Tropentag 2016, Vienna, Austria
September 18-21, 2016

Conference on International Research on Food Security, Natural Resource Management and Rural Development
organised by the University of Natural Resources and Life Sciences (BOKU Vienna), Austria

Maize Relay with Legume without Residue Burning Impact on Soil Erosion and N Loss in Northern of Thailand

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Introduction

Maize is grown on 1.14 million ha in Thailand, where 0.7 million ha is in the Northern region. Most of the maize area in Northern of Thailand is in the highlands, where water supply comes from the rain. Generally, after the maize harvest, farmers would leave the residues (e.g. leaves, stalks and husks) in the field until the next crop. Then farmers prepared land for the new crop in March - April, the residues and weeds are slashed and burned. The slash and burn method of agriculture is the main traditional farming system in the mountains. The slash and burn method of cultivation has many impacts on the environment. Osinname and Meppe (1999) reported maize grain yield of the second year dropped by nearly 50% under surface burning residue.

Soil erosion was a major environment and agriculture problem. Soil under highland agriculture in the northern region of Thailand were removed by 7.13 tons/ha/year (Deedlek, 2002). Soil erosion was increasing on slope cropland, in Nigeria cassava fields on slope 12% found soil loss 221 tons/ha/year, compared with flat land. Crop residue and plant biomass left on fields has reduced soil erosion and water runoff by intercept and dissipate raindrop (Pimentel et al., 1995). Ngwira et al. (2012) reported for maize grain yield by 4.0 - 4.9 t/ha in maize + legume and 3.5 t/ha in maize mono as well as Thierfelder et al. (2015) reported maize + legume intercropping system provide yield benefits for farmers without significantly. Moreover, leaving crop residue on previous crop reduces soil loss by 47% and 54% for the 50% and 100% maize population compared by land not planting (Wilson et al., 2008).

Due to the negative impacts of slash and burn monoculture in the highland, reduction of aboveground residue burning needs to be minimized and residue must be retained on the soil to maintain and increase soil fertility, soil biodiversity, minimizing erosion and protecting soil quality and maintaining of productivity. In this study, maize + legume cropping system will be chosen in this study. The objectives of this study was to evaluate soil erosion and N loss on the maize plantation without residue burning fields.

Material and methods

Soil erosion plot was installed in farmers' field at Na-loa village, Pong-Khum Highland Development Project Using Royal Project System area in Santi Suk district, Nan province in rainy season of 2014 - 2015.

The experiment designed in 3 x 3 RCBD, plot slope 33, 41 and 48 % in replicate 1, 2 and 3 respectively. The treatment consisted of:

1. Control : Maize + residue burning (slashes and burn crop residue from the previous crop)

2. Maize + without residue burning (slash without residue burning)
3. Maize + without residue burning + lablab (slash without residue burning)

Maize growing

Land preparation before maize sowing involved slashing of the residues, followed by burning in the control treatment and without burning in treatment 2 and 3. The maize seed hybrid (CP 888) was sown in late May. Spacing between plants by 0.5 m and between rows by 0.75 m with 2 seed/hill and seed rate was 19 kg/ha. Fertilizers were applied 20 days after planting with 125 kg/ha of urea (46% N) and 125 kg/ha of 16 – 20 - 0 (% N - P_2O_5 - K_2O) at 60 days after planting. Maize was harvested in mid-November, the ears were removed by hand and straw was slashed down in between legume rows.

Legume growing

Lablab were sown in late August at seed rate of 50 kg/ha, planting between the maize rows at the spacing 0.30 m between plants, 30 days before the maize harvesting, and no fertilizer was applied. Lablab were harvested in March (180 days), pods were removed and residues were left in the field.

Soil erosion plot site

The erosion plots (10 m x 4 m) (Wilson et al., 2008) were bounded by galvanized sheet 0.30 m. At the bottom of the plot, a catch-pit was made of tank with radius 0.54, height 0.88 m, at the volume of about 200 liters.

Data collection

1. Soil sediment: collected after raining
   1) Soil sediment was collected from the catch-pits.
   2) Sample was measured from the level of water and soil sediment in the catch-pit tank.
   3) The water and soil sediment were mixed and dissolved at 500 ml.
   4) The sample (water + sediment) was evaporated by a hot air oven at 105 $^{\circ}$C for 24 hours.
   5) Cleaning up the catch-pit tank.
2. Grain yield: Maize was collected from 12 hills (2.25 m^2) and lablabs were collected from 1 m^2. The grain yields were calculated at 14 % moisture**.**
3. Residues dry weight: residue (without cobs) of maize was collected in 12 hills (2.25 m^2) and lablabs were collected in 1 m^2 on harvest stage. The samples were dried by hot air oven at 75 $^{\circ}$C for 72 hours.
4. Statistical analysis was conducted by using Statistix version 8 (SXW)

Results and discussion

Yield

Maize grain yield was non-significant difference in the first and the second years, there was a small effect between residue burning and without residue burning, and significantly larger effect by the method of without residue burning adding legume (Table 1). Maize grain yield increasing by 23% in maize without residue burning + lablab fallowing by 15% in maize without residue burning compared to maize + burning (Ngwira et al., 2012; Thierfelder et al., 2015). Lablab grain yield by 0.8 t/ha in 2014 and 0.2 t/ha in 2015.

Residue

Maize residue in season 2014 and 2015 was no significant difference among cropping systems, season 2014 ranged from 3.6 – 3.8 t/ha and 3.6 – 4.0 t/ha in season 2015 (Table 2). The residue in lablab was 2.5 t/ha in 2014 and 2.5 t/ha in 2015.

The total crop residue left in the soil was significant difference among cropping systems (Table 2). In season 2014 and 2015, crop residue in maize without residue burning + lablab was increased by 80% and 81% compared to maize residue burning. In the season 2014 and 2015, total crop residue in maize monoculture was no significant difference. While crop residue in maize + burning was lost by burning.

Table 1 Maize and lablab grain yield in maize cropping system at Na-loa village, Santi Suk district, Nan

Treatment	Maize yield (ton/ha)		Lablab yield (ton/ha)	
	2014	2015	2014	2015
Maize + burning	3.5	3.4 c	0	0
Maize + without burning	3.5	3.9 b	0	0
Maize + without burning + lablab	3.6	4.2 a	0.8 (0.17)	0.2 (0.03)
mean	3.5	3.8		
F-test	ns	**		
$LSD_{.05}$	-	0.28		

** = significant difference $P < 0.01$, ns = non-significant difference, mean in the same column follow by different letter indicates significant difference $P < 0.05$, Values in parentheses was standard deviations.

Table 2 Maize and lablab residue in maize cropping system at Na loa village, Santi Suk district, Nan

Treatment	Maize residue (ton/ha)		Lablab residue (ton/ha)		Total residue (ton/ha)	
	2014	2015	2014	2015	2014	2015
Maize + burning	3.6	3.6	0.0	0.0	3.5 b	3.6 b
Maize + without burning	3.7	4.0	0.0	0.0	3.7 b	4.0 b
Maize + without burning + lablab	3.8	4.0	2.5 (0.20)	2.5 (0.31)	6.3 a	6.5 a
mean	3.7	3.9			4.5	4.7
F-test	ns	ns			*	*
$LSD_{.05}$	-	-			1.0	0.8

* = significant difference $P < 0.05$, ns = non-significant difference, mean in the same column follow by different letter indicates significant difference $P < 0.05$, Values in parentheses was standard deviations.

Soil erosion and N loss

Soil erosion in season 2014 and 2015 was significant difference ($P < 0.01$) among cropping systems ranging from 33.8 to 77.5 t/ha in 2014 and 7.5 to 52.5 t/ha in 2015. In 2014, soil loss was decreased by 57 and 60 % in maize without residue burning and maize + lablab respectively compared to maize burning residue. However, soil erosion was no significant difference between maize without residue burning and maize without residue burning + lablab (Table 3). Season 2015, soil loss was decreased by 86 % in maize without burning + lablab fallowing 61% in maize without residue burning compared to maize burning residue (Wilson et al., 2008; Pimentel et al.,1995).

N loss in season 2014 and 2015 was significant difference among cropping systems ranging from 5.6 to 16.9 t/ha in 2014 and 1.3 to 11.3 t/ha in 2015. In season 2014, N loss was decreased by 67 and 67 % in maize without residue burning and maize without burning + lablab

respectively compared to maize burning residue. However, N loss was no significant difference between maize without residue burning and maize without residue burning + lablab (Table 3). Season 2015, N loss was decreased by 88 % in maize without burning + lablab and 61% in maize without residue burning compared to maize burning residue.

Table 3 Soil erosion and N loss in maize cropping system at Na-loa village, Santi Suk district, Nan

Treatment	Soil erosion (ton/ha)		N loss (ton/ha)	
	2014	2015	2014	2015
Maize + burning	77.5 a	52.5 a	16.9 a	11.3 a
Maize + without burning	33.1 b	20.6 b	5.6 b	4.4 b
Maize + without burning+ lablab	33.8 b	7.5 c	5.6 b	1.3 b
mean	48.1	26.3	9.4	5.6
F-test	**	**	**	**
$LSD_{.05}$	13.2	12.0	5.4	4.2

** = significant difference $P < 0.01$, ns = non-significant difference, mean in the same column follow by different letter indicates significant difference $P < 0.05$, Values in parentheses was standard deviations.

Conclusions and outlook

Growing maize without residue burning and relay with legume practice is promising as a method to reduce soil erosion and nutrients loss, increasing grain yields and farmer's income, and lessening the impact on haze problems. Further studies should explore more legumes for relaying and a participatory research to determine the feasibility of how this practice may be adapted to be managed by highland farmers.

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