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Adoption of leucaena-based feeding systems in Sumbawa, eastern Indonesia and its impact on cattle productivity and farm profitability

Adopción de sistemas de producción basados en leucaena en Sumbawa, Indonesia Oriental, y su impacto en la productividad bovina y rentabilidad del sistema de producción

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Abstract

Leucaena has been fed to cattle by the Balinese community in Sumbawa and West Sumbawa districts on Sumbawa Island since the 1980s. However, prior to 2011, this practice was not adopted by the local Sumbawanese farmers. Since then, a model leucaena-based cattle fattening system was developed in Sumbawa and West Sumbawa districts in a collaborative research project between the Assessment Institute for Agricultural Technology (BPTP), University of Mataram and The University of Queensland (UQ) funded by the Australian Centre for International Agricultural Research (ACIAR), followed by a scaling-out project involving collaboration between the University of Mataram and CSIRO (Applied Research and Innovation Systems in Agriculture - ARISA project) funded by DFAT (Department of Foreign Affairs and Trade) promoting public-private partnerships. Further promotion of leucaena-based fattening systems occurred in Dompu, Sumbawa, through a project with the University of Mataram and Massey University funded by the New Zealand Ministry of Foreign Affairs and Trade (MFAT). By the end of October 2018, more than 2,500 farmers on Sumbawa Island were practicing leucaena-based cattle fattening. The main drivers of adoption of cattle fattening with leucaena were: (1) The high growth rates achieved (0.4–0.6 kg/d for bulls fed 100% leucaena and 0.66 kg/d when maize grain was added to the leucaena basal diet) compared with 0.16 kg/d for the traditional system, combined with high profitability; (2) the needs of farmers being met in terms of relevance and cultural appropriateness; (3) field extension staff being well trained and mentored, and respected by the farmers; (4) the local government being highly supportive of leucaena-based cattle fattening; and (5) additional benefits being increased dressing percentage and high carcass quality. The rapid increase in the use of leucaena for cattle fattening in eastern Indonesia is expected to have a significant positive impact on household incomes as well as on regional economic growth.

Keywords: Cattle fattening, farmer income, growth rate, tree legumes.

Resumen

Leucaena ha sido usada, desde la década de 1980, para la alimentación de bovinos por la comunidad balinesa en los distritos de Sumbawa y Sumbawa Oriental pertenecientes a la isla de Sumbawa. Sin embargo, previo al 2011 esta práctica no fue

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adoptada masivamente por los agricultores locales. Desde esa fecha en adelante, se desarrolló un sistema modelo de engorde de bovinos basado en leucaena en dichos distritos en un proyecto de investigación colaborativa entre el Assessment Institute for Agricultural Technology (BPTP), la universidad de Mataram y la universidad de Queensland (Australia), financiado por el Centro Australiano para la Investigación Agrícola Internacional (ACIAR), y seguido de un proyecto de ampliación de escala con la colaboración entre la universidad de Mataram y la Organización de Investigación Científica e Industrial del Commonwealth (CSIRO; Proyecto ARISA: Applied Research and Innovation Systems in Agriculture), financiado por el Departmento de Relaciones Exteriores y Comercio de Australia, el cual promueve las asociaciones público-privadas. Los sistemas de engorde basados en leucaena se promovieron también en Dompu, Sumbawa, mediante un proyecto con la universidad de Mataram y la universidad de Massey (Nueva Zelanda), financiado por el Ministerio de Relaciones Exteriores y Comercio de Nueva Zelanda. A fines de octubre de 2018, más de 2,500 productores en la isla de Sumbawa adoptaron el engorde de bovinos a base de leucaena. Los principales impulsores de la adopción de esta tecnología fueron: (1) las altas ganancias de peso de los toretes (0.4–0.6 kg/d cuando la ración fue 100% leucaena y 0.66 kg/d cuando se añadió grano de maíz a la dieta basal de leucaena), en comparación con 0.16 kg/d en el sistema tradicional, además de una alta rentabilidad; (2) tecnología adaptada a las necesidades de los agricultores en términos de relevancia e idoneidad cultural; (3) extensionistas bien capacitados y orientados, además de respetados por los agricultores; (4) fuerte apoyo por parte del gobierno local de la tecnología de engorde de bovinos a base de leucaena; y (5), como beneficio adicional, mayor porcentaje y alta calidad de la carcasa. Se espera que el rápido aumento en el uso de leucaena para el engorde de ganado en el este de Indonesia tenga un significativo impacto positivo en los ingresos de los productores, así como en el crecimiento económico regional.

Palabras clave: Engorde de ganado; ingresos, leguminosas arbóreas, tasa de crecimiento.

Introduction

Beef consumption per capita in Indonesia is low at 1.5 kg/person/yr in 2000 and 2.5 kg/person/yr in 2015. However, local supply plus imports, mainly from Australia, are limited and the tight supply-and-demand relationship is reflected in the retail price of beef, which has quadrupled from 2000 to 2015 (Waldron et al. 2015; Shelton and the Project Team 2017). This has led to changes in policy in recent years, with large amounts of frozen buffalo meat and beef being imported from India. A projection by the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) suggested that the value of national beef consumption in Indonesia will increase 13-fold from 2009 to 2050 (Gunning-Trant et al. 2015).

The Indonesian Government has initiated programs to boost domestic beef production in an endeavor to achieve self-sufficiency. The majority of cattle in Indonesia are kept by about 6.5 M smallholder farmers, supplemented by a small number of much larger cattle ranches and larger feedlots, especially in Java and Sumatra.

Lifting the productivity of smallholder-fattened cattle to meet the increasing demands of the Indonesian population for beef has been nominated by provincial agencies as one of the most important ways to improve the incomes of the rural poor. The Indonesian provinces of West Nusa Tenggara (NTB) and East Nusa Tenggara (NTT) (Figure 1) have been identified as areas with high potential for expansion of smallholder beef production.

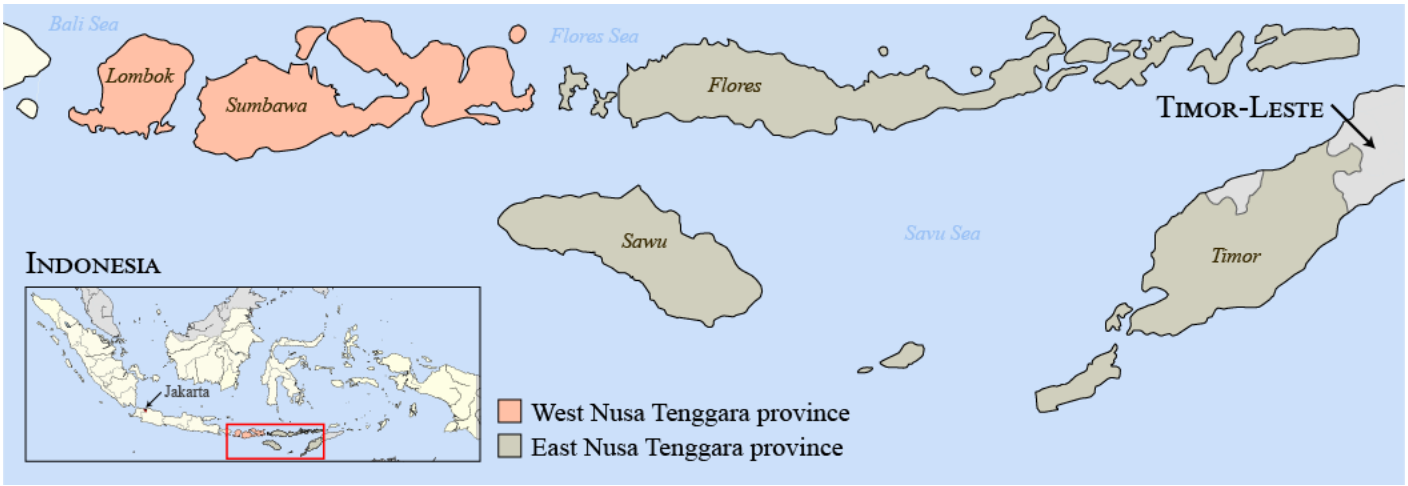

Figure 1. Map of Indonesia showing West Nusa Tenggara, with the islands of Sumbawa and Lombok, and East Nusa Tenggara provinces.

Currently, smallholder fattening systems in these regions are characterized by irregular, slow turn-off and poor carcass quality, largely resulting from very poor nutrition of cattle fattened under traditional feeding systems, which comprise cattle free-grazing on native rangeland or on rice stubble after crop harvest (Figure 2). This has negative consequences for the overall cattle population in Indonesia because too many young females are slaughtered to meet the growing demand for beef rather than being retained for breeding.

Prospects for expansion of the smallholder sector are constrained by:

1. Low production efficiency due to: low growth rates (0.15–0.25 kg/d); low calving rates (~65%); high calf mortality (10–20%); low sale live weights (averaging 250 kg); low carcass dressing percentages (48%); low genetic potential of local breeds; and poor management of the herd.
2. Socio-economic limitations due to: poor understanding of opportunities for improvement of smallholder cattle fattening enterprises; lack of knowledge and experience in forage improvement; problems with supply of credit; limited availability of land; and poor extension services and training.

In 2011, a 5-year collaborative research project between the Assessment Institute for Agricultural Technology (BPTP), University of Mataram and The University of Queensland (UQ), funded by the Australian Centre for International Agricultural Research (ACIAR), was initiated to improve smallholder cattle fattening systems based on promoting the use of forage tree legumes entitled 'Improving smallholder cattle fattening systems based on forage tree legume diets in eastern Indonesia and northern Australia' (LPS-2008-054). The project focused on the most viable option to improve diet quality in eastern Indonesia, which was to feed cattle with the foliage of high-quality forage tree legumes (FTL). The successful cattle fattening model was then scaled-out by a CSIRO/DFAT (Department of Foreign Affairs and Trade)-funded project promoting public-private partnerships, and further supported by a New Zealand Ministry of Foreign Affairs and Trade (MFAT)-funded project based in Dompu, Sumbawa.

Examples of such systems, in which cattle were fattened on FTL, already existed in Indonesia. Sesbania (*Sesbania grandiflora;* known locally as turi) was fed in south-central Lombok in NTB, and leucaena (*Leucaena leucocephala;*

a. Limited wet season communal grazing (Island of Sumbawa).

b. Lack of quality forage in dry season.

c. Lack of forage in dry season.

d. High calf mortality due to inadequate nutrition.

Figure 2. Lack of adequate forage severely limits nutrition of beef cattle in eastern Indonesia.

known locally as lamtoro) was fed in Sumbawa District in NTB and in Amarasi District of NTT. Both species were capable of greatly improving the protein nutrition of cattle. These systems were locally successful, but were not widely adopted outside these regions despite similar physical and socio-economic conditions.

This paper reports findings from the ACIAR and other projects in terms of: the history of cattle fattening in Sumbawa; the impact of leucaena-based fattening on cattle productivity and quality and farm profitability; and the progress made with an extension strategy designed to promote the uptake of leucaena planting and feeding for fattening cattle by smallholder farmers.

Early history of cattle fattening in Sumbawa

The use of leucaena for cattle feeding in eastern Indonesia was originally thought to occur mainly in the Amarasi District of West Timor (Piggin and Nulik 2005). However, in August 2010, as the ACIAR project got underway, we discovered that leucaena feeding was common practice for Balinese communities in Sumbawa and West Sumbawa districts. These Balinese communities had been using leucaena to fatten cattle since the 1980s with very little input from government agencies, or adoption by the local Sumbawanese farmers. The Balinese communities had very little cropping land and grew leucaena to fatten cattle on the steeper slopes behind their villages as their main source of income. In contrast, the Sumbawanese farmers had greater areas of land and spent most of their labor and time on cropping activities in the wet season, while raising cattle traditionally on communal grazing lands.

Balinese settlers first came to Sumbawa in the 1970s to work in the shrimp nursery. However, incomes from the shrimp nursery were not sufficient to support their families, so they acquired low-value steeper dryland nearby and planted crops, especially maize. In the 1980s, a Government scheme provided a couple of cows to some households and they managed to breed and grow a small herd. With previous experience from Bali that leucaena could be fed to cattle, they began growing leucaena to feed cattle and it became a common practice within this community. The leucaena was planted with support from an International Fund for Agricultural Development (IFAD) program. Initially the leucaena variety used was brought from Bali but was of unknown origin. Later, a variety called 'Lamtoro Gung' was used; it was found to be *L. leucocephala* cv. Cunningham, originally imported from Australia. By 2010, there were more than 100 Balinese households in the Sumbawa and West Sumbawa districts, who were feeding leucaena as the sole diet for fattening cattle. One of these Balinese villages (Jatisari) became a demonstration site for the new ACIAR project to describe and promote leucaena-based cattle fattening to other farmers in these districts.

Methods

The ACIAR project commenced by conducting a survey of 21 farmers and collecting data from 276 Bali bulls between 2011 and 2016 to determine the characteristics of the leucaena-based cattle fattening used by the Balinese in the hamlet of Jatisari in Sumbawa district on Sumbawa Island. Parameters measured included area of land planted to leucaena, length of fattening period and the growth of the Bali bulls (*Bos javanicus*) including bull live weight, average daily gain (ADG), feed offered including amount of leucaena in the diet and purchase and sale weights (Panjaitan et al. 2014; Shelton and the Project Team 2017).

In concurrent controlled animal trials, Dahlanuddin et al. (2014) studied the growth rate of Bali bulls and lactating cows fed leucaena hay compared with native or introduced grass, and the effect of supplementing with maize grain, maize stover and mineral mix.

Results

Survey of cattle production, profitability, carcass percentage and meat quality

The survey revealed that:

1. Farmers had an average of 2.8 ha of land with 0.8 ha (0.1–5.0 ha) of planted leucaena. They purchased bulls with an average live weight of 191 ± 41 kg at 18 ± 7 months of age and fattened them for periods averaging 127 ± 58 days (Panjaitan et al. 2014).
2. The average percentage of leucaena in diets throughout the year was 80% with 13% maize stover and 7% native grass. The percentage of leucaena was highest (100%) in the wet season, and lowest (approximately 50%) in October, when limited availability of leucaena meant farmers supplemented diets with crop residues.
3. Based on more than 3 years of monitoring (Figure 3) daily liveweight gains of Bali bulls ranged from 0.4 to 0.6 kg/d (Dahlanuddin et al. 2014; Panjaitan et al. 2014) on these rations. This was at least double the ADG of Bali bulls (0.2 kg/d) achieved in the traditional rearing system. ADGs peaked (0.56–0.61 kg/d) in the months of May, June and January, when feed supply and percentage leucaena in diets were highest (close to 100%), and the most efficient individual farmers achieved monthly maximum weight gains ≥0.8 kg/d, which is close to the genetic potential of Bali bulls.

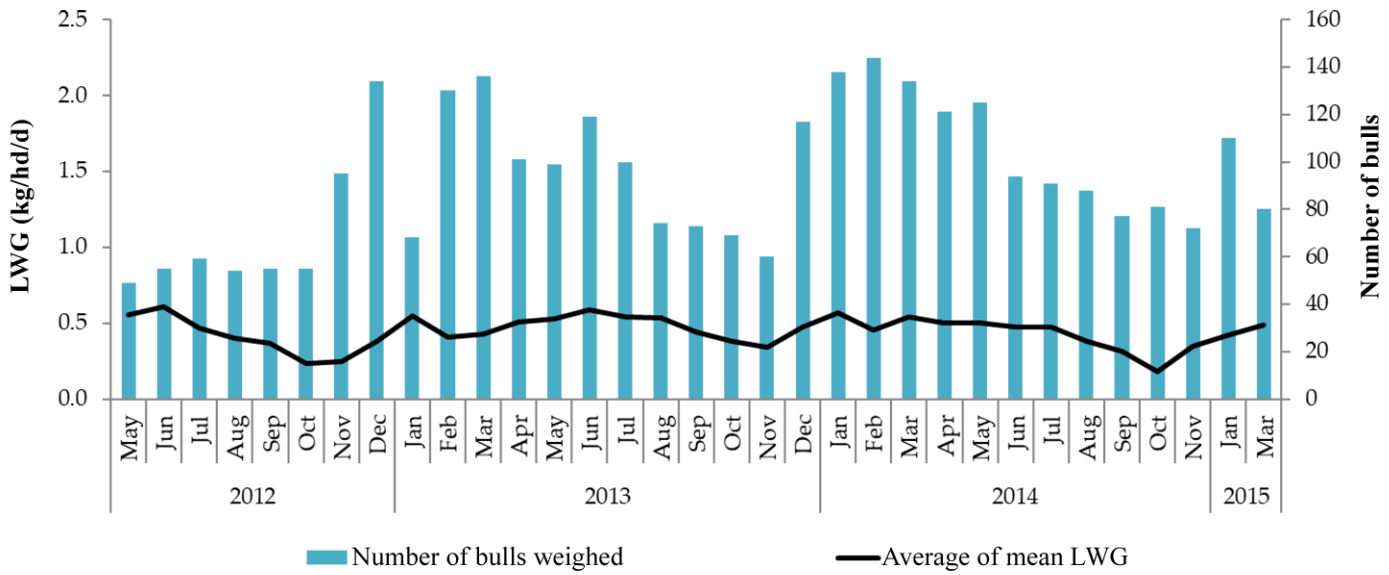

Figure 3. Liveweight gains and number of cattle fattened in Jatisari village, Sumbawa.

Pen-feeding trials

In controlled animal trials, Dahlanuddin et al. (2014) reported that the growth rate of Bali bulls fed 100% leucaena hay was 0.47 kg/d, more than double the growth rate of Bali bulls fed native grass. When leucaena hay was supplemented with 10 g maize grain (DM)/kg LW, growth rates increased to 0.66 kg/d (Dahlanuddin et al. 2018). In another experiment, Bali bulls fed 100% fresh leucaena ad libitum gained 0.50 kg/d; this growth rate reduced to 0.46 and 0.39 kg/d when maize stover was substituted for fresh leucaena at 25 and 50% of the diet, respectively (Soares et al. 2018).

Feeding high levels of leucaena hay (leaf and thin branches) to lactating cows increased milk production and calf growth. The milk production of cows fed leucaena hay ad libitum and 10 g maize grain DM/kg LW was 2.1 kg/d, double the milk production of cows fed 8-week-old regrowth of king grass ad libitum. Consequently, pre-weaning calf growth was significantly higher when cows were fed leucaena plus maize grain (0.37 kg/d) than when cows were fed king grass (0.16 kg/d) (Dahlanuddin et al. 2016).

As part of the IFSCA (Innovative Farming System and Capability for Agribusiness) project, a collaborative program between Massey University, New Zealand and University of Mataram, a feeding trial was conducted in Dompu district of Sumbawa using 20 growing Bali bulls fed: 100% leucaena ad libitum + 5 g rice bran DM/kg LW/d; 85% leucaena and 15% gliricidia mix ad libitum + 5 g rice bran/kg LW/d; 70% leucaena and 30% gliricidia mix ad libitum + 5 g rice bran/kg LW/d; or 55% leucaena and 45% gliricidia mix ad libitum + 5 g rice bran/kg LW/d (all diets supplemented with mineral mix at 3% of rice bran). Bulls in all treatments grew at 0.4–0.5 kg/d with no significant differences in growth rate between diets.

Meat quality

In response to anecdotal evidence that leucaena feeding results in dark meat and yellow fat, 5 bulls from the Dompu trial (fed fresh leucaena ad libitum plus 5 g rice bran/kg LW/d and mineral mix supplement) were slaughtered to measure carcass dressing percentages and meat quality. Carcass dressing percentages exceeded the average carcass dressing percentage of Bali bulls grazed traditionally and slaughtered at an abattoir in Sumbawa (52.4% vs. 48%). Meat quality tests (O. Yanuarianto pers. comm.) demonstrated that meat color of leucaena-fed bulls was cherry red and fat color was white. These parameters plus tenderness and marbling scores were similar to those from local beef animals considered as 'grade one' beef by Indonesian standards (W. Yulianto pers. comm.). Marbling score was low (mean of 2.4 on a 0–9 scale), which was mostly genotype-related.

Profitability of leucaena-based feeding systems

Based on the production parameters above, an economic analysis was conducted on cattle fattening on a leucaena-based diet in Jatisari (for details see Waldron et al. 2015). Production regimes are quite variable and speculative in the village, as knowledgeable and entrepreneurial farmers have become skilled at estimating weights and the

fattening potential of feeder cattle, and adjusting fattening numbers according to periods for seasonal feed availability and prices. While this variability should be taken into account, this section reports values for a 'representative (typical) household', with scenarios explored in Waldron et al. (2015).

Compared with other areas of eastern Indonesia, bull fattening on leucaena in Jatisari was highly profitable, especially in the wet season, primarily because of the high growth rates (0.5 kg/d) achieved. As a result, households can grow and turn-off cattle relatively quickly (e.g. growing from 130 kg to 200 kg in 140 days).

With these high growth rates farmers have expanded pen operations to an average of 10 head on leucaena during the wet season. There are large 'upfront' land, labor and capital costs in developing this capacity (IDR 6.5 million for pens and IDR 1.7 million for 3,000 leucaena trees; USD 1 = IDR 14,000). However, if house-holds can meet these costs (as a household, community or with external support), costs are low when spread over 20 years and hundreds of cattle. Variable costs – transport and veterinary – are also low. Transport costs are not significant as households source feeder cattle from their own herds, a nearby trading area or traders, and cattle are sold at the farm gate.

With regard to revenue, cattle prices (about IDR 37,000/kg live weight in 2015) were lower on Sumbawa than for Lombok (because of the transport and permit costs), but markets were competitive and buoyant. As mentioned, farmers seek favorable alignments between the input (feeder cattle) and output (finished cattle) prices. While farmers use some of the manure from pens on nearby fields and leucaena trees for firewood, cattle sales make up 99% of revenue.

After accounting for these costs and revenues, farmers earn gross profits of up to IDR 160,000 per day from cattle fattening. However, a typical household also incurs significant capital costs (for expensive cattle) and, more importantly, significant labor costs (for 10 cattle on leucaena). A typical household spends 5.7 person hours per day doing cattle work, the majority of which is for forage collection, followed by pen work and buying/selling cattle. However, even after taking these costs into account, the 'returns to labor day' (i.e. the amount made per 8 hours of work) was IDR 185,000. This is far higher than off-farm work (IDR 50,000 per day). It is important to note, however, that the returns per person day are far lower in the dry season (IDR 31,000) when weight gains are lower (0.35 kg/d) and accordingly households reduce the number of cattle on feed (to 3 head).

Based on the results of the Applied Research and Innovation Systems in Agriculture (ARISA) project impact assessment study (R. Caudwell pers. comm.), the leucaena-based cattle fattening system increased net income by 60% over the base case where leucaena was not fed.

Adoption of leucaena-based cattle fattening system in West Nusa Tenggara Province

The ACIAR project was also designed to test the hypothesis that: "FTL feeding practices can be successfully transferred to neighboring districts provided the constraints for diverse groups of farmers were identified and effectively tackled through participatory adaptive research and 'Roll-Out' efforts, and provided specific technical issues that might limit their use were resolved".

An extension strategy was developed with the following key components:

1. Awareness-raising regarding the use and benefits of FTLs in cattle farming;
2. Adaptive on-farm trials and demonstration of FTL management systems;
3. Capacity building on the management and use of FTLs;
4. Facilitation of access to inputs and services related to FTL management;
5. Support for FTL/cattle farmer groups; and
6. Establishment and fostering of inter-institutional relationships.

We found that there was a lack of understanding of the nutritional needs of animals, and especially of fattening bulls, and the comparative nutritive values of the various feeds available to smallholder farmers. Many farmers did not understand the large differences in nutritional value among various forage resources, especially the superiority of leucaena compared with rice straw, crop residues, grasses or banana stems. Another reason for not adopting leucaena was concern about leucaena toxicity, which proved to be a short-term problem, as cattle quickly adapted even when on 100% leucaena diets.

The establishment of on-farm demonstration sites was a critical component of this work (Figure 4). These sites allowed for the assessment and refinement of practices and the development of extension materials, and were used for cross-visits to promote good management practices to other farmer groups. An integrated package was developed comprising recommendations for the establishment, management and feeding of leucaena, and included recommendations for provision of water, hygiene and health. The project also recommended a basic model fattening shed (kandang) which could be easily replicated by farmers or farmer groups, in single or multiple units, either exactly as recommended or modified to suit local construction materials.

a. Leucaena seedling nursery

b. Leucaena bare stems ready for planting

c. Leucaena rows inter-planted with maize

d. Leucaena ready for harvest

e. Freshly harvested leucaena

f. Fresh leucaena being fed to Bali bulls

Figure 4. Establishing, harvesting and feeding of leucaena for cattle fattening in Sumbawa.

Barriers to and opportunities for adoption

Initially, there was very slow adoption by local Sumbawanese farmers even after they were taken to the Balinese village to observe the system in operation (Figure 4).

The project team then approached some local innovative farmers, rather than farmer groups, who had started to plant and use leucaena. This included a radio technician, who was interested in planting forages on his own land to feed goats. After several visits by the project team, these individual farmers became convinced to plant the new variety of leucaena, cv. Tarramba, and began fattening some young bulls. They soon found the system to be very profitable and became trainers for other farmers. Since then, the adoption rate has increased, driven by these local examples and by the high cattle prices obtained for fattened bulls. By the end of 2015, 535 farmers were involved in the leucaena-based fattening system in West Sumbawa and Sumbawa districts at various stages of adoption (Shelton and the Project Team 2017).

The barriers to and opportunities for adoption of FTL in Indonesia are now well understood. Our findings were first

presented in the paper by Kana Hau et al. (2014), and an updated list of barriers and opportunities for adoption was described in the final report to ACIAR on Project LPS/2008/054 (Shelton and the Project Team 2017) under the principal categories: Nature of the innovation; technical constraints; project leadership and staffing; engagement with farmers; socio-economic and agribusiness issues; and Government policy and involvement.

Applied Research and Innovation Systems in Agriculture (ARISA) project

Commencing in 2016, a collaborative research project was initiated between the University of Mataram and Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia as part of the Applied Research and Innovation Systems in Agriculture (ARISA) project funded by the Australian Department of Foreign Affairs and Trade (DFAT). While this new initiative was aimed at improving incomes by developing partnerships between the private sector and farmers, the most successful activity was a continuation of scale-out of the intervention to improve supply of high quality forages using leucaena.

By October 2018, 2,500 farmers (direct adoption from other farmers) in Sumbawa and West Sumbawa districts had adopted leucaena fattening. These farmers initially used a local leucaena variety, which they had harvested from wild leucaena growing on roadsides or forest margins, which had survived the psyllid infestations in the 1980s. Based on survey figures from June 2018, 733 new farmers on Sumbawa and West Sumbawa had planted the improved more psyllid-tolerant cultivar Tarramba and 133 of them were already fattening their cattle with this new cultivar (Figure 5). The total area planted to cv. Tarramba was 567 ha.

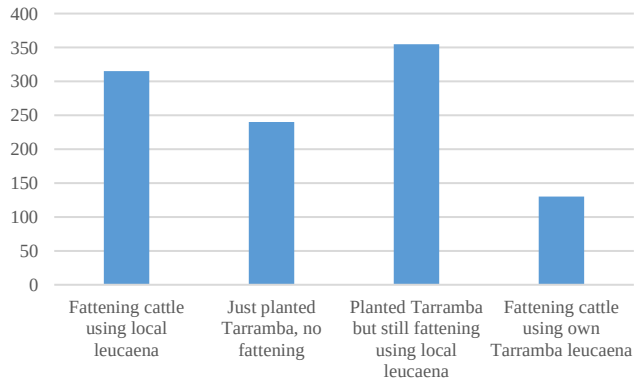

Figure 5. Numbers of farmers directly adopting leucaena-based cattle fattening in Sumbawa and West Sumbawa districts at various levels of adoption.

Innovative Farming System and Capability for Agribusiness (IFSCA).

The number of newly planted leucaena areas continued to increase rapidly and the practice was scaled-out to the neighboring district of Dompu through the IFSCA project, a collaborative program between Massey University, New Zealand and University of Mataram. The aim of this project was to increase income from cattle-crop (especially maize) integration by improving capacity of all participants in the value chain. One of the interventions was to scale-out proven innovations in cattle production, one of which was the leucaena-based cattle fattening system. Through this project, more than 200 farmers have been involved in cattle fattening using leucaena as the main component of the diet. The number is increasing rapidly and is expected to at least double in the next financial year.

Conclusions

Having one community, e.g. the Balinese community in Sumbawa and West Sumbawa districts, feeding leucaena successfully to cattle for decades does not necessarily mean that another community, e.g. the local Sumbawanese farmers, would adopt the strategy, partly due to cultural and communication barriers.

It took a combined research effort between BPTP, the University of Mataram and The University of Queensland, supported by ACIAR, DFAT and MFAT, to develop a model leucaena-based cattle fattening system, which was then introduced to the Sumbawanese farmers to dramatically change the situation. This, combined with a well-planned extension strategy including on-farm demonstrations, resulted in more than 2,500 Sumbawanese farmers (1,050 directly influenced by the project plus more than 1,000 copying farmers) on Sumbawa Island adopting cattle fattening based on leucaena by October 2018, 7 years after the study commenced.

The main drivers of adoption of fattening with leucaena were:

1. The high growth rates achieved compared with the traditional system, combined with the high cattle price (up to IDR 50,000/kg live weight) that resulted in high profitability;
2. The needs of farmers being met in terms of relevance and cultural appropriateness to local cattle production systems, land being available for planting leucaena and input costs being low;
3. Field extension staff being well trained and mentored, so they gained the respect of the farmers;
4. The local government being highly supportive of leucaena-based cattle fattening, and actively supporting

adoption by farmers. With the improved availability of leucaena, local government was successful in attracting additional central government funding for cattle development on the island;
5. Increased carcass dressing percentage compared with traditionally fattened Bali bulls and meat characteristics being of high quality; and
6. Observing farmers of their own ethnic community successfully practicing the system of feeding.

The adoption of leucaena-based cattle fattening has proven to be a very effective forage improvement strategy in the dry areas of eastern Indonesia. Using similar strategies to those employed should improve uptake of new technology in similar situations in the region. Rapid increase in the use of this cattle-fattening strategy in eastern Indonesia is expected to have a significant positive impact on household incomes as well as on regional economic growth.

Acknowledgments

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(Note of the editors: All hyperlinks were verified 20 August 2019.)

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