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Turmeric Production under Shade Management and Fertilization in Degraded Landscapes of Sumba Timur

Pratiknyo Purnomosidhi, Suci Anggrayani, Gerhard S. Manurung, James M. Roshetko, and Ventia SE Purwaningsih

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About the authors

Pratiknyo Purnomosidhi is a livelihood specialist in World Agroforestry (ICRAF) in Southeast Asia Programme Office in Bogor. Indonesia. He was site manager in many ICRAF development project in Indonesia; specifically Lampung, Aceh, Sulawesi and Sumba. He has a MSc degree from Brawijaya-Gadjah Mada University, Indonesia in Soil Water Management and Bachelor from Brawijaya University, Indonesia in Land Evaluation.

Suci Anggrayani previously worked for World Agroforestry (ICRAF) as a data base manager and statistician in the IRED-ICRAF Sumba project. Currently she is a statistician with Bogor Agriculture Institute. During her tenure with ICRAF, she designed and implemented data collection operations in Sumba.

Gerhard Sabastian Manurung is an Associate Scientist in Agroforestry System with World Agroforestry (ICRAF). He has worked with ICRAF for 20 years in eight different research and development project in Indonesia. Gerhard is the Project Manager of IRED-ICRAF project. His major area of research is in smallholder agroforestry systems with focus on the development of silvicultural management for timber and NTFP species to enhance local livelihoods and sustainable ecosystem services. Gerhard has a PhD in Forestry Management from the Australian National University and a MSc in Natural Resources Management from the Bogor Agricultural University.

James (Jim) M Roshetko is a Senior Agroforestry Systems and Integrated Natural Resource Management Scientist with World Agroforestry (ICRAF) He has 39 years of experience, including 35 years working in Southeast and South Asia and 24 years living in Indonesia. Jim was the Senior Team Leader of the IRED-ICRAF project: linking knowledge to action project. His career has focused on generating and applying science-based knowledge to enhance rural development options through improved sustainable environmental management. The central theme of his research is smallholder agroforestry systems and enterprises as viable components of a climate-smart, multifunctional landscape-management approach that enhances local livelihoods, protects environmental services, and achieves sustainable environmental management. Jim has a PhD in Geosciences and Natural Resource Management from the University of Copenhagen and a MSc in Forest and Agroforestry Management from Michigan State University.

Ventia Sabathini Estri Purwaningsih is graduated from Adventist University of the Philippines holding a Bachelor of Science in Nursing. Her interest in environment grew from her deployment to Sumba Timur, Nusa Tenggara Timur (NTT) by Wahana Visi Indonesia. The impacts of land degradation on community health and children welfare being too obvious to ignore. Currently she manager in WVI's Area Program in Sumba Timur and Barat Daya with the aim to improve children welfare from all aspects, particularly on health, livelihood and environment.

Abstract

Research to increase the farm production and income of the people of Haharu Sub District, Sumba Timur was conducted through an understory cropping trial by ICRAF, the local community, Lutheran World Relief (LWR) and Wahana Visi Indonesia (WVI). Turmeric was proposed as a priority crop by LWR because the commodity has a good market in Waingapu for both local use and off-island export. An intercropping trial was established on farmers' land in Mbatapuhu Village, Haharu Sub District, Sumba Timur. Shade treatments included turmeric cultivation under: 1) the canopy of a three-year-old mahogany stand (38% shade); 2) the canopy of a seven-year-old mahogany stand (52% shade); 3) 55% artificial shade; 4) 75% artificial shade; and 5) full sun (0% shade) as a control. Fertilizer treatments included: 1) no fertilizer; 2) 400g organic fertilizer (cattle dung); 3) 800g of organic fertilizer; and 4) 400g organic fertilizer+20g NPK. The results showed turmeric production under 55% artificial shade with 800g organic fertilizer (cattle dung) produced 6.2-7.1 tonnes of rhizome per ha, much higher than production under any of the other treatment combinations. Turmeric perform less well under mahogany stands probably due to heavy competition for water and nutrition. Under the three-year-old mahogany trees competition was moderate and turmeric production was possible, but under seven-year-old trees competition both above and below ground was intense, making turmeric production impractical. Turmeric market opportunities exist for farmers in Haharu but require further development.

Keywords

Demonstration trials, Turmeric, Shading, Haharu Sub District, Sumba Timur

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1. Introduction

Indonesia is a diverse tropical country located along the equator. It is considered the second most diverse country after Brazil. Indonesia has ± 17000 islands, which have diverse climates, landscapes and soil types. The province of Nusa Tenggara Timur is one of the more unique areas of the country, being semi-arid it is more similar to East Africa than the more widely recognized humid tropical parts of Indonesia. The topography of Sumba Timur varies from flat in the coastal areas, to gently sloping and undulating up to 100 meters, to hilly and mountainous up1000 meters. A range of mountains and steep limestone hills dominate the inland area of Sumba Timur. Agricultural land is found mainly in the northern coastal plains where adequate surface water and big rivers exist (Mulyoutami *et al*., 2016). The daily temperature ranges from 35ºC during the day to 18ºC at night. Dry season occurs annually (May to November) restricting the development of the agricultural sector in Sumba Timur and NTT. Furthermore farming methods rely on traditional practices in terms of determining crop species fertilizers, response to weather, harvesting and post-harvest periods. These methods have been utilized by generations on farmers with limited change. To modify the practices that has been used for generations requires time and examples in the field. This means that the community members should be invited to collaborate in planting, maintaining, and observing crop production under the new methods. It is expected that farmers will adapt and replicate the new practices in their own fields the following season.

A marketing study conducted by LWR (2017, 2018) reported that turmeric (*Curcuma longa*) is one of seven agricultural commodities that have a strong market in Sumba Timur. To achieve productive yields turmeric requires a temperature between 20ºC and 30ºC, it also need a large amount of rainfall or soil moisture. Turmeric plants are harvested for the rhizomes and are re-established by planting parts of rhizomes in the following season. The rhizomes are yellow-brownish with a dull orange interior. The main rhizome tends to measure 2.5-7.0 cm in length and around 2.5 cm in diameter (Prasad and Aggarwal, 2011).

Turmeric is a spice and medicinal plant used in traditional cuisine and medicine industries. Turmeric is an annual plant in the *Zingeberaceae* family, its above ground portion resembles a shrub. It is common in the tropics, thriving in the wild in forest areas, tree gardens and other agricultural lands. It is not sensitive to soil conditions and can be cultivated in any type of soil (Sholehah, *et al*., 2016). Turmeric is a component of traditional medicine, raw material for the herbal and cosmetic industries and cooking spice (Hartati, 2013). In Javanese society turmeric is widely used as an herbal medicine because it is effective in soothing, cleansing, drying, eliminating itching and curing tingling. Turmeric also has anti-inflammatory, antiviral, antibacterial and antioxidant characteristics (Simanjuntak, 2012).

According to Listyana (2018) Indonesian turmeric production in 2016 amounted to 107.8 tonnes from a cultivated area of 51.7 thousand ha. The crop is produced mainly in 5 provinces: East Java (33.3 tonnes), Central Java (27.6 tonnes), West Java (9.7 tonnes), Bengkulu (4.5 tonnes) and Kalimantan Selatan (4.1 tonnes). According to Amiruddin (2016) Indonesian industry, including traditional herbal medicine sector, requires 1.5 to 6 tonnes of raw turmeric per month. Domestic demand increases by 10-25% per year. The domestic supply and demand of turmeric commodities is not balanced; the

highest demand is ahead of the holidays when supply is greatest. International demand for turmeric is currently increasing both in the form of saffron rhizomes and its filtrate, however the global demand for turmeric has not been pursued by Indonesia. There has been no serious national effort to produce and process turmeric for export. For example, India wants to import from Indonesia at least 7000 tonnes of wet turmeric per month but this has not been supported by Indonesian farmers, even though this opportunity is very promising for turmeric producers and traders.

Based on the commercial opportunities provided by the commodity, an intercropping trial was conducted on community land to determine the potential for turmeric cultivation to increase the incomes of smallholder farmers. The trial design, establishment and management were conducted with farmers to be sure the practices and management level would be adoptable.

2. Material and method

2.1 Site characterization

The trial was conducted in the Mbatapuhu Village, Haharu Sub District, Sumba Timur District, Nusa Tenggara Timur (NTT) (Figure 1). Haharu Sub-District has climatic conditions that differ from those of other parts of Sumba. This district faces drought and food shortages every year because the rainy season is only 3.5-4.0 months from December to April. During 2008–2013, Sumba Timur District recorded less than 45 annual rain days with total annual rainfall of less than 700 mm (Lassa *et al*., 2014). Haharu Sub District, where the IRED project operates experienced 219 mm rainfall in 2014/15 over 96 days and in 2016/18 rainfall averaged less than 300 mm (Figure 2).

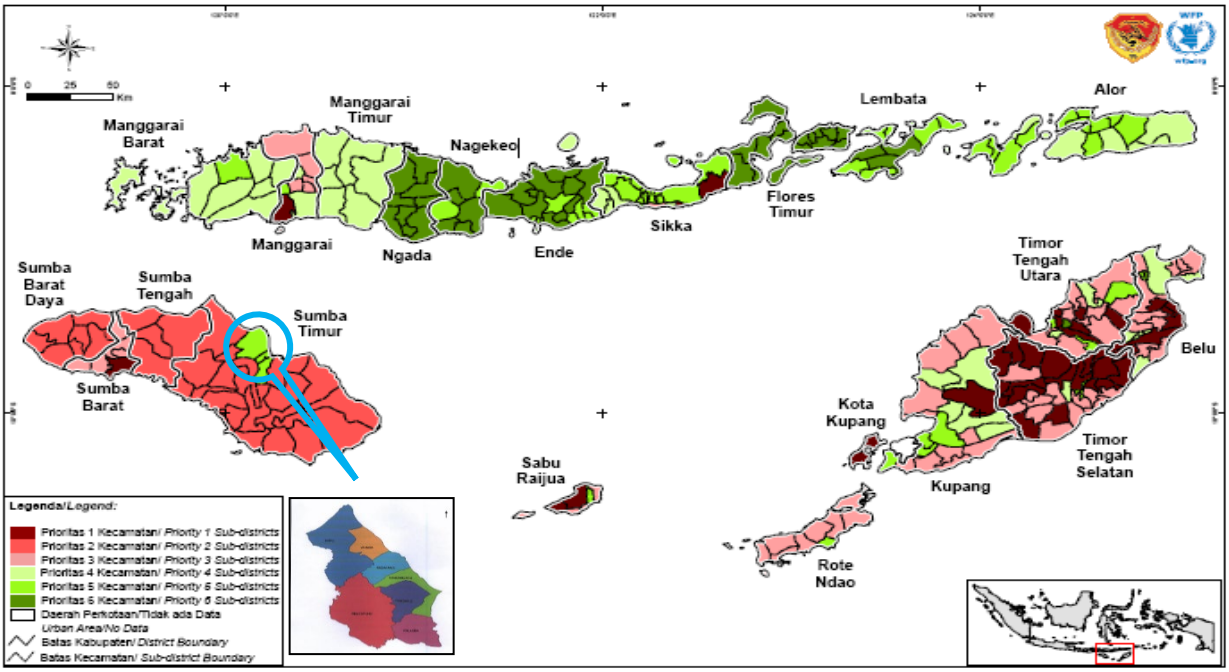


Figure 1. Map of study site in Sumba Timur, Nusa Tenggara Timur (NTT) (Martini. *et al*. 2016)

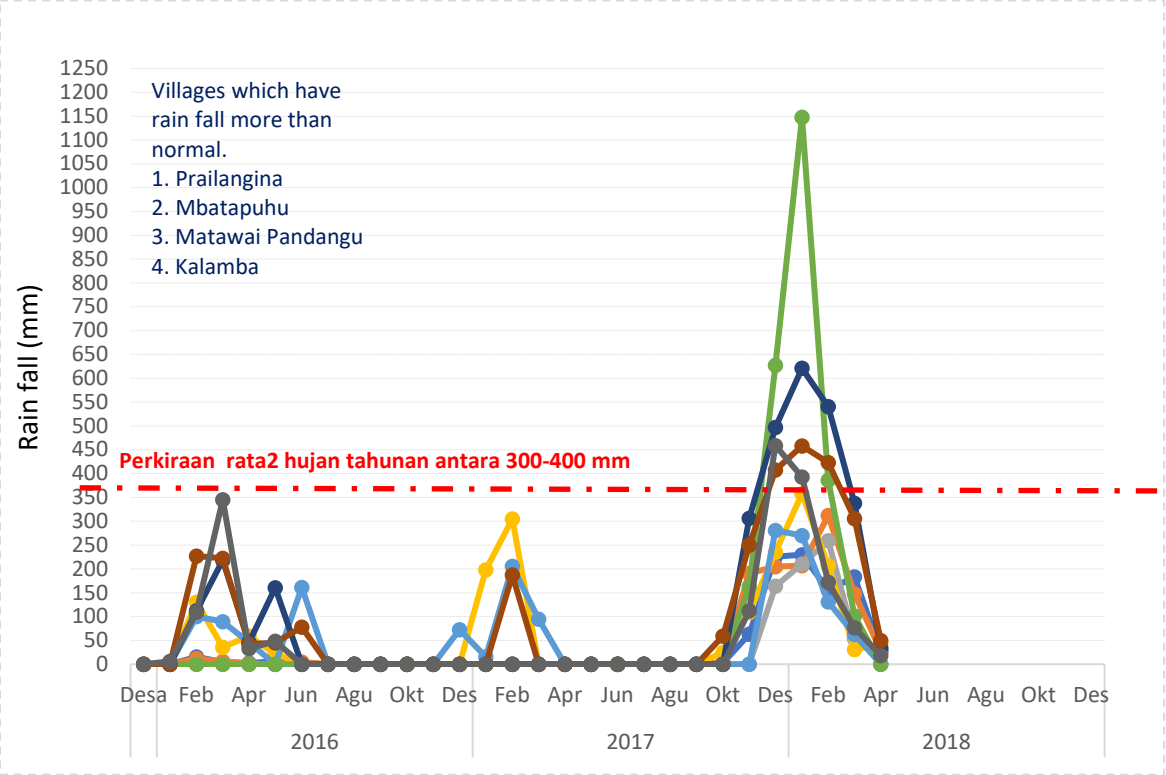


Figure 2. Rainfall (mm) from 2016 to 2018 at Rambangaru, Praibakul, Kadahang, Kalamba, Mbatapuhu, Matawai Pandangu, Wunga, Napu and Prailangina Villages, Haharu Sub District, Sumba Timur District, NTT

The Haharu landscape consists of degraded limestone savanna with remnant hilltop forests and scattered riparian trees in deep gullies. Coral appears on the soil surface with pockets of topsoil to depths of 25 cm, texture is dominated by clay, pH averages 7-8.3 (alkaline), with low carbon and available N (Appendix 1). Formerly known as Sandalwood Island, forest area on Sumba declined significantly during the 20th century and was almost entirely lost by the early 2000s. Over-harvesting of the valuable native trees including sandalwood (*Santalum album*), 'lobung' (*Decaspermium sp*), 'injuwatu' (*Pleiogynium timorense*) and 'kosambi' (*Schleichera oleosa*) has resulted in almost total deforestation and degradation of the land area.

The main causes of deforestation are: 1) large-scale timber extraction; 2) repeated clearance and burning of savannah for cultivation; 3) freely grazing livestock; and 4) unsustainable fuelwood harvesting. The near complete absence of trees in the savanna, combined with limited rainfall leads to annual water shortages and suboptimal food production, exacerbated by poor soil and water-management practices (McWilliam 2000; McWilliam 2001). Sulaiman and Webb (2015) classified Sumba as severely vulnerable to food and nutrition insecurity.

Farming is typically conducted from December to March as the main economic activity of most families. Land ownership is 1–3 ha per household, but nearly a third (31.3%) of all farmland is fallowed at any time. Agriculture engages about 92% of households with 87% farming private land. Food crops including maize, peanut and cassava are grown for household consumption by 90% of families. Yields are low 3.1 and 10.7 tonnes/ha for maize and cassava respectively. Total average household income per year is USD 1205 with an average number of household members of 5.7 (JRI

Research, 2013; BPS Sumba Timur, 2015; IRED, 2016). Farmers have limited or no knowledge of or access to professional technical assistance for agriculture, land restoration, seed sourcing, market access and sustainable forest management.

Good agricultural practices (GAPs) can be an effective tool for developing smallholder tree-based farming systems. Adoption of GAPs enable farmers to benefit from quality germplasm, appropriate plant spacing, intercropping, fertilizing and agrobiodiversity conservation. To provide agricultural technical assistance for smallholders and to improve the potential adoption of GAPs, this research paper evaluates the effects of shading levels from mahogany (*Swietenia macrophylla*) trees and artificial shades and fertilization levels on rhizome production of turmeric under conditions common to smallholder farmers.

2.2 Research design

The trial sites were located on the land of various farmers in Mbatapuhu Village**.** Trial establishment occurred in December 2016 and turmeric harvesting in August 2017. Harvesting was conducted 5 months early due to drought and the resulting occurrence of disease.

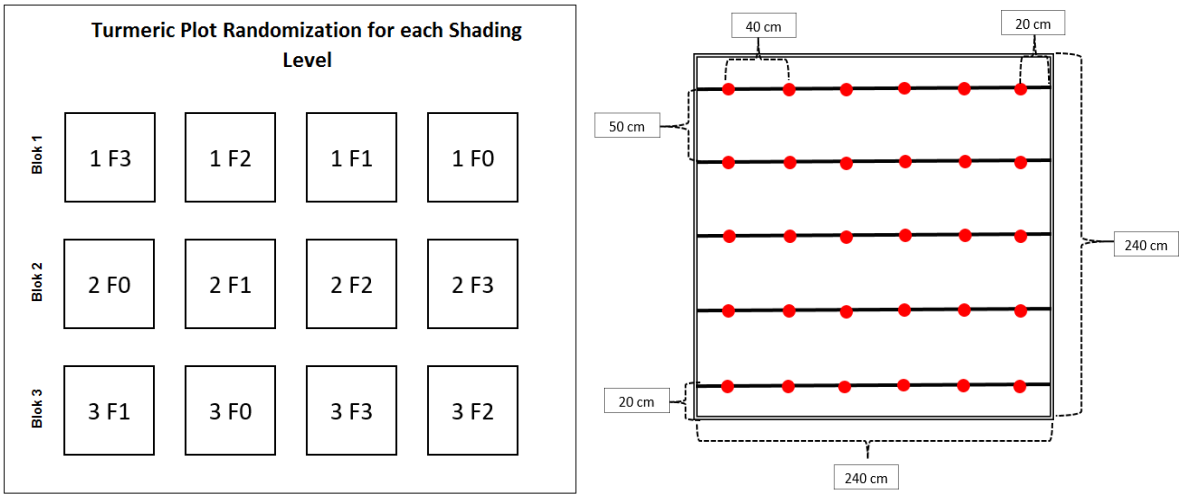


Figure 3. Shading treatment as the main plot and fertilization treatment as the inner plot

The research trial was a split plot design (SPD) composed of 15 subplots, five shade levels times three replications (Figure 3). The shade treatments consisted of: 1) 0% - full sun as control (no shading), 2) 38% – under 3-year-old mahogany trees, 3) 52%– under 7-year-old mahogany trees, 4) 55% - artificial shading, and 5) 75% artificial shading. The fertilizer treatments consisted of: 1) F0 - no fertilizer, 2) F1 - 400g organic fertilizer (cattle dung), F2 - 800g of organic fertilizer, and F3 - 400g organic fertilizer+20g NPK.

The shade percentage under tree canopy was measured with a ***densiometer***. The artificial plastic shading used in the trial are the common netting available to farmers in Sumba Timur.

3. Result and discussion

Crop performance after 4 months in full sun, under 3- and 7-year-old mahogany stands and artificial shading of 55% and 75% are illustrated in Figure 4.

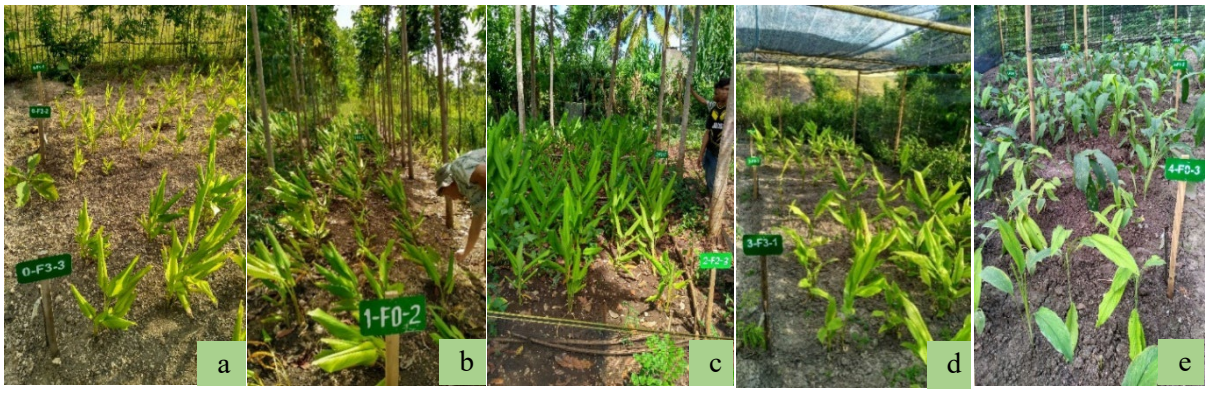


Figure 4. Turmeric performance under different shading levels: (a) full sun, (b) 3-year mahogany canopy, (c) 7-year mahogany canopy, (d) 55% artificial shading, and (e) 75% artificial shading (Photos: Pratiknyo Purnomosidhi)

Seven months after planting, the rhizomes were harvested and fresh weight measured for each subplot. Data was recorded in excel sheets and data analysis was conducted using a pivot table and ANOVA. The ANOVA analysis was conducted using SPSS 23.0 software.

The fresh weight yields of turmeric rhizomes by shading x fertilizer treatments are presented in Figure 5. The data shows that regardless of the fertilizer application the turmeric yields were greatest under 55% artificial shading followed by 75% artificial shading followed by 3-year-old mahogany trees and full sun (no shading) and lowest under 7-year old mahogany trees (Figure 5).

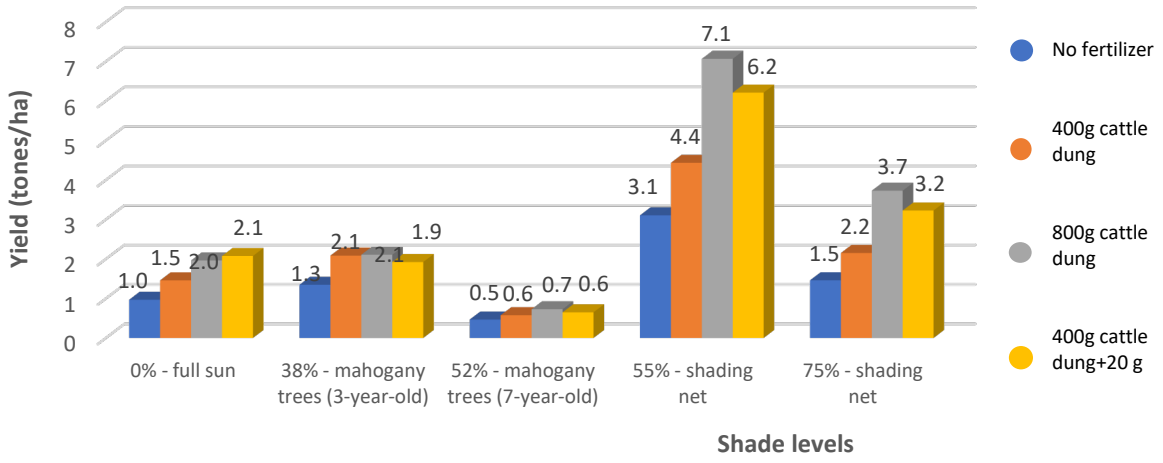


Figure 5. Average total fresh weight (yields) in tonnes/ha by treatment



Figure 6. Turmeric rhizomes production under 55% shading level (***Photos***: *Pratiknyo Purnomosidhi*)

The yield difference is due to competition for water and nutrients between turmeric and the mahogany trees. Seven-year-old mahogany trees produce shading of 53% similar to 55% artificial shading, however yields under 55% artificial shading are 7 to 10 times higher than those under 7-year-old mahogany trees. Similar results were reported by Syahid *et al.* (2012) who observed that turmeric yields under six-year-old teak trees were smaller, due to competition for soil nutrients under teak stands. According to Rahardjo and Rostiana (2005) the addition of manure is most important to improve long-term soil and growing conditions rather than the short-term goal of increasing turmeric yields. Once the site soil and growing conditions are good, turmeric will respond with increased yields. Rahardjo and Rostiana (2005) reported turmeric rhizomes production increased significantly in the second year after soil amendment with manure.

In this trial turmeric production under the 55% and 75% of artificial shading performed significantly better compared to yields under mahogany intercropping. The production reduced by approximately half with increased shading from 55% to 75%. However, yields under both shade netting treatments were greater than intercropping with mahogany or under full sun. In all shading treatments fertilizer application increased the turmeric production compared to no fertilizer application. Under shading net treatments (artificial shading), fertilizer treatments of cattle dung 400g + NPK 20g/planting hole and cattle dung 800g/hole increased turmeric production by more than 100% compared to no fertilizer application. Rhizomes yields increased by approximately 300% when comparing 55% shading net and full sun plot for each fertilizer treatment.

Table 1. The significant values of production, shading, fertilization and the interactions

Treatment		Productivity of fresh rhizome /plant (kg)		Plant survive/plot (max 30 /hole)		Water content in rhizome (%)	
Main plot							
Shading		N**		N*		TN	
	S0 (Control)	11.17	a	25.78	a	71.33	a
	S1 (Natural shading 38%)	12.90	ab	26.95	a	73.64	a
	S2 (Natural shading 52%)	4.18	c	24.60	a	72.03	a
	S3 (Artificial shading 55%)	35.97	d	27.53	b	74.40	a
	S4 (Artificial shading 75%)	18.26	b	27.08	abc	75.82	a
Split plot							
Fertilizer		N**		N**		TN	
	F0 (No-fertilizer)	12.70	a	24.64	a	73.39	a
	F1 (Manure 400g/hole)	18.50	ab	26.58	b	72.15	a
	F2 (Double manure 800g/hole)	26.94	c	26.96	b	74.85	a
	F3 (Manure 400g+20g NPK)	24.34	bc	27.36	b	73.40	a
Interaction (Shading*Fertilizer)		TN		TN		TN	

Note:
N: Significant, TN: No-significant, *: significant α = 0.05, **: significant α = 0.01, KK: deviation standard coefficient. Numbers followed by different letters in the same column show significantly different results based on tests LSD α=0.05

Statistical analysis of the trial is presented in Table 1. Results demonstrate that artificial shading 55% and fertilizer treatments of cattle dung 800g/hole or cattle dung and 400g+ 20g NPK/ planting hole yielded the best results. The interaction between these shade and fertilizer treatments was significantly positive. Manure application gives a positive impact that is significantly greater compared to no fertilizer controls. The application of manure probably improves the soil structure and fertility, facilitating rhizomes development. Additionally, the presence of manure retains soil moisture in the area where rhizomes grow. A very significant impact on yield also occurred when manure of 400g/hole was combined with chemical fertilizer (NPK) of 20g/hole. Turmeric survival was greatest under shading net 55% and 75% combined with any fertilizer application. The water content of rhizomes was not affected by shade or fertilizer treatments (Table 1).

Intercropping turmeric with mahogany (or other tree crop) can be a good option for smallholders to improve the productivity of their tree-based farming systems. In the degraded landscapes of Sumba Timur with low soil fertility and water shortage condition, intercropping turmeric under mahogany with the addition of organic fertilizer (cattle dung) is the good option for the first three years after tree planting. In the trial, turmeric produced up to 2.1 tonnes/ha under three-year-old mahogany. The production of rhizomes decreases as trees grow bigger. In this study, competition for soil nutrients, water and light between the 7-year-old mahogany and turmeric caused production of turmeric to decrease to 0.6-0.7 tonnes/ha.

The use of shade netting provides shading levels that facilitate high turmeric yield, avoiding competition for soil nutrients and moisture between turmeric and the tree overstory. Shade netting while readily available in Sumba Timur is too expensive for resource-limited smallholder farmers. An

alternative option is required. It is recommended that farmers cultivate turmeric under the shade of lamtoro (*Leucaena leucocephala*) and gamal (*Gliricidia sepium*) stands. Both tree species are common in Sumba Timur and are classified as multi-purpose legume trees that fixing nitrogen and can contribute nitrogen-rich biomass to increase soil fertility. Additionally, shade levels of lamtoro and gamal are easily managed by pruning and harvesting; both species readily coppice quickly regenerating shade as necessary. The harvested material of both species can be used for green manure, animal fodder, fuelwood, small timbers and other products (Roshetko. 2001). The use of animal fodder has a high potential in intercropping systems, as livestock are a form of wealth accumulation, and the livestock manure can be returned to the site as fertilizer to maintain soil fertility and enhance the production of turmeric or other crops.

4. Marketing of turmeric in Sumba Timur

Results from the trial demonstrate that turmeric production is a viable option for smallholder farmers in Sumba Timur. Household demand for cooking and medicinal needs is limited and can be achieve by growing turmeric in traditional home gardens. If smallholders are to engage in commercial production of turmeric market linkages need to be developed. Currently most farmers sell farm products at the farmgate and are not aware of Sub District market channels beyond the village even though Kapunduk Village in Haharu Sub District includes an active retail market and Waingapu a major retail market. A simple illustration of turmeric marketing in Haharu Sub District is provided in Diagram 1. Market price and transportation costs are two key factors farmers need to know when deciding to cultivation turmeric as a commercial commodity.

In addition, farmers need to consider the distance from their gardens to the market. If turmeric is planted in the vicinity of Rambangaru Village, the production site is not too far from the Kapunduk market. However, the situation will be different if the garden is in Mbatapuhu Village or Matawai Pandangu Village. Those villages are far from the market, transport costs could be significant if the price of turmeric is low. If farmers do not profit from turmeric sales, they are not likely to cultivate turmeric again. The costs of transportation from Haharu Sub District to the local market in Kapunduk Village or even to the Waingapu market must be considered. Farmers may need assistance to calculate transportation costs in addition to production costs.

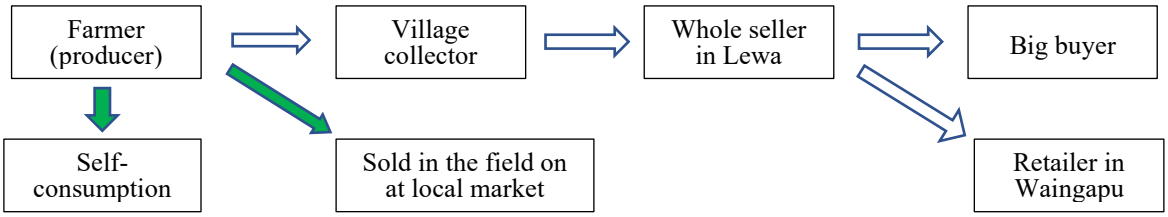


Diagram 1. Turmeric marketing flow

Additionally, the form of turmeric traded in local value-chains needs to be considered. A survey conducted by LWR identified two turmeric value-chains available to farmers in Sumba Timur.

Large traders in Lewa Sub District purchase turmeric from farmers as a sliced commodity, not fresh or in powdered form. Processing turmeric by slicing decreases in water content by 60-70% after sun drying for 2-3 days. The price for sliced turmeric is Rp. 10.000- Rp.17.000 per kg. These traders do not accept turmeric powder because experience indicates that powered turmeric is often mixed with other ingredients, decreasing the quality and purity of the commodity.

In the Waingapu market there are 19-24 retailers who trade in turmeric. These retailers purchase fresh turmeric rhizomes from farmers for about Rp. 5.000/kg. These retailers also do not purchase powered turmeric for the reason mentioned above. This value-chain represents a good opportunity, that Haruru farmers are not currently utilizing. The Waingapu retailers procure most of their turmeric stocks from large scale producers. Only 2% of the turmeric purchased is sourced from smallholder farmers, mainly from Wairinding Village in West Sumba and Lewa Sub District. Haharu farmers have never sold significant quantities of turmeric to the Waingapu retailers.

5. Conclusion

In terms of developing good agricultural practices (GAPs) for turmeric cultivation by farmers in Haharu Sub District, a number of conclusions can be drawn from this study. Shading level management, fertilization and the interaction of the treatments significantly influence the production of turmeric. Regardless of the fertilizer application, turmeric yields were greatest under 55% artificial shade (netting). The addition of organic fertilizer (cattle dung) 400g + NPK 20g/planting hole or cattle dung 800g/hole further increased yields under the 55% shading level. Turmeric production under 75% artificial shade produced roughly 50% of the yield under 55% artificial shade regardless of fertilizer application. Intercropping turmeric with 3-year-old mahogany trees or under full-sun was successful, producing approximately one-third the yield compared to 55% artificial shade. Under 7-year-old mahogany trees turmeric production failed due to competition for soil moisture and nutrients. Intercropping turmeric under trees is a good option for smallholders to improve the productivity of their tree-based farming systems. However, the level of shade and competition for soil moisture and nutrients are critical factors. It is recommended that turmeric cultivation be tested under the shade of lamtoro and gamal trees, two species which can be heavily pruned to manage shade levels and provide nitrogen-rich green manure to maintain soil fertility. The addition of organic and chemical fertilizers will further enhance turmeric production under lamtoro and gamal trees.

Turmeric marketing options are available to farmers in Haharu Sub District. Farmers can sell sliced turmeric to traders in Lewa Sub District for a price of Rp. 10.000-Rp.17.000 per kg. However, farmers consider a price of Rp 20.000 per kg is required to compensate for processing, 2-3 days of sun drying and slicing. Additionally, the drying process reduce rhizome weight by 60-70%. There is also opportunity for farmers to sell fresh turmeric to retailers in Waingapu for Rp 5.000 per kg. This can be a profitable price for Haharu farmers, considering limited processing is required (only cleaning) and the crop weight is not reduced. However, currently Haharu farmers do not pursue this opportunity. It is suggested that farmers should develop market relationships with commercial traders. The locations of the traders are not too far from Mbatapuhu Village. Developing this relationship is very important, it would provide farmers accurate market intelligence regarding monthly demand for turmeric in fresh or dry forms. In addition, a group marketing approach could be developed for the mutual benefit of both farmers and traders.

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Appendix

Appendix 1. The picture of soil properties in Mbatapuhu village

No	Sub Village	Village	Soil Depth (cm)	Texture			pH		Walkley & Black C (%)	Kjeldahl N (%)	Olsen P2O5 (ppm)	Morgan K2O (ppm)	CEC cmolc/kg
				Sand (%)	Silt (%)	Clay (%)	H20	KCl	Score	Score	Score	Score	Score
1	Karoku	Mbatapuhu	0-25	28.0	29.0	43.0	7.9	7.1	2.68	0.19	17	75	30.12
2	Karoku	Mbatapuhu	25-50	32.0	23.0	45.0	8.0	7.3	1.92	0.16	13	42	23.59
3	Retiahu (Laingadal)	Mbatapuhu	0-25	17.0	29.0	54.0	8.3	7.4	0.87	0.08	5	60	52.85
4	Retiahu (Laingadal)	Mbatapuhu	25-50	21.0	34.0	45.0	8.2	7.3	1.12	0.11	11	61	29.00
5	Pau	Mbatapuhu	0-25	22.0	24.0	54.0	8.1	7.1	2.03	0.18	12	83	29.70
6	Pau	Mbatapuhu	25-50	23.0	21.0	56.0	8.2	7.0	1.26	0.13	10	82	24.05
7	Praimarada	Mbatapuhu	0-25	22.0	32.0	46.0	8.1	7.1	3.12	0.29	13	169	39.15
8	Praimarada	Mbatapuhu	25-50	33.0	14.0	53.0	8.2	7.4	1.26	0.13	7	59	17.34
9	Pemetilayaku	Mbatapuhu	0-25	39.0	21.0	40.0	8.0	7.4	2.83	0.22	13	60	21.85
10	Pemetilayaku	Mbatapuhu	25-50	49.0	8.0	43.0	8.3	7.7	1.17	0.11	8	21	8.72
11	Wairara 1	Mbatapuhu	0-25	36.0	22.0	42.0	8.1	7.3	0.84	0.07	9	164	19.09
12	Wairara 1	Mbatapuhu	25-50	39.0	23.0	38.0	8.2	7.4	0.30	0.03	8	125	18.59
13	Wairara 2	Mbatapuhu	0-25	26.0	25.0	49.0	8.2	7.4	1.79	0.15	11	84	15.16
14	Wairara 2	Mbatapuhu	25-50	35.0	17.0	48.0	8.2	7.5	0.86	0.08	7	29	9.51

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United Nations Avenue, Gigiri • PO Box 30677 • Nairobi, 00100 • Kenya
Telephone: +254 20 7224000 or via USA +1 650 833 6645
Fax: +254 20 7224001 or via USA +1 650 833 6646
Email: worldagroforestry@cgiar.org • www.worldagroforestry.org

Southeast Asia Regional Program • Sindang Barang • Bogor 16680
PO Box 161 • Bogor 16001 • Indonesia
Telephone: +62 251 8625415 • Fax: +62 251 8625416
Email: icraf-indonesia@cgiar.org • www.worldagroforestry.org/region/SEA