# Improved Short Fallows: Impact on Weed Populations and Maize Growth in Humid Tropics of Asia

**U.R. Sangakkara**[1], **P. Stamp**[2], A. Soldati[2], P.S.D.R. Bandaranayake[1] and K.B. Attanayake[1]

1.Faculty of Agriculture University of Peradeniya 20400, Sri Lanka sanga@ids.lk
2.Institute of Plant Sciences, ETH Zentrum, 8092 Zurich, Switzerland peter.stamp@ipw.agrl.ethz.ch

## Abstract

Depleted soil organic matter and weeds are significant problems of smallholder tropical highland farming systems. As improved fallows in Africa have helped overcome these problems, field studies were carried out in Sri Lanka, to evaluate the effect of two popular fallow crops, which are also used as green manures, on weed management, growth and yields of a succeeding maize crop, using a natural fallow for comparison. Crotolaria and Tithonia added 250% and 160% more biomass to the soil at the end of the fallow, in comparison to the natural fallow. These fallows also had less weeds. While establishment of the succeeding maize crop was not affected by the improved fallows, they increased biomass, stover and most importantly seed yields (30% in Tithonia and 27% in Crotolaria fallow plots) when compared to the natural fallow. In comparison to the natural fallow, weed populations were also reduced in maize planted in improved fallow plots (42% and 54% in Crotolaria and Tithonia plots). The study has demonstrated significant benefits of using improved fallows in seasons when crops cannot be grown due to drought in the smallholder highland cropping systems of tropical humid Asian regions.

## Media summary

Improved fallows using fast growing species such as *Crotolaria* and *Tithonia* could reduce weeds and enhance growth and yield of succeeding maize crops in smallholder farming systems in the rainfed highlands of tropical Asia..

## Key Words

Improved fallows, Weeds, Maize, Yields

## Introduction

Tropical Asian cropping systems are being called upon to provide increasing quantities of food, from decreasing land areas. This has led to crop production in marginal areas, declining fertility, increasing problems of pests, diseases and weeds, and crop losses due to inclement weather (Devendra and Chantalakhana, 2003). The rising costs of fertilizers do not facilitate optimal use, resulting in the use of organic amendments to maintain productivity (Devendra and Thomas, 2002), although the amendments alone do not provide sufficient nutrients, especially for rice farming systems (Dawe *et al*, 2003). Similar studies do not exist for highland systems of Asia, which do produce cereals such as maize grown under rainfed conditions. Maize is very sensitive to soil fertility, and yields are generally low due to the poor quality of soils in intensively cropped highland soils. Improved rotational short term fallows with fast growing species offer a possible solution to replenish soil fertility in highland cropping systems, especially in Africa (e.g. Sanchez, 1999), although similar studies in Asia have concentrated primarily on rice systems (Timsina and Conner, 2001).

Weeds can negate crop productivity through competition, allelopathy and perpetuation of pests and diseases (Cheruiyot et al, 2003). Weed management in smallholder highland systems are labor intensive, especially as herbicides are predominantly used in rice systems. Hence weed management strategies in highland systems become important for successful arable cropping. Short term fallows have reduced weeds in succeeding crops such as maize and cassava in Africa (Ekeleme et al, 2003, Sileshi and Mafongoya, 2003), while similar results are scarce in the Asian context. A field study was carried out to determine the impact of two improved fallow species (*Crotolaria juncea* and *Tithonia diversifolia,* the latter being used widely in Africa – Phiri *et al*, 2003), on weed populations within the fallow period and in a

succeeding maize crop along with its impact on maize productivity. The impact of the improved fallows was compared to a traditional fallow in terms of weeds, biomass and impact on the succeeding maize crop in the tropical humid climate of Sri Lanka.

**Materials and Methods.**

The studies were carried out at the experimental station of the University of Peradeniya, in two monsoonal seasons of 2001 – 2002, on an Ultisol (Rhododult). The characteristics of the site and climate (see Sangakkara *et al* 2003) represent several humid tropical regions. At the onset of the rains in late April, 2001, corresponding to the minor season, plots of dimensions 6 x 4 meters were prepared and Crotolaria seeds and Tithonia cuttings were planted at spacings of 30 x 7.5 cm and 30 x 15m respectively. Another plot of similar dimensions was kept as a natural fallow, as practiced by the farmers in times of drought. At the onset of the next season (October), the biomass of all three fallows was determined using 1 x 1 m quadrats, incorporated into the soil and maize (Var. Ruwan – open pollinated) was planted at a spacing of 60 x 30m, and managed as per recommendation for Sri Lanka (Sangakkara *et al,* 2003). The measurements made in the fallow season and maize crop were as follows:

*Fallow season:*

- Plant populations in Crotolaria, Tithonia and natural fallow plots
- Weed species within the three plots at 4 and 8 weeks after planting
- Light availability at ground level 6 weeks after planting the two crops, using a
- Portable Li Cor – Quantum sensor to measure radiation at top and base of canopy
- Biomass of the three plots

*Maize season:*

- Maize establishment using 1 x 1m quadrats
- Dry weights of 5 maize plants per plot at silking
- Weed populations and biomass at every weeding
- Seed and stover yields at maturity

The experiment which consisted of three fallow treatments was replicated four times within a RCB Design. The data was analyzed statistically to determine significance of treatment differences.

**Results and Discussion**

The natural fallow had the highest numbers of plants, all of which were weeds (Table 1). The predominant species were grasses such as *Panicum maximum Echinocloa* spp., *Setaria* spp, *Digitaria* spp and some *Imperata cylindrica*, with some *Cyperus rotundus* as the predominant sedge. There were some broadleaved species such as *Commelina* and *Amaranthus* spp. This high population of weeds was due to the availability of adequate light in the absence of an improved fallow crop. Populations of Crotolaria and Tithonia were low due to systematic planting, and the wider spacings reduced the numbers of plants of the latter species. Weed populations under these two were significantly lower, due to the interception of light (65% and 85%) by Crotolaria and Tithonia canopies. The weeds under the two species were primarily broad leaved types such as *Amaranthus*, *Oxalis* and *Commelina* spp, although there were some plants of *Setaria* and *Cyperus* spp, especially under Crotolaria., The improved fallows, especially Tithonia suppressed weeds, as seen in Africa (Cheruiyot *et al,* 2003), which could also reduce or prevent the build up of weed seed banks.

The biomass added was highest in Tithonia (250% in relation to natural fallow) (Table 1) followed by Crotolaria (160%). This showed the value of developing improved fallows to provide quality organic matter during this period, which could help develop soil fertility, while suppressing weeds.

**Table 1. Characteristics of the three fallows adopted in the wet season**

| Type of | Population of plants | Light penetration at ground | Weed Population | Added fresh |
|---|---|---|---|---|

| fallow | ($m^2$) | level (%) | ($m^2$) | Biomass (g/$m^2$) |
|---|---|---|---|---|
| Natural | 84 (5) | 68 (4) | 84 (5) G, BL | 185 (19) |
| Crotolaria | 45 (3) | 35 (3) | 18 (2**)** BL | 482 (13) |
| Tithonia | 25 (2) | 14 (4) | 7 (2) BL | 649 (20) |
| LSD p=0.05 | 11 | 20 | 7 | 200 |

Numbers in parentheses are std. dev., G=grasses, BL = Broadleaved spp. of weeds, Prominent spp. in bold

Incorporation of improved fallows did not reduce establishment of maize (Table 2), but increased plant populations by 20%. Hence these two species did not develop allelopathic effects on germinating maize. The improved fallows increased maize biomass at silking, although Crotolaria had a greater impacts than Tithonia presumably due to the high nitrogen content of this legume. This resulted in significantly greater seed yield (28% in Tithonia and 19% in Crotolaria plots) than in the natural fallow plots. The correlation between biomass at silking and seed yields was significant ($r^2 = 0.76$). The improved fallows also produced greater stover yields than the natural fallow (3% and 5% in Tithonia and Crotolaria plots respectively) which is an important source of animal fodder in tropical smallholder farming systems (Devendra and Chantalakhana, 2003). However the differences between biomass of maize at silking and stover at harvest in the Tithonia and Crotolaria plots declined with time, although the Crotolaria fallow plots had a marginally higher stover yield, which would be due to the greater nitrogen supply by the legume. The slightly lower yield may indicate that Crotalaria utilized more water than Tithonia which reduced the water available for seed fill and reduced HI compared to Tithonia. The higher seed and stover yields following the improved fallows resulted in significantly greater harvest indices, thus suggesting the better and effective use of resources through improved fallows.

**Table 2. Biomass accumulation and seed yields of maize as affected by fallows**

| Type of fallow | Establishment (%) | Biomass at silking (g/ $m^2$) | Seed yield (g/ $m^2$) | Stover yield (g/ $m^2$) | Harvest Index |
|---|---|---|---|---|---|
| Natural | 66.5 | 405 | 365 | 769 | 0.32 |
| Crotolaria | 81.6 | 494 | 436 | 812 | 0.35 |
| Tithonia | 83.9 | 449 | 469 | 794 | 0.37 |
| LSD (p=0.05) | 9.4 | 22 | 74 | 20 | 0.02 |

**Table 3. Weed populations and management in maize plots following different fallows**

| Type of fallow | Weeds per $m^2$ | Weed biomass (g/ $m^2$) | Prominent weeds | Number of manual weedings |
|---|---|---|---|---|
| Natural | 18.3 | 50.9 | G, BL | 3 |
| Crotolaria | 10.5 | 36.4 | BL, G | 1 |
| Tithonia | 8.4 | 34.8 | BL | 1 |
| LSD (p=0.05) | 3.1 | 14.4 | | |

G=grasses, BL = Broadleaved spp. of weeds, Prominent spp. in bold

Weed populations in maize declined by 42% and 54% in maize plots following Crotolaria and Tithonia (Table 3). The predominant weeds present in the improved fallow plots were broadleaved species such as *Amaranthus* and *Oxalis* while aggressive grasses such as *Panicum* were observed in the maize following the natural fallow The higher maize seed yields in these plots could be partially due to reduced competition by the broadleaved weeds to maize in contrast to species such as *Panicum* in the natural fallow plots.

The two improved fallows also reduced weed biomass when compared to the natural fallow (28% in Crotolaria and 32% in Tithonia plots). The greater biomass of weeds in comparison to weed numbers in the improved fallows was due to the presence of a few but heavier broadleaved species in these plots. However the greater impact of Tithonia fallow in reducing weeds in the succeeding maize crop is due to its growth habit which prevents weed emergence in the fallow period, due to shading. Importantly, as labor is a seasonal and expensive commodity in smallholder systems, the improved fallows reduced the numbers of weedings required as these plots were weeded once in contrast to three weedings in maize following a natural fallow. Hence improved fallows, although occupying a potential cropping season, impart many beneficial effects both in terms of greater maize yields and reduced labor use.

**Conclusions**

Most small holder farms in the tropical humid Asian regions face dry periods in one season and farmers tend to leave fields fallow for diverse reasons. The use of fast growing species such as Crotolaria and Tithonia could help increase productivity of succeeding crops such as maize, an important cereal, and also reduce weed populations and costs. This field study illustrated the benefits of using Tithonia and Crotolaria as improved fallows along with commercial fertilizers. Tithonia, which is being recommended for Africa could also be used in Asia to increase seed yields of maize and reduced weed incidence during fallow periods and in the succeeding maize crop. Crotolaria, a popular and common legume in Asia also produced similar effects, but to a lesser extent . The benefits accrued by the improved fallows were the addition of organic matter to soils, better maize establishment, higher seed and stover yields, lower weeds and lower labor use in weeding. Tropical Asian farmers could benefit by these improved management practices for better returns to scarce inputs.

**References**

Cheruiyot EK, Mumera M, Nakhone NL and Mwonga SM (2003) Effect of legume managed fallow on weeds and soil nitrogen in following maize and wheat crops in the Rift valley highlands of Kenya. Australian Journal of Experimental Agriculture 43 597 – 604.

Dawe D, Dobermann A, Ladha AK, Yadav RL, Bao L, Gupta RK, Lal P, Panaullah G, Sariam O, Singh Y, Swarup A and Zhen QX ( 2003) Do organic amendments improve yield trends and profitability in intensive rice systems? Field Crops Research 83, 191 – 213.

Devendra C and Chantalakhana C (2003) Animals, poor people and food insecurity: Opportunities for improved livelihoods through efficient natural resource management. Outlook on Agriculture 31, 161 – 175.

Devendra C, and Thomas D (2002) Smallholder farming systems in Asia. Agric. Systems **71:** 17 – 25

Ekeleme F, Akobundo IO, Isichei AO and Chikoye D (2003) Cover crops reduce weed seed banks in maize cassava systems in southwestern Nigeria. Weed Science 51, 774 – 780

Phiri S, Rao IM, Barrios E and Singh BR (2003) Plant growth, mycorrhizal association, nutrient

uptake and phosphorus dynamics in a volcanic ash soil in Colombia as affected by the establishment of *Tithonia diversifolia*. Journal of Sustainable Agriculture. 21, 41 – 59.

Sanchez P A, (1999) Improved fallows come of age in the tropics. Agroforestry systems 47, 3 – 12

Sangakkara, U.R., W. Richner, M.K. Schneider and P. Stamp, 2003: Impact of intercropping beans (*Phaseolus vulgaris* l) and sunhemp (*Cotalaria juncea* l) on growth, yields and nitrogen uptake of maize (Ze*a mays*) grown in the humid tropics during the minor rainy season. Maydica (in Press)

Sileshi G and Mafongoya PL (2003) Effect of rotational fallows on abundance of soil insects and weeds in maize crops in eastern Zambia. Applied Soil Ecology 23, 211 – 222.

Timsina J and Conner DJ (2001) Productivity and management of rice-wheat cropping systems: Issues and challenges. Field Crops Research 69, 93 – 132.