Raised beds improve secondary crop production in the rainfed rice-based cropping systems of Southern Lombok, Eastern Indonesia

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Abstract

In semi-arid tropics, unreliable water supplied from the erratic rainfall restricts production of the primary rice crop (*Oryza sativa*), and of secondary crops grown in rotation with rice. Various secondary crops grown under a range of new land and water management systems were compared with secondary crops grown under the conventional system (gogorancah) on Vertisols in two different climatic regions. At each site, the yield of soybean (*Glycine max)* grown after rice on permanent raised beds with or without tillage was not significantly different from that with gogorancah (flat land with tillage), or on flat land with no tillage (mean 1.3 t/ha in 2002; 1.6 t/ha in 2003). In 2003, chilli (*Capsicum frurescens*) after onion on permanent raised beds gave the highest economic revenue of Rp.?7.3 x 10^6/ha (Site 1 - Wakan) and Rp.?4.3 x 10^6/ha (Site 2 - Kawo); followed by intercropped tomato-mungbean (*Lycopersicon esculentum-Vigna radiata*) after intercropped maize-soybean (*Zea mays-Glycine max*) on wavy raised beds with Rp.?4.03?x?10^6/ha (Site 1) and Rp.?3.6?x?10^6/ha (Site 2). The lowest financial return of less than Rp.?1.5?x?10^6 /ha was from soybean (*Glycine max*) on each system. Thus, on rainfed Vertisols of Southern Lombok, at current prices, the secondary crops of chilli on permanent raised beds without tillage, or intercropped tomato-mungbean on wavy raised beds without tillage, could successfully replace soybean on the conventional gogorancah.

Media summary

Permanent raised beds on rainfed Vertisols of Southern Lombok provided a greater diversity of secondary crops that could be grown than did the conventional system on flat tilled land, whilst simultaneously generating four times as much revenue as conventionally grown soybeans.

Key Words

Crop diversity, land and water management, no-tillage, vegetables.

Introduction

Unreliable water supplied from the erratic low rainfall, plus poor management, often restrict agricultural production in rice-based (*Oryza sativa*) cropping systems on rainfed Vertisols in the semi-arid tropics of Southern Lombok (Ma`shum et al. 2003). The region is influenced by monsoonal rainfall with a short wet season from November/December to March/April, and 7 to 8 dry months from April/May to October.

With the unreliable rainfall in Southern Lombok, the conventional system of gogorancah, with intensive tillage on flat land, is no longer suitable due to low water use efficiency (Ma`shum et al. 2003) and the high cost of labour required for land preparation and weed control (Meindertsma 1997). Secondary crops, usually soybean (*Glycine max*) or tobacco (*Nicotiana tabacum*), are most successful when sufficient water is stored in the soil, plus water is supplied from that harvested in dams (embungs) during the wet season. Therefore, new systems with higher water use efficiency that better match crop growth to water supply should be developed for Vertisols in the region

Permanent raised beds have been widely reported elsewhere to increase diversity of crop production, alleviate waterlogging in soils, improve soil structure (Van Cooten and Borrell 1999), and enable rice to be rotated with other crops (Garside et al. 1992). In Western Australia, raised beds also significantly increased yield of pasture, even in seasons that were drier than average (Hamilton et al. 2003). Information on improving production and economic revenue of secondary crops under raised beds in the semi-arid tropics is still limited. This paper compares the yield and revenue from the secondary intercropped tomato-mungbean (*Lycopersicon esculentum*-*Vigna radiata*) on permanent raised beds, and from chilli (*Capsicum frurescens*) on wavy raised beds with the yield and revenue from soybean grown under gogorancah on Vertisols in Southern Lombok..

Materials and methods

Field experiments were established at two sites in Southern Lombok, Indonesia, in the dry season of 2001. The experiments were: Site 1 - Wakan (District East Lombok, Sub-district Keruak; $8^{o?}$44’S, 116^{o} 30’ E; 90 m above sea level, with 700 to 1300 mm average rainfall), and Site 2 - Kawo (District Central Lombok, Sub-district Pujut; 8^{o} 45’ S, 116^{o} 20’ E; 180 m above sea level, with 1000 to 1400 mm average rainfall). The Vertisols (USDA 1998) at each site were dominated by montmorillonite (Krisdayanti 1996), and contained 668 g clay /kg soil (Site 1) and 624 g clay/kg soil (Site 2).

Each experiment was a randomized block with 3 replicates (Table 1). Plots (each 10 m long and 6 m wide) were separated by border bunds (0.2 m high, 0.5 m wide), with an outer furrow 0.8 m wide. Before the secondary crop was sown, each plot was mulched with residue from the primary crop. Treatments with permanent or wavy raised beds consisted of 4?raised beds, each 1.2 m wide and 0.2 m high, and were irrigated from the embung with water harvested from each treatment during the wet season. Secondary crops were sown after the primary crops were harvested (Table 1). Pests were controlled by applying appropriate insecticides in each treatment.

Table 1. Treatments used in experiments on Vertisols at Site 1 (Wakan) and Site 2 (Kawo).

Treatment	Secondary crop	Row spacing (cm)	Nutrients applied (kg/ha)
S1. Permanent raised beds, no tillage[a]	Soybean after rice	20 x 20	Phosphorus[b], 24
S2. Permanent raised beds, tillage[a]	Soybean after rice	20 x 20	Phosphorus[b], 24
S3. Permanent raised beds, no tillage[a]	Chilli after onion	50 x 60	Phosphorus[b], 16 Nitrogen[c], 115
S4. Flat land, no tillage, flooded	Soybean after rice	20 x 20	Phosphorus[b], 24
S5. Wavy raised beds, no tillage[d]	Tomato-mungbean[e]	[f]	
S6. Flat land, tillage, flooded[g]	Soybean after rice	20 x 20	Phosphorus[b], 24

[a]Flat Beds 0.2 m higher than base of furrows
[b]Superphosphate banded at depth of 5 cm
[c]Composted dung and plant residue was also applied at 5 t/ha.

[d]Centre of beds 0.4 m higher and edges of beds 0.2 m higher than base of furrows
[e]Intercropped after intercropped maize-soybean. In 2002, intercrops planted at the same time; in 2003, tomato transplanted one week before mungbean sown
[f]One row of tomato (intra-row spacing of 40 cm) between two rows of mungbean (spacing 20 x 20 cm)
[g]Gogorancah, as used by local farmers

At harvest, yield was determined on samples from two quadrants (each 1 x 1.5 m) from a) the two middle beds of each treatment on permanent, or wavy, raised beds, and b) in the middle of each treatment on flat land. Data were analysed using Analysis of Variance for the yield in treatments with soybean and lsd was calculated to compare means.

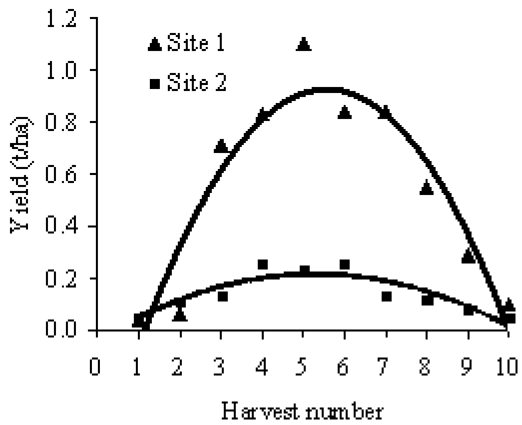
Results and discussion

Soybean yield did not differ significantly ($P<0.05$, data not shown for each treatment) treatments S1, S2, S4 or S6 at either site in 2002 and 2003 (Table 1; Table 2). At each site, the yield of chilli (S3), and of intercropped tomato-mungbean (S5), were higher than the average yield from local farms in that area (Table 2). The yield of tomato was higher in 2003 (tomato transplanted early, and well established before mungbean sown) than that in 2002.

Table 2. Yield of secondary crops (t/ha) at Site 1 (Wakan) and at Site 2 (Kawo), and average yields on local farms.

Crop	2002		2003		Local farms	
	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2
Soybean[a]	1.3	1.3	1.6	1.7	0.3 to 0.5	0.3 to 0.4
Chilli - S3	3.5	0.7	5.3	1.4	0.9 to 1.5	0.9 to 1.2
Tomato[b] - S5	3.4	1.7	12.3	12.7	NA[c]	NA[c]
Mungbean[b] - S5	1.0	1.4	1.1	0.9	0.2 to 0.3	0.2 to 0.3

[a]Mean yield of all treatments with soybean as secondary crop (S1, S2, S4, S6 - Table 1)
[b]Intercropped
[c]Not applicable



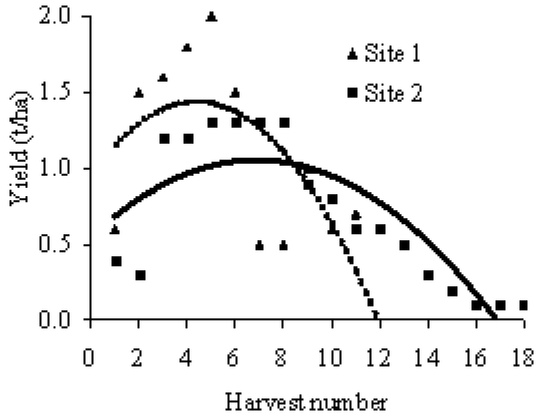


Figure 1. The yield of chilli (Table 1) at sequential harvests (harvest number) in 2003 at Site 1 (Wakan) and Site 2 (Kawo).

Figure 2. Yield of tomato intercropped with mungbean (Table 1) at sequential harvests (harvest number) in 2003 at Site 1 (Wakan) and Site 2 (Kawo).

The lower yield of chilli at (Site 2) compared to at Site 1 in both 2002 and 2003 (Table 2) was due to a viral disease during early growth, reflecting the higher rainfall recorded at this site. Chilli, a crop that requires small amounts of water, performed better in the drier than wetter climate. In 2003, the maximum yield of chilli (Harvest 6) was higher at Site 1 than that at Site 2 (Figure 1).

The maximum yield of tomato at the drier site (Site 1) was reached at an earlier harvest, and the growing season was shorter, than those at Site 2 (Figure 2).

Of all treatments, chilli grown on permanent raised beds produced the highest revenue, followed by intercropped mungbean-tomato on wavy raised beds (Figure 3). Also the canopy of the secondary crops on the permanent raised beds and the wavy raised beds , suppressed weeds in both the current crop, and also the next wet season (data not shown), resulting in reduced labour costs for for weeding. Furthermore, chilli from Southern Lombok is sold about one month before that sold from other regions on Lombok, resulting in a price advantage of up to Rp. 4000/kg.

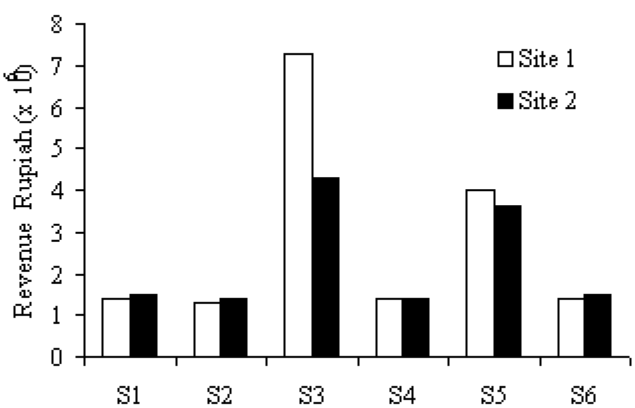


Figure 3. Revenue of secondary crops in 2003 (Table 1) at

Site 1 (Wakan) and at Site 2 (Kawo). (LSD (P < 0.01) Site 1 = 0.15; Site 2 = 0.13).

Conclusion

At current prices, the secondary crops chilli on permanent raised beds without tillage, or intercropped tomato-mungbean on wavy raised beds without tillage, provide a viable alternative to the current system of growing soybean on gogorancah on rainfed Vertisols of Southern Lombok..

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