Maize Performance in Terrace and Non-Terrace Sloping Land


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ABSTRACT. In Indonesia, convertion of fertile agricultural lands into, among others, industrial and residential areas has triggered more intensive and extensive exploitation of marginal- and deforested- sloping lands. In Gorontalo province, about one-fifth of sloping forested area has been deforested and converted to upland agriculture or abandoned as schrubs, bushes, and bare lands. This study demonstrates the benefit of using terrace and manure in sustaining maize yield and land productivity as well as reducing soil erosion of cultivated sloping land. It was revealed that maize height, leaf number, kernel number and weight at terrace plot were higher than that of control. Broader variability's of the observed vegetative and generative variables were also identified at terrace plot.

Keywords: maize yield, sloping agricultural lands, terraces

Introduction

In Indonesia, convertion of fertile agricultural lands into, among others, industrial and residential areas has triggered more intensive and extensive exploitation of marginal- and deforested- sloping lands. The situation is worsened by the recently local autonomous policies which converted high quality agricultural lands to governmental and public facilities. As a result, the availability and suitability of lands for food crops have become limited.

During the last decade, for instance, about one-fifth of sloping forested area in Gorontalo province has been deforested and converted to upland agriculture or abandoned as schrubs, bushes, and bare lands. About 9,000 ha (56%) out of 16,000 ha of the sloping upland, which is not implementing soil and water conservation techniques, is planted to maize. It was estimated that soil erosion in that area could have reached 2800 mt/ha/y. In other words, about 2 mm/ha/y soil has lost and sedimented to rivers and lakes. The data is quite alarming since maize is the second most important cereal crop after rice in terms of the occupied area, relative to the total area for all food crops in Indonesia (Swastika *et al.* 2004). In Benin, West Africa, maize farming system without soil and water conservation practices caused soil erosion five times higher than that of land planting to Ipomea (Wolf *et al.* 2001).

Bench terrace increased the average soil moisture content in 90 cm soil depth by more than 50% than that of non terraced land. Within the bench terraced, field compartmental bunding increased soil moisture by 18.2% higher than that of plain bed (control) with a coefficient of variation of 20.6% and ridges and furrows increased by 27.8% with coefficient of variation of 29.3%. This indicates that in-situ moisture conservation measures are effective to increase soil moisture compared to plain bed. It is also found that mean soil moisture fluctuation in the soil profile is moderately more at 60 cm depth compared to 30 cm irrespective of type of conservation techniques.

This study aims to demonstrate the benefit of using terrace and manure in sustaining maize yield and land productivity as well as reducing soil erosion of cultivated sloping land in Gorontalo Province, Indonesia.

Materials and Methods

Study Site

To determine the effect of bench terraces combined with inorganic fertilizer and organic manure, an experiment was carried out at sloping farming land located at 50 m above sea level in Biyonga Basin Gorontalo ($00^0$41‘15"N-$122^0$59‘23"E) Indonesia. The basin area was 5000 ha consisted of 150 ha flat and 4850 ha hilly lands. Geomorphologically the area was formed by hilly to mountainous Vulcan (Soil and Agro Climate Research Center, 2000). Mean annual rainfall, temperature, and relative humidity were 1020 mm, 29^{o}C, and 80%, respectively (Gorontalo in Figure 2012). Soil texture was clay loam and soil properties are listed in Table 1.

Experimental Design

An experimental area of 2000 m^2, constituted by gradually flat to hilly land having slope from 5 to 40%, was split into two experimental plots: terrace and control. Prior to the experiment, the plots were cleared from weeds followed by twice moldboard plough for the control plot. Bench terraces having dimension of 150-200 cm width by 75-100 cm height were constructed along the contour lines of 15 to 40%, hoed and filled with top soil on its surface. In order to reduce water runoff and promote water infiltration, 20 cm width by 10 cm depth waterway was also constructed at terrace toe of each terrace wall. Besides, 30- 40 cm slips of Gliricidia *(Gliricidia sepium)* were planted with 30 cm distance along the terrace edge as to strengthen the terrace and to provide organic material and symbiotic nitrogen for the soil as well as to later maintain alley rows. A dosage of 5,000 kg/ha decomposed horse manure was applied and mixed to terrace soil surface.

Three seeds of maize (Lamuru, an open pollinated variety) per hill were planted by means of dibble at sowing depth of 5 cm with space distance of 75 cm inter and 75 cm intra row which resulting in 18,000 plants/ha. Agronomic properties of maize are presented in Table 2. Recommended fertilizer application of 200 kg/ha urea, 100 kg/ha TSP, and 50 kg/ha KCl was manually applied twice in 5 cm depth and at 10 cm distance from the plant.

Replacing dead seedlings were performed 7 day after seeding (DAS), weeding 10 DAS, removing and leaving 1 vigorous plant at 14 DAS, soil in between the plant was hilled up at the base of the plants at 28 DAS. Irrigation was applied twice during plant growth; at planting day and cob initiation.

Table 1. Soil physical and chemical Properties of terrace and non-terrace land, Biyonga Basin, Gorontalo, Indonesia.

Soil properties	Terrace	Non-terrace
pH	6.46	6.66
C-org, %	0.66	0.24
N total, %	0.035	0.01
P_2O_5 available, ppm	8	8.79
K_2O available, mg/100	1.74	2.7
Sand, %	42.8	36.1
Silt, %	33.96	31.16
Clay,%	23.24	32.74

Table 2. Agronomic properties of open pollinated Lamuru variety.

Properties	Remark
Maturity	95 days
Plant height	190 cm
Grain color	Yellow
Grain shape	Pearl
1000 grain weight	275 gram
Yield potential	7-8 ton per ha

Sampling and Analytical Methods

Soil sampling from terrace and non-terrace plots was performed prior to seeding (Table 1). Plant height, leaf number, and grain weight were sampled from 100x100 cm terrace and non- terrace areas. Plant height and leave number were recorded every three days since three-leaf appearance and terminated at tassel initiation. Dry grain weight of each ear and 100 grain weight was measured after harvesting. Mean differences of the measured variable were statistically analyzed employing t-Student test.

Results and Discussions

Plant height observed from 36 to 65 DAS is presented in Figure 1. The plant height at the terrace plot was higher than that of control. The highest plant at terrace plot was 156.6 cm while for control was 73.92 cm. In addition, broader

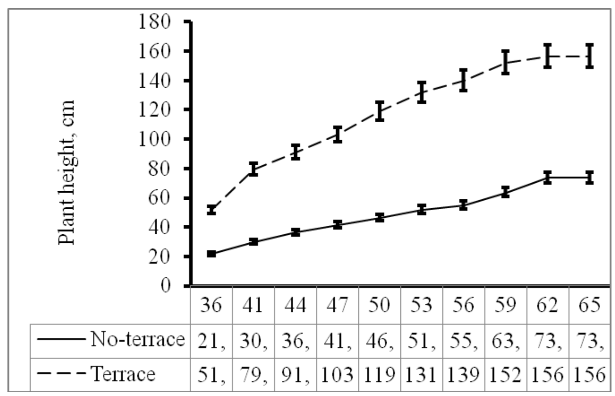

Figure 1. Comparison of plant height at terrace and no-terrace plots observed from 36 to 65 DAS. Error bar represents the variability at confidence interval of 95%.

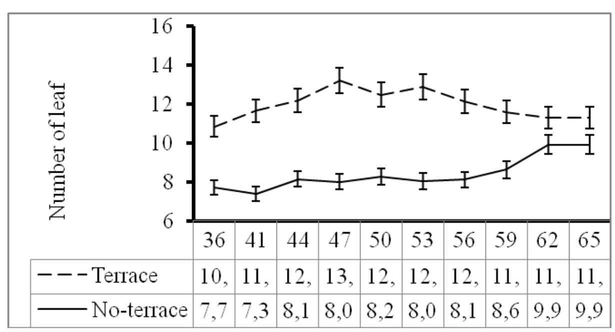

Figure 2. Comparison of leaf number of maize at terrace and non-terrace plots observed from 36 to 65 DAS. Error bar represents the variability at confidence interval of 95%.

variability of plant height was also identified at terrace plot compared to that of control.

The leaf number of terrace plot was higher than that of non-terrace while the leaf number variability of terrace plot was slightly broader than that of control. Highest leaf number of terrace plot was 12 leaves while for control was 8.17 leaves (Figure 2).

Comparison on grain number is presented in Figure 3. It shows that the grain number of terrace plot was higher (the highest was 486) than that of control (the highest was 218). Meanwhile, its variability was broader for terrace plot compared to that of control.

Finally, weight of 100 dry grains was higher for terrace plot (the highest was 29 g) compared to that of control (the highest was 24 g). Grain weight variability of terrace plot was broader compared to that of control plot (Figure 4).

Statistical analysis was summarized in Table 3. It shows that vegetative and generative performances of maize planted in terrace were higher than that of control (non-terrace). All differences among the observed maize performance were statistically significant.

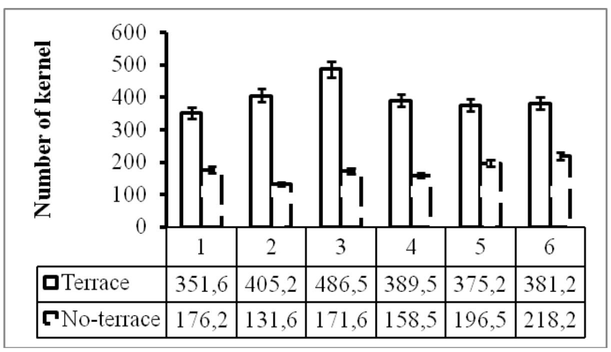

Figure 3. Comparison of grain number at terrace and no-terrace plots observed at 6 rows. Error bar represents the variability at confidence interval of 95%.

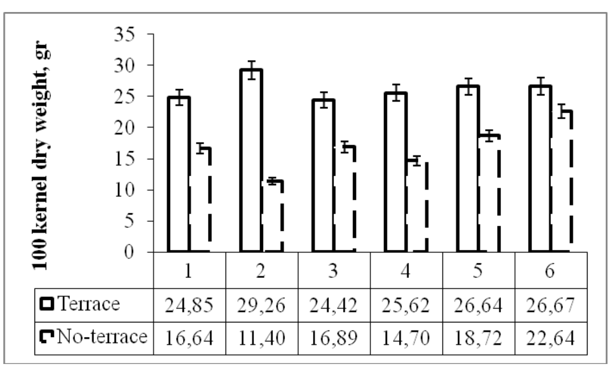

Figure 4. Comparison of 100 dry grain weight at terrace and non-terrace plots observed at 6 rows. Error bar represents the variability at confidence interval of 95%.

Table 3. Statistical parameter of vegetative and generative performances of Lamuru variety at terrace and non-terrace plots, Biyonga Basin, Gorontalo, Indonesia.

Variables	Statistical parameter	Terrace	Non-terrace
Plant height, cm	Mean	121.67	44.67
	t-test (0.05)	t-calc.	0.94[a]
		t-tab.	1.81[b]
Number of leaf	Mean	12.33	8.17
	t-test (0.05)	t-calc.	0.44[a]
		t-tab.	1.81[b]
Number of dry grain	Mean	382	175.67
	t-test (0.05)	t-calc.	0.77[a]
		t-tab.	1.81[b]
100 dry grain weight, g	Mean	26.225	16.83
	t-test (0.05)	t-calc.	0.54[a]
		t-tab.	1.81[b]

Better vegetative and generative performances of maize planted on the terrace were attributed to the ability of the terrace to reduce runoff, promote infiltration that maintain favorable soil moisture required by the plant as well as to provide nutrients for vegetative and generative developments.

Conclusions

1. Terrace construction and organic matter application are required in attaining high yield of maize in sloping agricultural lands.
2. Further study on technical and socio-economic aspects are needed to assess the sustainability of the system as well as the capability and willingness of farmers to adopt.

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