Increasing Fertilizer Use Efficiency, Availability of Phosphorus and Crop Yield in Furrow Cultivation for Sustainable Agriculture on Sloping Land

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INTRODUCTION

The sustainable highland agriculture are depending on soil and water conservative cultural practices, which are able to maintain high nutrient availability, consequently increased nutrient use efficiency and crop productivity. It was proved during the last decade that the best strategy for building a sustainable highland rainfed agriculture was the IWAM, *Integrated Water harvesting, Anti-erosion, and Multiple cropping" technique* (Panomtaranichagul et al., 2010). The technique consisted of furrow cultivation, mulching with biodegradable materials, multiple and alley cropping system.

This field trial was a part of the research titled *"The improvement of anti-erosive and water harvesting practices in alley cropping to increase sustainable rainfed multiple crop production on sloping land"*, under The Uplands Program (NRCT-DFG). In general, the soil pH, fertility and nutrient availability of cultivated sloping land on mountainous areas are low, particularly, available phosphorus (P) and zinc (Zn). Therefore, it is necessary to improve soil pH, fertility and nutrient availability in order to increase soil and crop productivity. This may be achieved by applying lime, organic fertilizer and inorganic fertilizer including foliar Zn application, under IWAM cropping system. This experiment aimed to study the effects of integrated cultural practice, zinc, lime, and fertilizer (organic and inorganic) applications on phosphorus availability, crop growth, and yields, in contour cultivated furrow cropping system.

METHODOLOGY

The experimental plot was located on a cultivated area in Mae Chaem District, Chiang Mai Province, Northern Thailand (Figure 1). The experiment designed was a Split-split Plot in a Completely Randomized Design (Split-split Plot in CRD) with 3 replicates of 6 combination-treatments, which were 2 methods of cultivation and 3 practices of fertilizer/lime applications (Table 1 and Figure 2). Main plots were conventional planting (CP) and furrow cultivation (CF) with dimension of 5x15 m each. Sub plots were foliar - zinc (Zn_1)/no zinc (Zn_0) applications and sub-sub plots were liming (L) and organic/inorganic fertilizer (OF/IF) applications.

The crops were planted as a multiple rotational relay cropping system. Sweet corn (*Zea mays saccharata*) was sown as the 1st crop at the early rainy season followed by peanut (*Arachis hypogaea L.)* as the 2nd crop in the middle of rainy season. Lablab bean *(Lablab perpureus Linn.) was* the 3rd crop planted at the late rainy season. Soil sample was collected monthly before planting until the harvesting period to measure soil pH, organic matter (OM) and extractable phosphorus (Ext.P). Crop yield and biomass productions were measured as dry weight of seed yield and total dry matter above ground level per unit area.

Figure 1: The experimental plot is located at altitude 1,238 m, latitude 18° 31' 04.81" N, and longitude 98° 17' 29.46" E.

Table 1 : Experimental design comprised 6 combination-treatments.

Conventional Planting (CP)		Furrow Cultivation (CF)	
Zinc (Zn_1)	None- Zinc (Zn_0)	Zinc (Zn_1)	None- Zinc (Zn_0)
No liming and fertilization/ Control (CP)	No liming and fertilization/ Control (CP)	No liming and fertilization/ Control (CF)	No liming and fertilization/ Control (CF)
Lime (L)	Lime (L)	Lime (L)	Lime (L)
Organic-Fertilizer (OF)	Organic-Fertilizer (OF)	Organic-Fertilizer (OF)	Organic-Fertilizer (OF)
Inorganic-Fertilizer (IF)	Inorganic-Fertilizer (IF)	Inorganic-Fertilizer (IF)	Inorganic-Fertilizer (IF)

Figure 2: The experimental main plots consisted of conventional planting (CP) and furrow cultivation (CF) with sub-plots and sub-sub plots of Zn, L, OF and IF applications in each main plot.

RESULTS

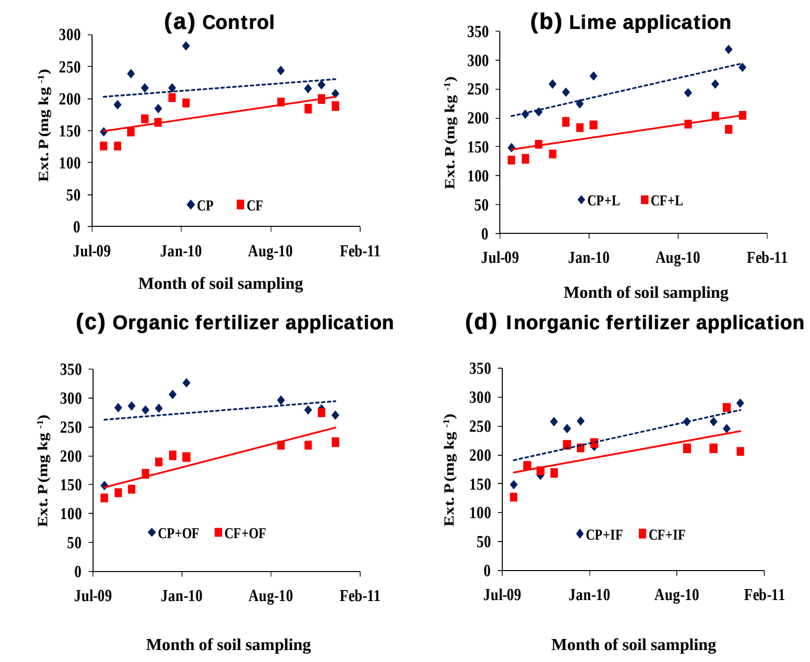
Effects of Treatments on Extractable Phosphorus

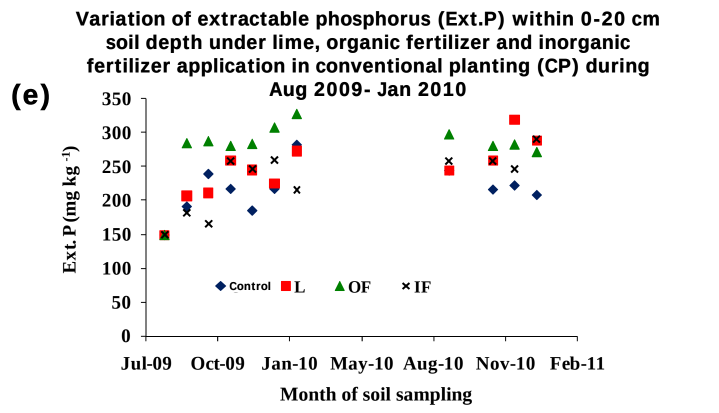
The trends of changing the amount of Ext.P in limed and fertilized plots under CP and CF are shown in Figure 3a – 3e . CP tended to result in higher amount of Ext.P than CF (Figure 3a - 3d). This might be caused by the lower crop development and P consumption under CP than CF. Both CF and CP tended to increase the Ext.P after applying of lime, organic fertilizer and inorganic fertilizer. OF applying in CP plot tended to give the highest residual amount of Ext.P compared to L, IF and control (CP only). However, applying lime and fertilizers in CP plot tended to give largely varied amounts of Ext.P during the two experimental years (Figure 3e). Conversely, in CF plot, the applications of lime and fertilizers tended to give little variations and similar amounts of Ext.P (Figure 3f). In general, the residual amounts of Ext.P under the main effects of the studied treatments were not significantly different. This might have resulted from interactive effects of different treatments (cultivation methods, liming and fertilizer applications), the amount and distributions of rainfall and crop developments during different growing stages.

REFERENCE

Panomtaranichagul, M., Karl Stahr , Michael A. Fullen , Dalop Supawan, and Warakun Srivichai. 2010. 10 Year-development of intergrating culturalpractices "IWAM"for sustainable highland rainfed agriculture in northern Thailand. Sustainable Land Use and Rural Development in Mountainous Regions of South East Asia. International Uplands Symposium 2010. 21-23 July 2010, Hanoi, Vietnam.

RESULTS





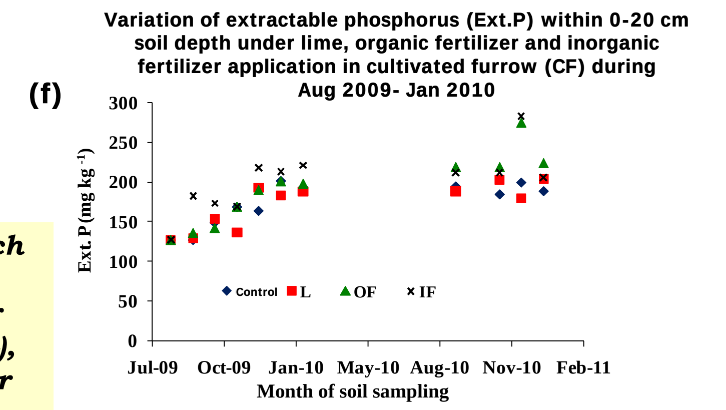


Figure 3a - 3d: comparing the trends of changing of each soil ameliorate between CP and CF.
Figure 3e and 3f: comparing the change of Ext. P under CP and CF respectively in the control plot, using lime (L), organic fertilizer (OF), and inorganic fertilizer (IF) under (i) CP and (ii) CF.

Effect of Cultivation and Zinc Application on Crop Growth

Figures 4a and 4b show that furrow cultivation (CF) resulted in better growth of lablab bean than conventional planting (CP), and foliar zinc application (Zn_1) was better than no zinc application (Zn_0). This was due to better rain harvesting, more soil water storage, less surface runoff and soil loss including nutrient loss under CF than CP. More efficiency of fertilizer application was found in CF plot than CP plot. Foliar Zn application (Zn_1) promoted better crop development than Zn_0 because the natural Zn content in soil was very low, and was not sufficient for plant growth (Figure 4b).

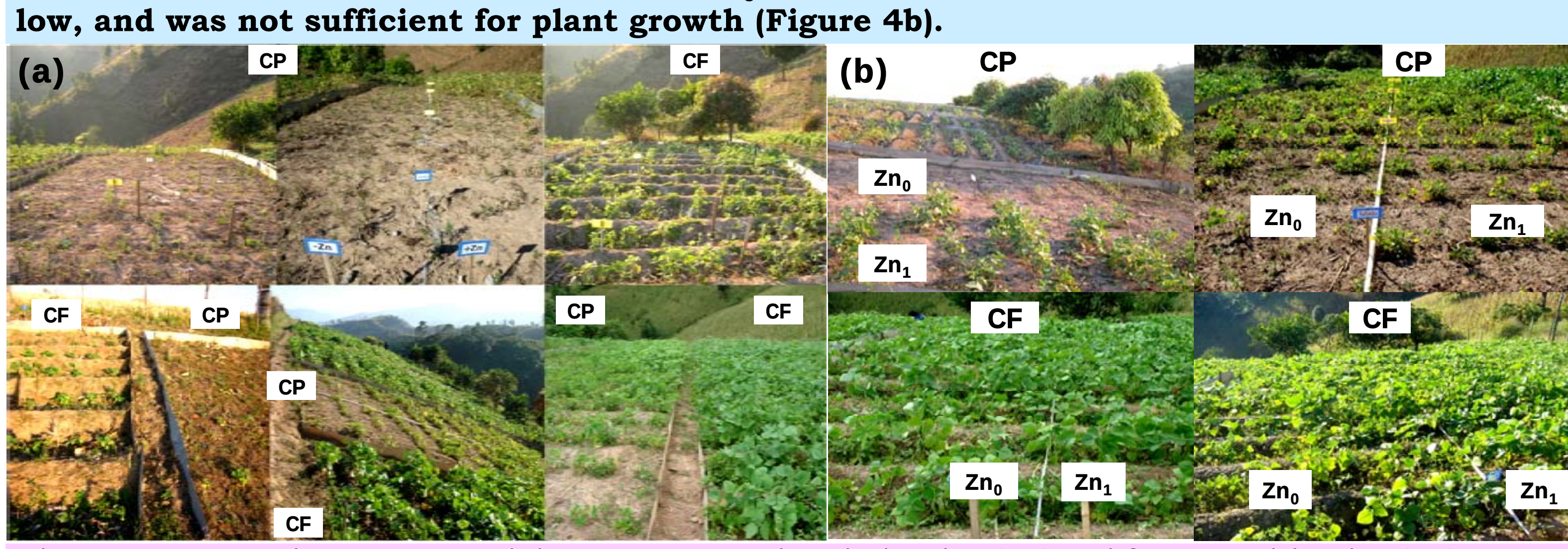


Figure 4a: comparing crop growth between conventional planting (CP) and furrow cultivation (CF)
Figure 4b: comparing crop growth between zinc (Zn_1) and no zinc (Zn_0) foliar application

Effects of Cultivation, Lime, fertilizer and Zn applications on Total Dry Biomass and Yields

The two cultivation methods (CP and CF) gave significantly different effects on total dry biomass and seed yield. The higher amounts of dry biomass and seed yield of lablab bean were found in CF plot than CP plot (Figure 5a, 5b). This was caused by higher rain harvest, more stored soil water, lower rates of runoff and soil loss, less amount of nutrients loss, leading to higher water and nutrient use efficiency in CF compared to CP. This results was supported by Panomtaranichagul et al. (2010) which reported that crop growth and yield production in cultivated furrow (CF) were significantly higher than those in conventional planting (CP), on sloping highland under rainfed cultivation. IF gave higher total dry biomass and seed yield than OF, L, and control which gave the 2nd, 3rd, and 4th high respectively. Zinc foliar application (Zn_1), also gave higher crop productions (total biomass and seed yield) than no zinc application (Zn_0). The reasons of these results were that zinc promoted nitrogen and phosphorus uptake, and functioned in protein synthesis and seed forming.

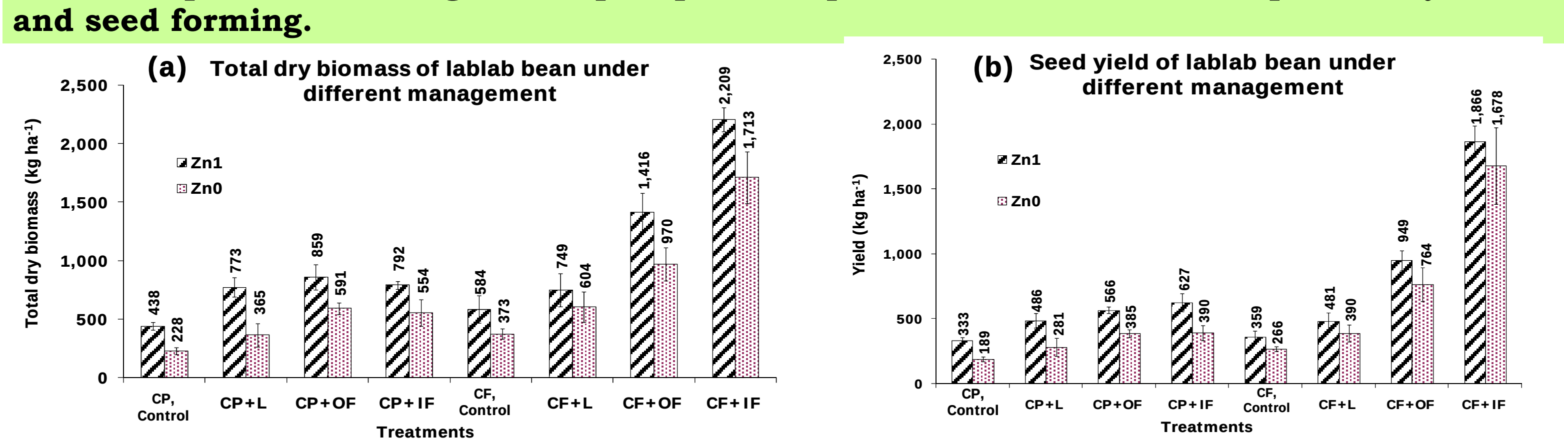


Figure 5a: comparing total dry biomass and Figure 5b: comparing seed yield of lablab bean between different soil amendments (lime, organic and inorganic fertilizer) together with zinc and no zinc foliar application under conventional planting (CP) and cultivated furrow (CF).

CONCLUSION

Furrow cultivation (CF) was the most efficient in conserving nutrients and water, leading to higher crop growth and yield than conventional planting (CP). Cultivation practices also affected Ext.P. CF gave lower Ext.P than CP because of better crop growth and more nutrient consumption. Applying lime and organic fertilizer increased more available phosphorus leading to higher crop growth and yield production compared to liming and control (CP or CF only) under both cultivation practices. Zinc foliar spraying had the greatest effect on crop growth, total dry biomass, and seed yield. Furthermore, combination of zinc and inorganic fertilizer application under CF gave the highest crop growth, total dry biomass and seed yield compared to other treatments.