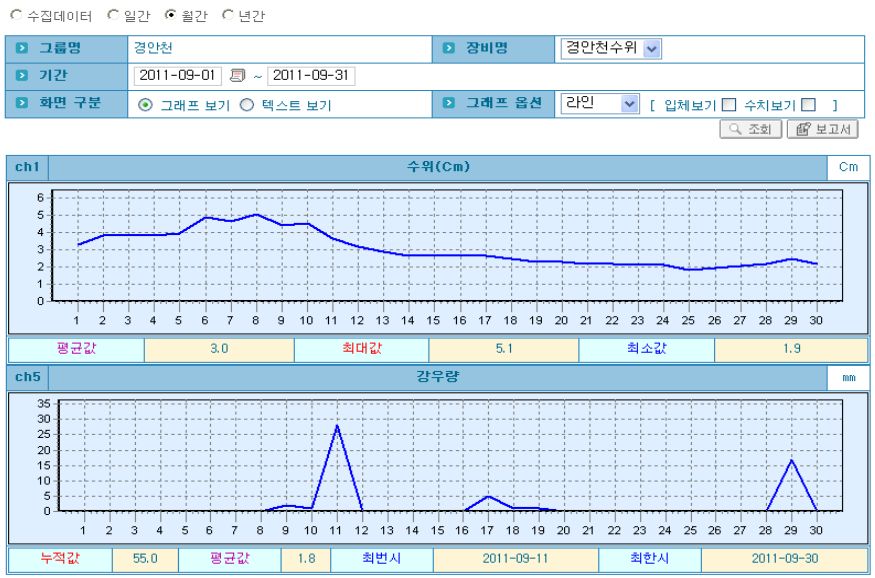
Monitoring

- ✓ *Rainfall station 1, water-level station 1, CDMA networking, web server operation (hour)*
- ✓ *Total 12 events (2011 June to October); streamflow, sediment, T-N and T-P*

Rating curve (2011)



Water level (T/M)



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Catchment data

❖ Monitoring process

Rainfall station

Catchment data

❖ Monitoring process



streamflow and water quality under rainfall event



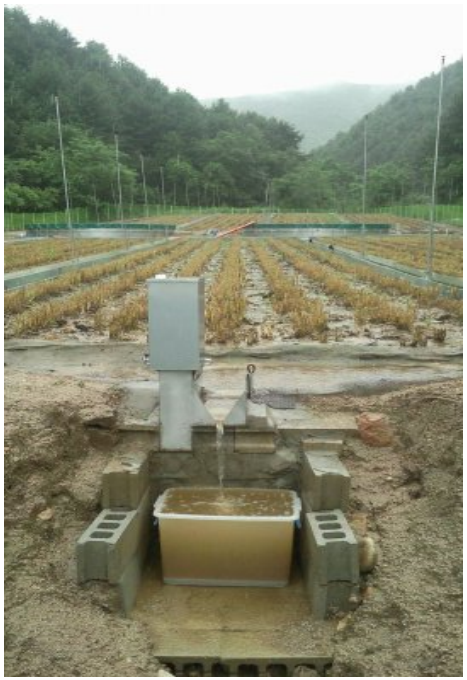
Material and method

❖ Rice straw covering

- ✓ *Eco-cycling, easy to obtain, easy to manage (spread and remove)*
- ✓ *Especially effective in poor soil conditions, reduce runoff and keep the soil & nutrients.*
- ✓ *Control soil erosion and maintain soil moisture*
- ✓ *Experimental plot data (from Kangwon Univ.)*

Latitude 37° 55´ to 37° 56´
Longitude 127° 46´ to 127° 47´
Area: 1,276.6 km^2, **Slope:** 3.2%






Material and method

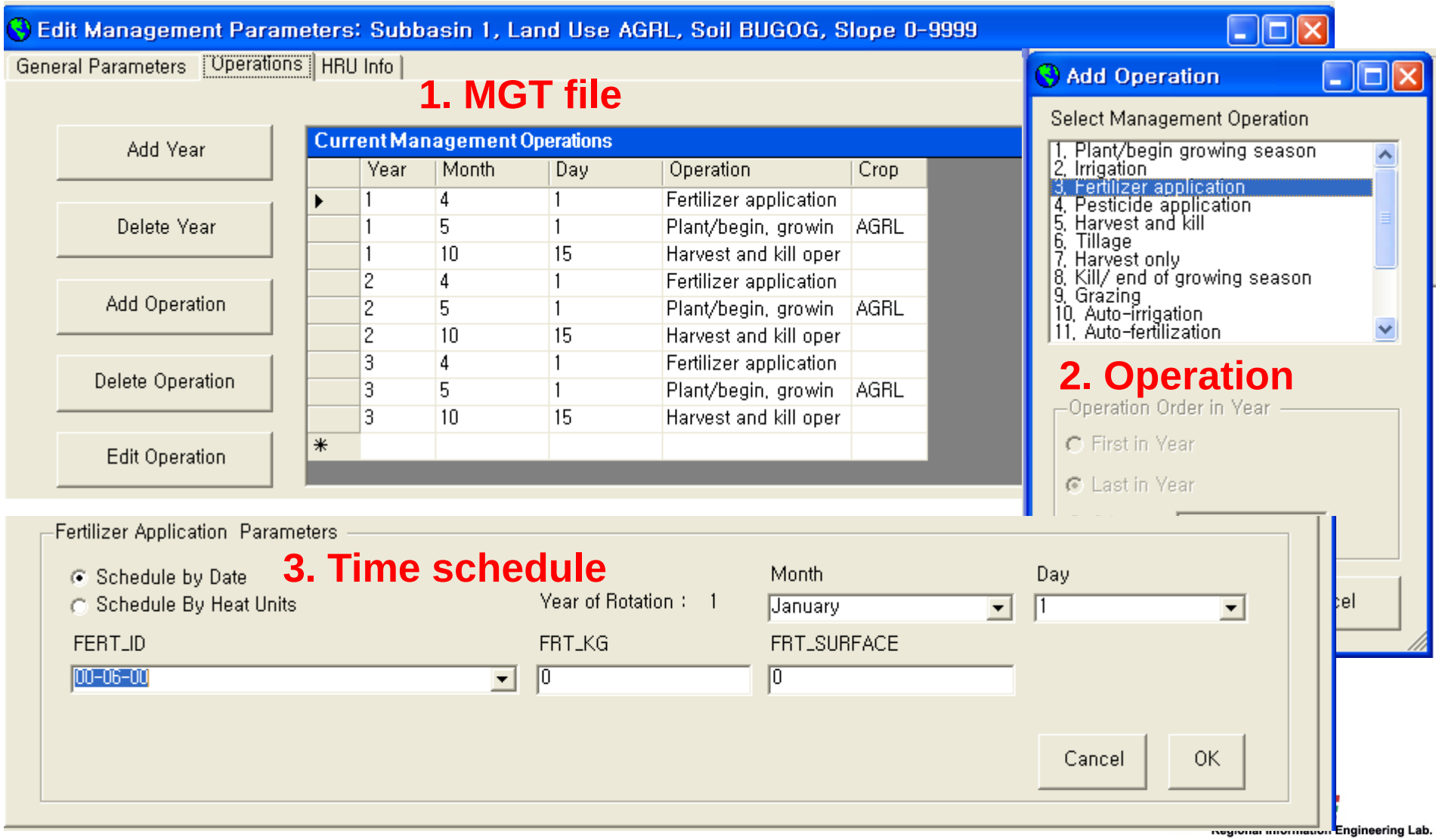
❖ Standard fertilizer application in South Korea

- ✓ ***SWAT uses Management files (.mgt) to describe plant growth, tillage, harvest, and fertilization practices.***

Crop	Plant	CN	Fertilizer (kg/ha)			Harvest
			N	P	K	
Paddy	1-May	78.0	0.17	0.045	0.057	15-Oct
Sweet potato	15-Mar	71.5	0.14	0.325	0.28	15-Oct
Potato	20-Feb	71.8	0.1	0.1	0.12	15-Jul
Soybean	1-May	70.3	0.08	0.14	0.12	1-Oct
Corn	1-Apr	69.7	0.073	0.03	0.06	1-Sep

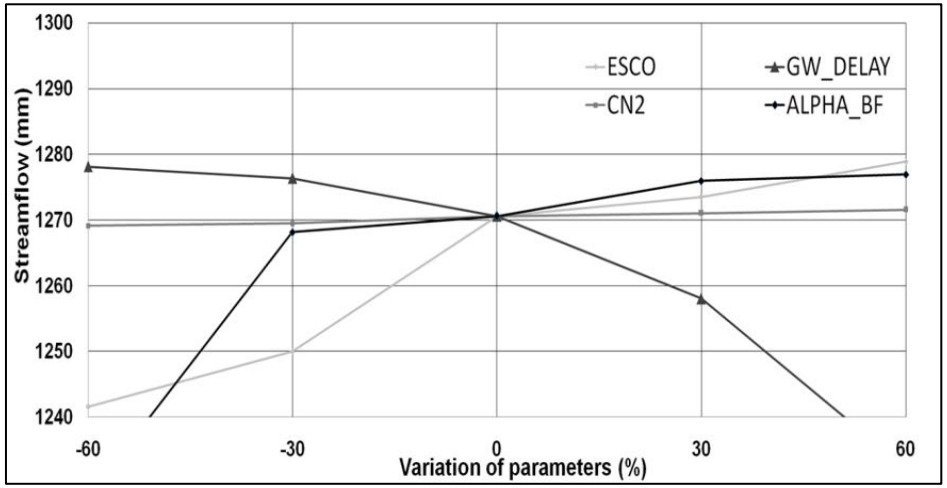
Material and method

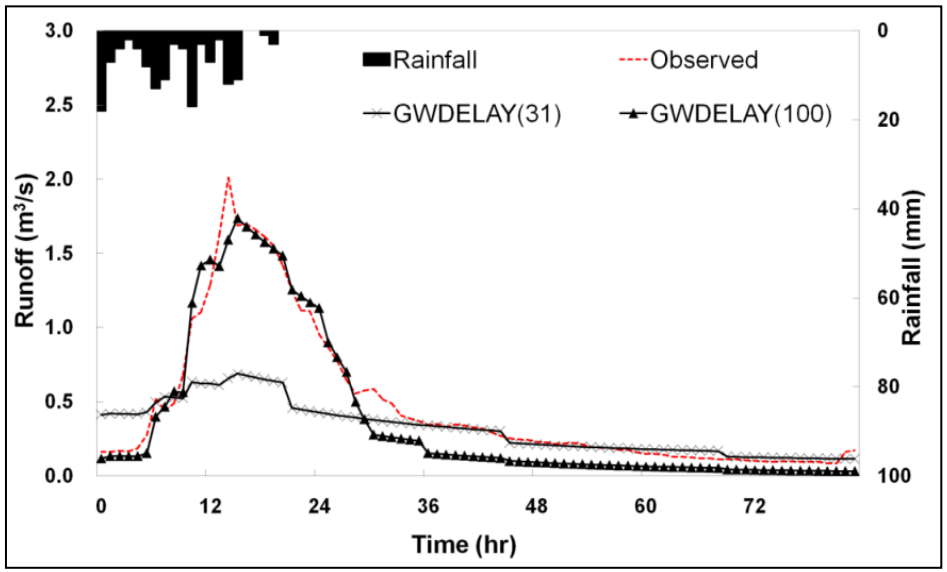
❖ Standard fertilizer application



Results and discussion

- **Sensitivity Analysis of SWAT parameters**
  - ✓ ***performed for 10 parameters***
  - ✓ ***ESCO (soil moisture), CN2 (surface runoff, sediment, phosphorus)***
  - ✓ ***GW_DELAY, ALPHA_BF (recession, nitrogen transport)***





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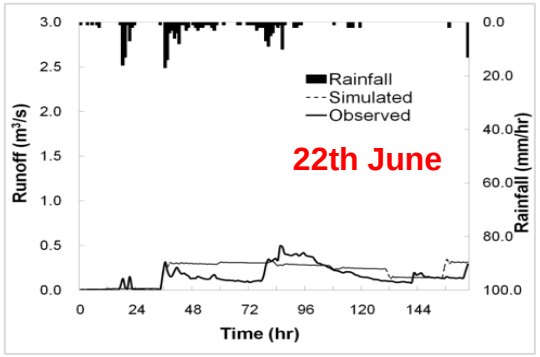
Results and discussion

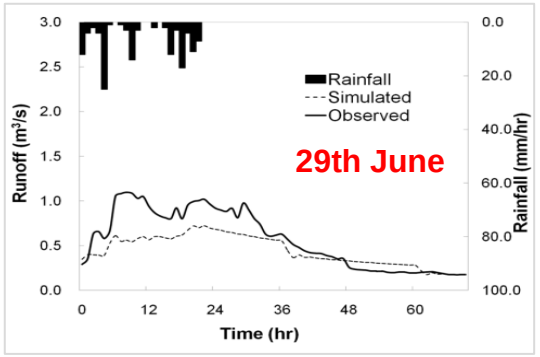
❖ Calibrated parameters

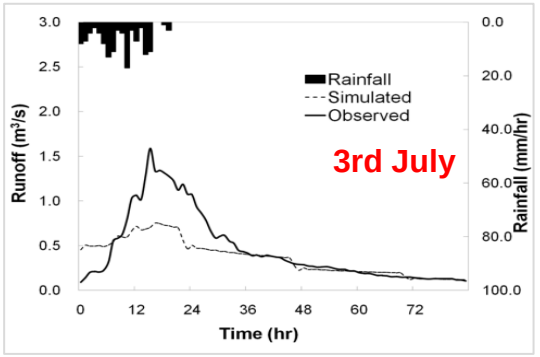
Parameter	Description	Calibrated Value	Range		Process
			Min.	Max.	
ALPHA_BF	Baseflow recession constant	0.8	0	1	Streamflow
ESCO	Soil evaporation compensation factor	1.0	0	1	Evapotranspiration
GW_DELAY	Delay time for aquifer recharge (days)	6.5	0	500	Ground water
GW_REVAP	Groundwater "revap" coefficient	0.02	0.02	0.2	Ground water
CH_COV	Channel cover factor	1.0	-0.001	1	Sediment
PRF	Peak rate adjustment factor for sediment routing in the main channel	2.0	0	2	Sediment
CH_EROD	Channel erodibility factor (cm/hr/Pa)	0.6	-0.05	0.6	Sediment
USLE_K	USLE equation soil erodibility K factor	0.5	0	0.65	Sediment
SHALLST_N	Nitrate concentration in shallow aquifer (mg/l)	100	0	1000	Total Nitrogen
CH_ONCO	Organic nitrogen concentration in the channel (ppm)	100	0	100	Total Nitrogen
NPERCO	Nitrogen percolation coefficient	1	0	1	Total Nitrogen
CN_OPCO	Organic Phosphorus concentration in channel	100	0	100	Total Phosphorus
GWSOLP	Concentration of soluble phosphorus in groundwater	150	0	1000	Total Phosphorus

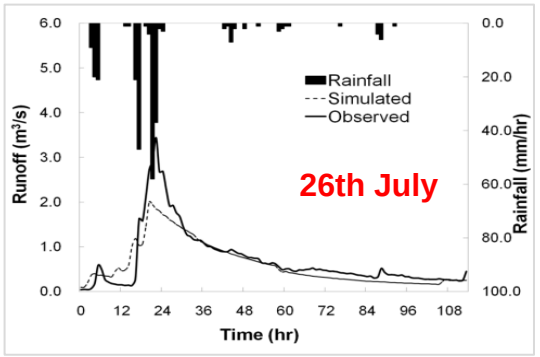
Results and discussion

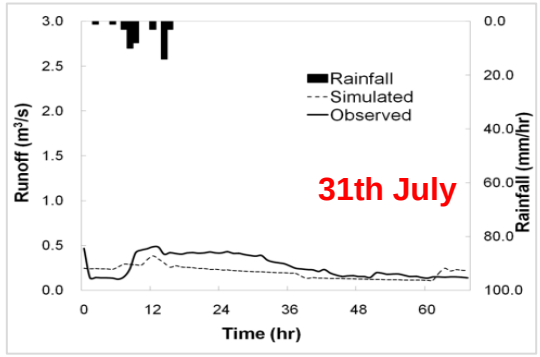
❖ Streamflow calibration

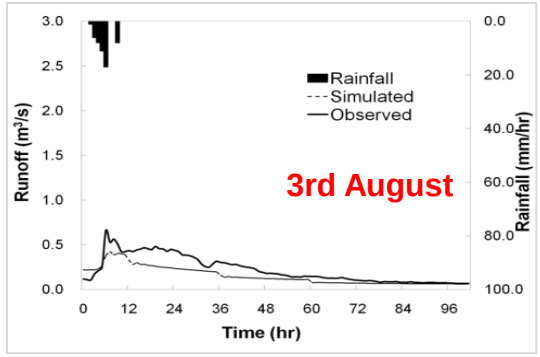


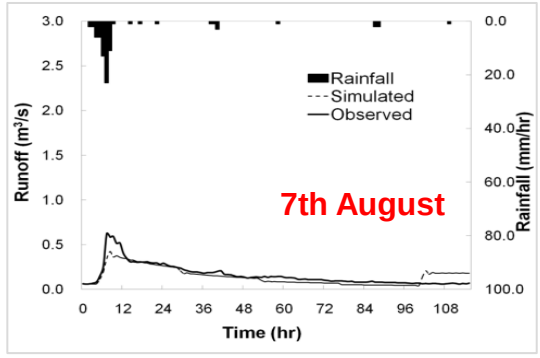


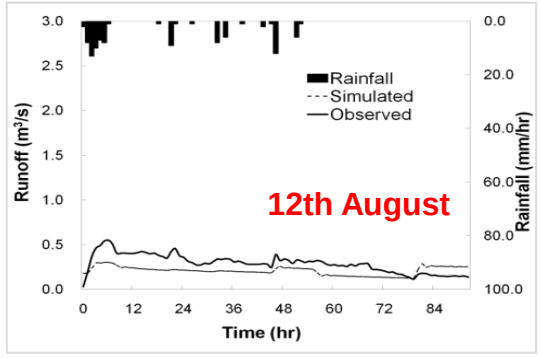


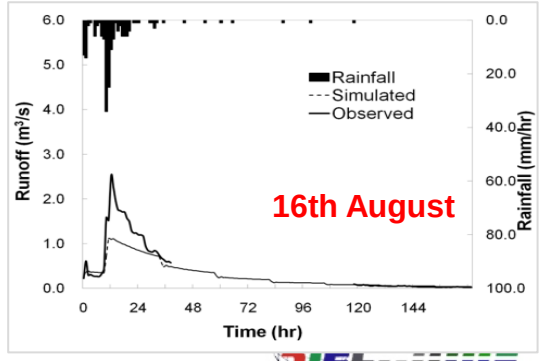






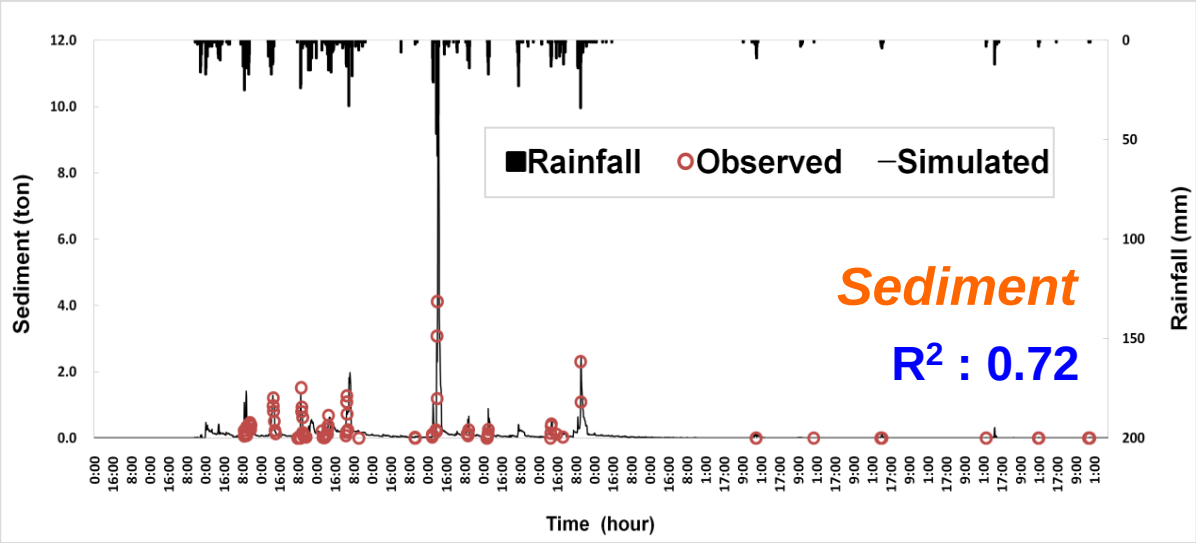


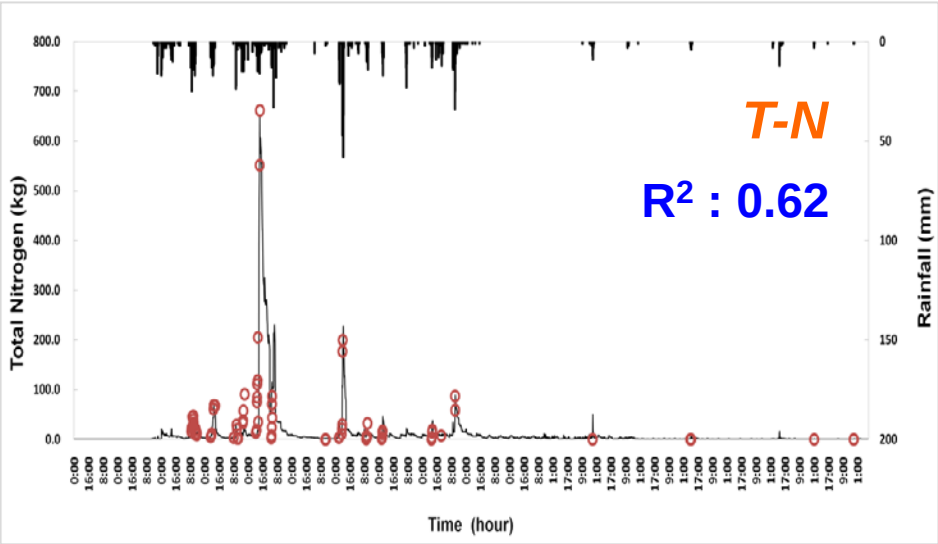


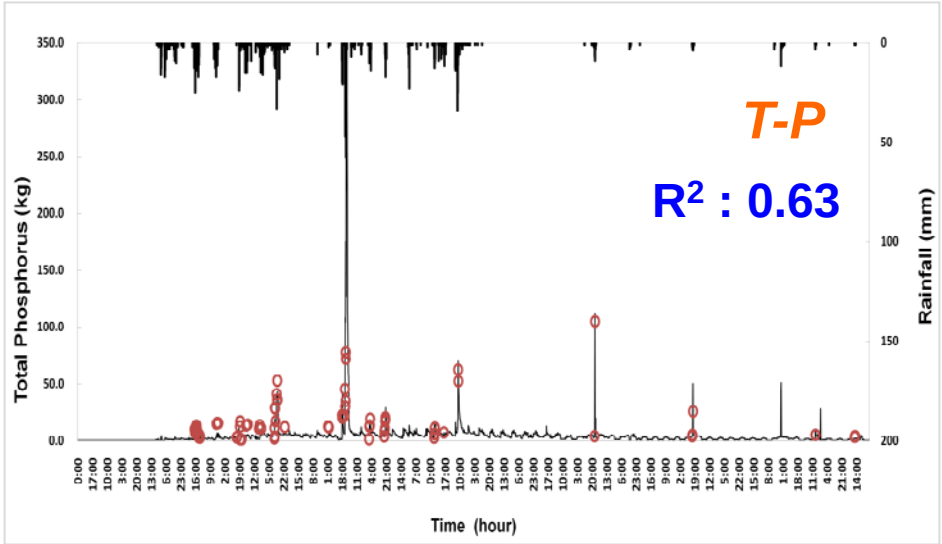


Results and discussion

❖ Stream water quality





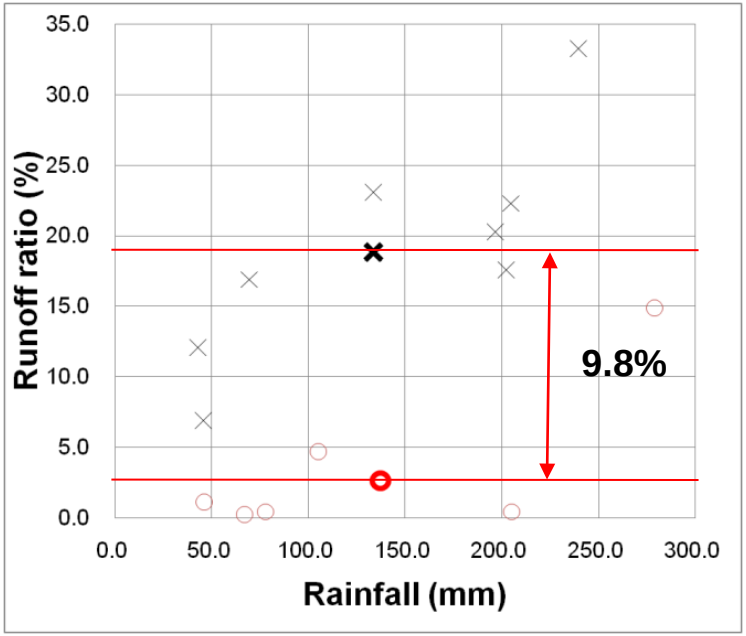


Results and discussion

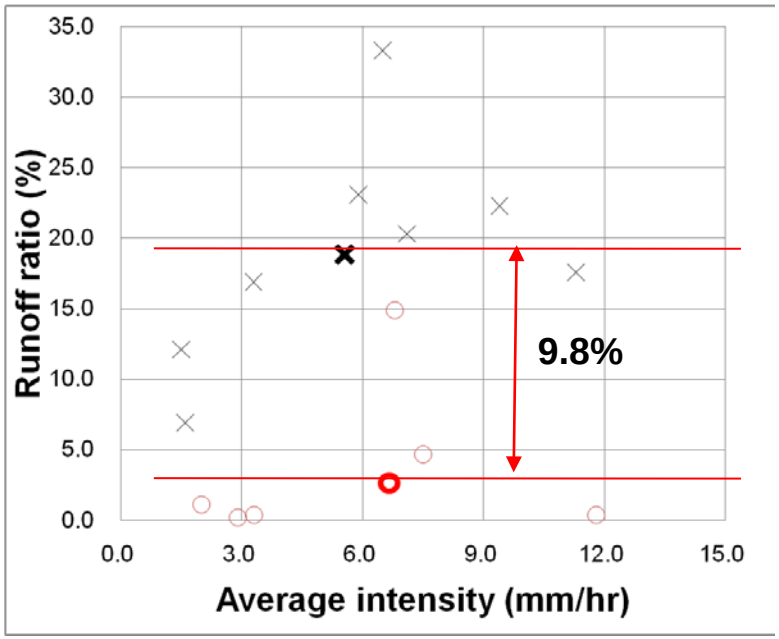
❖ Experimental results of rice straw covering to upland crop

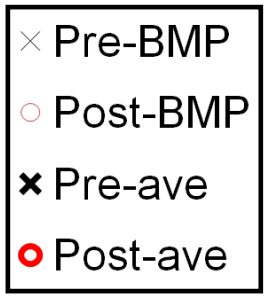
- ✓ *For 8 pre-covering and 6 post-covering data,*
- ✓ *The percent of decrease in surface runoff was 9.8 %.*
- ✓ *The removal efficiency of NPS loads were 89.7 % ~ 99.4 %.*

Rainfall-Runoff ratio



Intensity-Runoff ratio



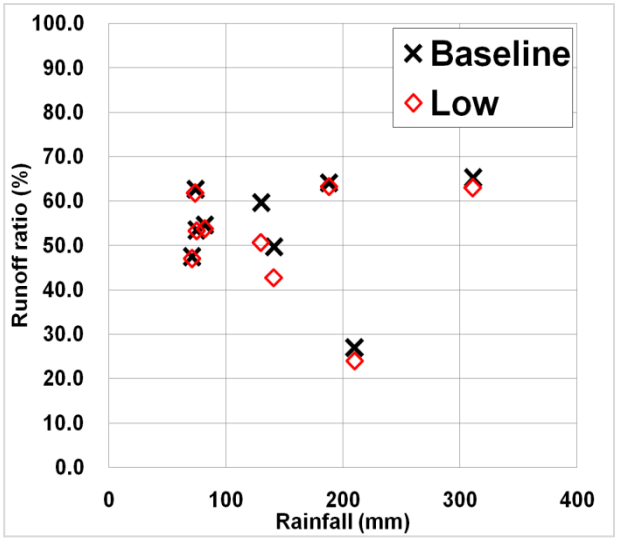


Results and discussion

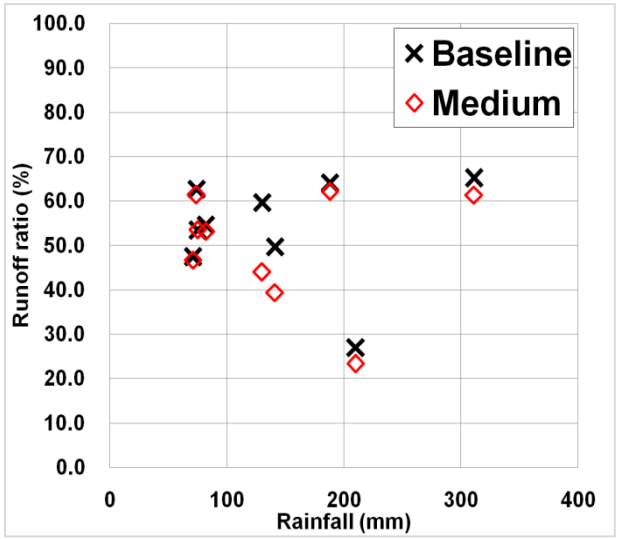
❖ SWAT application results

- ✓ *The saturated hydraulic conductivity (SOL_K) was adjusted.*
- ✓ *Three level of SOL_K was tested.*
  - ✓ *Low: 16.2 mm/hr (2.5 % of runoff decrease)*
  - ✓ *Medium: 21.2 mm/hr (5.0 % of runoff decrease)*
  - ✓ *High: 111.2 mm/hr (10.0 % of runoff decrease)*

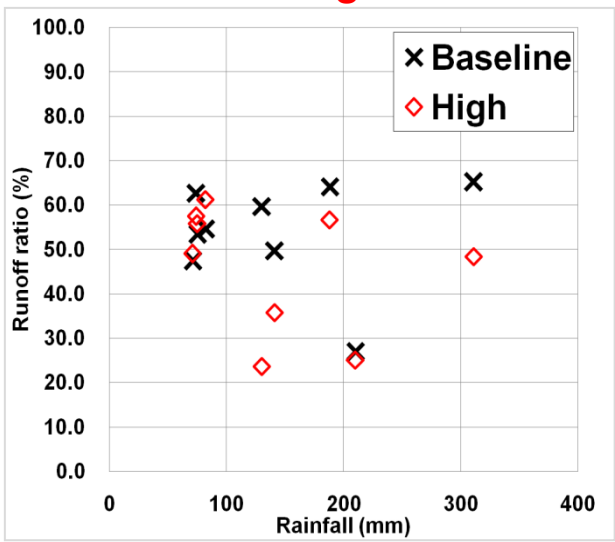
Low



Medium



High

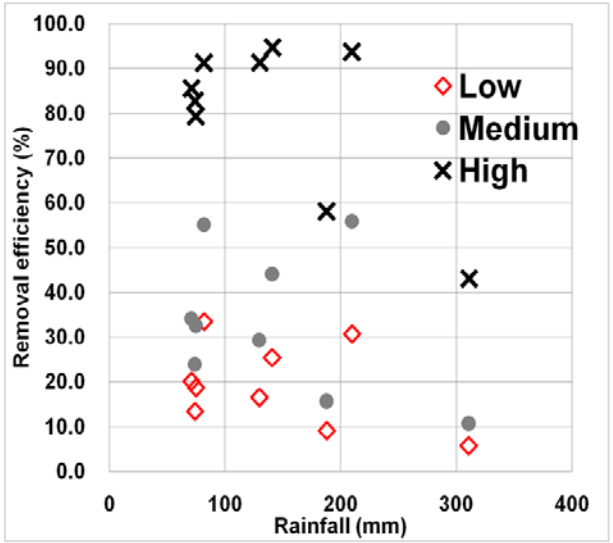


Results and discussion

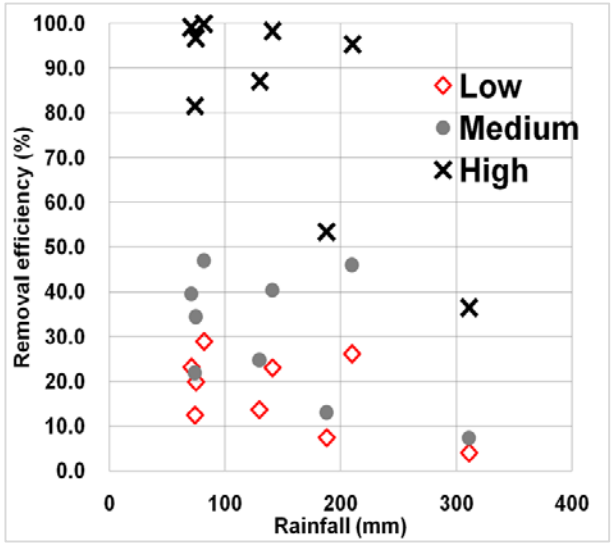
❖ SWAT application results

- ✓ **The removal efficiency**
  - ✓ *Sediment: 19.2 ~ 80.0 %*
  - ✓ *T-N: 17.7~ 83.2 %*
  - ✓ *T-P: 14.6 ~ 78.7 %*

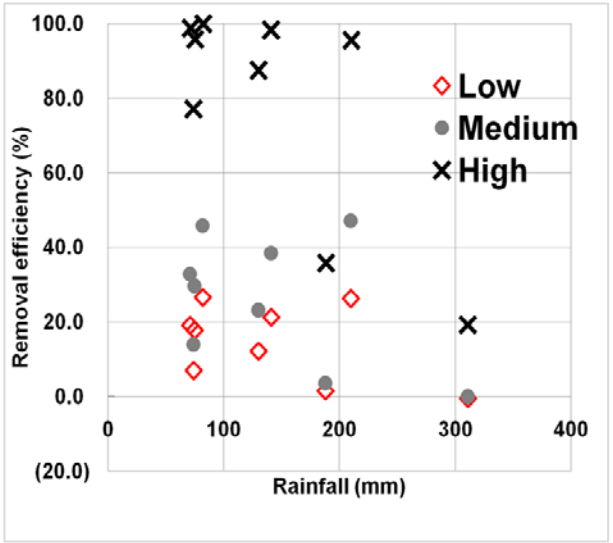
Sediment



T-N



T-P



Concluding remarks

- *We tried to reduce the NPS loads by covering rice straw in upland crop areas from a catchment.*

- *For SWAT modeling, we selected the parameter saturated hydraulic conductivity (SOL_K) to evaluate the covering effect.*
  - ✓ *To reduce surface runoff, increase infiltration*

- *Is there an idea for the evaluation of surface covering effect?*
  - ✓ *With limited field experimental results, For effective catchment evaluation*
  - ✓ *Other parameters?*

Thank you

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