Improving the supply of forage and staple food of smallholder farmers in therural marginal dry land of East Nusa Tenggara, Indonesia

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Abstract. Cattle and corn are important for small farmers in west Timor. However, owing to the lack of proper technologies, marginal lands and erratic rainfalls, productivity of both are low. To improve the productivity, a conservation agriculture approach was demonstrated during 2017-2019 at Camplong II village, on a marginal land with shallow top soil, rocky formation, with existing corn production of ≤1 ton/ha. The technology package in 2019, includes: (i) hedges of *Leucaena leucocephala* (planted at 2 m within the row and 4 m between the rows), (ii) Deep planting hole (40 cm x 40 cm x 40 cm) filled with mixtures of soil and cattle manure, (iii) planting of grass within the rows of Leucaena, (iv) cover crop legumes: cow pea, *Clitoria ternatea*, and *Mucuna holtonii* while using corn stover and cattle refusals as mulches. Forage was obtained from Leucaena and the grass, while herbaceous legumes were left uncut. The results include: (i) year round supply of high quality forage, (ii) improved the daily weight gain of fattening cattle (0.2 to 0.3 - 0.6 kg/head/day), (iii) reduced calves mortality down to 0%, (iv) and increased corn yield to 5 ton/ha and a second crop harvest as green corn.

1 Introduction

Corn and cattle are two important agricultural commodities for farmers in East Nusa Tenggara, as staple food and cash. In the rural areas of West Timor, some carst formation soils exist with a very low soil quality, having shallow top soil on rock formation [1]. This soil is not suitable for food crops, such as corn cultivation with very low plant growth and production performances. Thus a conservation agriculture (CA) was introduced, one of which was “the deep planting whole model”. In this conservation agriculture, the principle practices were: none to minimum soil tillage, and the uses of permanent organic soil cover (plants or plant residues), and plant species diversification to improve soil organic matters which in the end a healthier soil condition will be achieved [2, 3]. In CA the cover plant biomass was not allowed to be taken from the land, which may not be suitable to the farming practices in West Timor. Farmers in this area also raise cattle as part of the mixed farming systems conducted. Thus CA adoption would be difficult when no biomass can

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betaken from the land as farmers need forage biomass from t he land to feed their cattle. Thus a modification of CA in 2019 was introduced in order to provide feed for the cattle as well as improving soil quality and thus corn (staple food) production.

2 Matterial and Method

Site for the experiment demonstration was at Camplong II village, Fatuleu Subdistrict of district of Kupang in West Timor.Planting*Leucaenaleucocephala*cvTarrambaand cattle fattening assessments have been conducted in the village since 2015 [4], while conventional CA assessments have been started since 2017, involving 5 farmer groups.At the conventional CA no biomass of cover crops were allowed to be taken from the plots.

In 2018/2019 planting season an area of 0.4 ha was usedtostudythemodifiedCA.In the modified CA, rows of Tarrambawere planted at 2m x 4 mdistance.Permanent deep planting holes (40x40x40 cm^3at 80 cm within the row and 40 between the rows) were established between the rows of Tarramba. Good soil of each hole was mixed with 10 kg of cattle manure into each hole. Corn seeds were planted into the four corners of the hole, one seed in each corner at rainy season in December2018.A second crop of corn was planted in the early March 2019for green corn harvest, after the first harvest, only on the deep hole treatment.

Dwarf king grass *Cenchruspurpureus* CV Mott, formerly *Pennisetumpurpureum* [5] was planted within Tarramba row at 40 cm from each *Leucaenaleucocephala* plant, thus there were 150 bunch of grass in each row (5-10 tillers) at every 100 m row. Seeds of *Clitoriaternatea*, *Vignaunguiculata* (cow pea) and *Mucunaholtonii*, were planted at 20cm x 20 cm [6] within the whole plot as cover crops, arranged in a split plot, with the deep hole and without deep hole as the main plot and legume cover crops as sub-plots, replicated 3 times.

Corn was not fertilized with additional inorganic fertilizer (urea) but was fully rely on the mixed of soil and cattle manure.Manure application was conducted every year and the area was kept well covered with legume cover crops and the refusals from the animal feeding.

Measurements conducted, included: grain production of corn (from 1^{th} crop) and number of cobs harvest (from the 2^{nd} crop), biomass production of forage (obtained from the grass and *Leucaenaleucocephala*), and feeding effect of forage for cattle herd in the mixed farm was observed by weighing the animals and taking note on the number of calf mortality.Yield of corn planted in the deep hole was then compared to the control without deep hole analyzed using ANOVA.In the current article dry grain production and green corn production from the 2 harvests were converted into cash.

Results (corn and forages) from the previous assessments were also considered and descriptively reviewed when constructing the results and discussionsectionof this paper.

3 Results and Discussion

3.1. Forage Production

Assessments since 2015 for Tarramba planting [4] and CA demonstrated in this village were able to convert about 500 ha of the marginal unproductive land into an area of forage production obtained from mainlyTarramba, thus turning a free grazing area of native grasses, with low forage production of 2-5 tons dry matter [7], and low nutritive value of 3-5% protein, as generally found in East Nusa Tenggara [7, 8], into a productive area of high

quality forage obtained from *Leucaenaleucocephala* of > 24% protein [9], and from Mott grass of 11-12% protein [10].

When formulated as ration for cattle feeding it was recommended to give in the proportion of 60% grass and 40% leaf of Tarramba [7], approximately contained about 16.8% protein. The benefit from introducing Tarramba into this type of marginal land is that there could be a year round supply of high quality fresh forage for the livestock.

In the current CA 0.4 ha experiment, 1 year stand ofTarrambacan produce fresh edible forage of 3.5 to 4 ton each year ($\pm$1 ton fresh forage at every harvest at 3 months interval), and about 5.35 ton of fresh green Mott grass per year. The potential production of Tarrambawill increase with time or with the increase plant age [11], up to 27 to 38 ton of fresh forage weight at 3-5 year stands, or about 8 to 11 ton DM/ha/year, similar to what was reported before. Under good soil condition Mott grass can produce upto$\geq$60 ton of DM/ha/year [12], and when planting between the rows of *Leucaenaleucocephala* (1mx4m) Mott grass may produce 120 ton/ha fresh forage per year.

3.2. Corn Production

The deep hole planting technique without the intervention of integrating Tarramba and Mott forages may produce up to 6-8 ton of dry grain corn, increased with time as also recorded previously [13,14]. The current (2019) first yearmodifiedCA with deep hole producedan average of 5 ton corn grain/hawhich was higher than without deep hole($P<0.01$).There was no significant difference on grain production between the different legume cover crop treatments ($P>0.05$)(to be published separately). From average production of 7 ton in third year CA, if 2 tons of the grain was secured for 1 year staple food, then the extra 5 ton can be sold under the market price of 3,200 rupiahs/kg, given additional cash income of 16 Million rupiahs. While the second crop when harvested green it will give an additional income of 8 cobs x 2,000 holes/ha x IDR 1,000 equal 16 Million rupiahs. Thus from corn only, a total increase of income can be achieved from 1 ha of integrated deep planting hole of CA model was about 32 Million rupiahs from corn.Assuming no additional costs of household labor and cattle manure used (obtained from their own livestock farming).One of the benefits of introducing the deep holeplanting model in this CA assessment was it enabling the farmer households to ensure sufficient staple food for 1 year. In the existing practice, on the current area with the carst soil farmers were able to provide staple food (corn) for only about 6-8 month per year.

3.3. Animal Production

Under free grazing condition in this area calf mortality can reach between 25% to 50% [15, 16]. While under the current improved CA demonstration condition calf mortality can be reduced down to 0%, by giving Tarramba leaf supplement during the dry season. Thus in a family who owned 10 cows with 6-8 calves produced each year, the improved CA demonstrated can save 2-4 calves, which is equal to additional income of 7 – 14 Million rupiahs/year, if 1 year weaned calf can be sold at 3.5 Million/calf. At the feeding for fattening Bali Bull cattle an average daily body weight gain of 0.6 kg/hd/day was demonstrated, while under free grazing condition in this area the animals may only gained 0.2 kg/hd/day at best or either they may lose weight [7,17]. Thus assuming that by feeding 5 bulls in a year, a family with 1 ha of the CA model may gain additional 21 Million rupiahs more cash than under free grazing practices traditionally conducted in the area. Thus by running 1 ha of the current integrated CA model a farmer under this marginal land

may gain additional 28 to 35 Million rupiahs per year compared to the traditional free grazing condition. This was only the additional income that a family can achieve from raising 10 cows (combining grazing and calf supplement), and 5 fattening bulls.

4. Conclusion and Recommendation

4.1. Conclusion

Thus by improving the agricultural practices into an modified / integrated CA with deep hole planting model on 1 ha of rural marginal land of West Timor, a farmer with 10 free grazing cows and 5 fattening bulls may gain additional income of >60 Million rupiahs (through the increase of corn and cattle productivity), increase and ensure provision of sufficient staple food (corn) for 1 year, and provide year round high quality forage for feeding cattle herd (calves, cows and bulls).

4.2. Recommendation

It is however a hard work for the farmer to provide ±2,000 deep planting hole per ha on their land, so there are still many farmers who can not adopt the improved practiced and thus help from the agriculture department for the farmer to provide the deep planting holes would be highly recommended (eg. Using of machinery to dig for the holes).

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