Potential of forage production on dry land agriculture with mixed cropping pattern

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Abstract. Mixed farming system is an alternative to overcome the shortage of ruminants feed. This study aimed to observe the potential forage production in mixed cropping pattern on dry land agriculture. This research was conducted at the Agro Technology Innovation Center (PIAT) Universitas Gadjah Mada, from January until November. The research field size was 3.000 m² divided into 2 blocks for monoculture and mix-cropping. During rainy season the sweet corn was planted on monoculture plot; on mix-cropping plot 1.000 m² was planted with sweet corn and the rest was planted with *Brachiaria brizantha*, *Arachis hypogaea*, and *Manihot utilissima*. *Gliricidia maculata* is planted as a hedge that surrounds the mixed plot. After the first harvest, both plots were re-processed and planted with *Arachis hypogaea*. Forage sampling was done using the quarter method. The variables observed were the production of dry and organic matter of agricultural by-product, in vitro digestibility of dry and organic matter, and the economic income of the main crops. The data were analyzed using Independent sample t-test. The results showed an increase (P<0.05) of production, digestibility, and economic income with the existence of mixed cropping. Mixed cropping provides better production, digestibility and economic income compared to a single planting.

1. Introduction

Most agricultural areas in Indonesia are dominated by dryland agriculture. This area does not get technical irrigation, so the availability of water depends entirely on rainfall. In general, dry land is a stretch that has never been flooded. The typology of this land can be found from the lowlands (0-700 masl) to the highlands (> 700 masl). There is limited availability of water on this dry land; an appropriate cropping pattern is needed so that the availability and production can be increased. Cultivation of crops in areas where annual rainfall is more than 750 mm but less than 1150mm is called dry land farming. Dry spells may occur, but crop failures are less frequent. Higher evapotranspiration than the total precipitation is the main reason for moisture deficit in these areas. The soil and moisture conservation measures are the key to dryland farming practices in semi-arid regions. Drainage facility may be required especially in black soils [1].

The mixed farming system is one alternative to meet the shortage of ruminant feeds and increase farmers' income. This system is a planting management system in a land where there are several kinds of
plant species planted simultaneously. The planting pattern is done by planting plants alternately or planted around the core plants in the form of food crops. Types of food crops and forage that are often planted on dry land include; Peanuts (*Arachis hypogaea*), sweet corn (*Zea mays*), *Brachiaria brizantha*, *Gliricidia maculata*, and cassava (*Manihot utilissima*). These types of plants are widely used because they are tolerant of drought, easier to maintain, and there is no competition with each other. These plants can be planted with a monoculture system or planted together with a mixed crop pattern system. Mixed cropping systems in organic farming offer a yield buffering capacity by diverse growing demands and different periods of root, leaf and seed development of the plant varieties [2].

Dry matter production is a basic measure of the productivity of forage crops. Forage production is highly dependent on the type of forage crops, the intensity of light received, the availability of nutrients in the soil, and the procedures for management. The digestibility of feed ingredients is an important parameter in determining the quality of feed ingredients, the higher the value of the food ingredients the better the quality of the feed ingredients. Measuring forage digestibility can be done through several methods such as; *in vivo*, *in vitro*, and *in sacco*. The in vitro method is the most widely used method in determining forage digestibility. This method was chosen because it is easier to do, can use a lot of replication, and costs are cheaper than other methods. The principle of determining digestibility using in vitro methods is based on the processes that occur in the digestive system of ruminants where microbiological digestion occurs (in the rumen) and chemical and enzymatic digestion (post rumen). The high volume of agricultural by-products could be alternative feed for the animal because of the lower price of these by-products. Many researchers reported that crop residue can be used for cattle production. Adequate nutrients and digestibility of will affect on productivity of animal [3].

Mixed cropping systems are also expected to increase farmer income due to the optimization of land use. Mixed crop farming systems are expected to increase biomass production, continuity of land use and nutrient requirements for livestock to be fulfilled. This research is the first step in evaluating the benefits of implementing the cropping pattern on dry land so that the results achieved in this study can be the basis for applying mixed cropping patterns to farmers, especially in dryland farming systems.

2. Materials and methods

2.1. Time and place
This research was carried out at Agrotechnology Innovation Center (PIAT) Universitas Gadjah Mada, Kalitirto, Berbah, Sleman, Yogyakarta from January to November. The land used is the type of entisol soil which is at an altitude of 105 masl. Analysis of dry matter, organic matter, and in vitro digestibility was carried out in the forage and pasture forage laboratories, UGM faculties.

2.2. Materials
The equipment used in this study include: weighing scales ATS brand capacity of 25 kg with a sensitivity of 100 g, PAEMA brand weighing scales dial spring capacity of 5 kg with sensitivity of 20 g, measuring tape, analytical scales ATS brand with sensitivity 0,001 g, Willey mill with filter 1 mm, oven temperature 55° C, oven temperature 105° C, silica disc, and a set of in vitro digestion test kits. The materials used in this study include; ‘Genjah’ variety peanut seeds, sweet corn (*Zea mays*) varieties "Bisi", *Brachiaria brizantha* grass, *Gliricidia maculata* cuttings, cassava cuttings, compost, and NPK fertilizer.

2.3. Methods
The land used in this study was 2,500 m² which was divided into 2 plots of land, namely for mixed cropping patterns (1,500 m²) and monoculture (1,000 m²) cropping patterns. The land used for the mixed cropping system is taken 5 m along 50 m so that the two sides are 500 m². Before planting the land is
blended and given 3 tons/ ha of organic fertilizer. The planting process is divided into 2 periods. In the first period, corn plants were planted at a distance of 30 x 70 cm on mixed land and monoculture. In mixed fields, brachiaria brizantha was added on both sides (2x250 m) with a spacing of 90 x 30 cm, peanuts with a spacing of 90 x 65 cm, and cassava was planted with a spacing of 90 x 65 cm between the grass and peanut plants. *Gliricidia maculata* is planted as a hedgerow with a spacing of 150 x 150 cm. In the second period, after sweet corn plants were harvested, monoculture land and mixtures were planted with peanut plants with a spacing of 30 x 20 cm. Fertilization is done using urea fertilizer (200 kg / ha), TSP (100 kg / ha), and KCl (100 kg / ha) which is divided into 3 stages. Harvesting of sweet corn is done at 73 days, peanuts at 88 days, *Brachiaria brizantha* at 46 days, Cassava and Gliricidia at 10 months. The harvesting process is carried out using the ubiquitous method with 5 replications. The data analyzed include the production of dry matter and organic matter, the production of dry matter and undigested organic matter, and the value of production. Analysis of dry matter and organic matter was based on AOAC[4], digestibility of dry matter and organic matter using the Tilley and Terry method using two stages in vitro method[5]. The data obtained were tested by independent sample T-test[6].

3. Result and discussion

The mean yield of forage dry matter with a mixed cropping system was 3,420.13 kg/ha, the yield was higher (P<0.05) compared to the monoculture cropping pattern which only produced 2,922.67 kg/ha of dry matter. Higher production in mixed cropping patterns is due to plant variations in each planting period. Intercropping short and tall plants may benefit crop growth by increasing light and air diffusion. That condition will increase the production of the plant [7].

The average yield of forage organic matter with a mixed cropping system was 3,048.26 kg/ha, the yield was higher (P<0.05) compared to the products produced in the monoculture cropping pattern which only produced 2,621.93 kg/ha. The high production of organic matter is in line with the high production of dry matter because most organic materials can be found in dry matter of plants. Organic matter production will be correlated with dry matter production [8].

Table 1. Production and economic analysis of forage with mono-cropping and mixed-cropping pattern

| Parameter                                | Mono-cropping | Mixed-cropping |
|------------------------------------------|---------------|----------------|
| Dry matter production (kg/ha)*           | 2,922.67      | 3,420.13       |
| Organic matter production (kg/ha)*       | 2,621.93      | 3,048.26       |
| Production of digestible dry matter (kg/ha)* | 1,171.60 | 2,009.93 |
| Production of digestible organic matter (kg/ha) | 1,543.73 | 1,710.26 |
| Economics income (IDR/ha)*               | 18,851,986.7  | 19,312,533.3   |

*Significantly different

Production of digested dry matter with mixed cropping patterns was 2,009.93 kg/ha, these results are higher (P <0.05) compared to the production of digested dry matter in the monoculture cropping pattern which only produced 1,171.60 kg/ha. The variation of plant species such as *Gliricidia maculata* and cassava in mixed cropping patterns causes higher nutrient content of forage compared to forage in monoculture cropping patterns which are only planted with peanuts. An increase that occurs especially in the content of easily digestible components such as crude protein and nitrogen-free extract. Crude protein content and digestibility both increased linearly [9].

The production of undigested organic matter for feed with a mixed cropping pattern was 1,710.26 kg/ha, this result was higher (P <0.05) compared to the production of undigested organic material in the monoculture cropping pattern which only produced 1,543.73 kg/ha.

The application of a mixed cropping system can increase (P <0.05) the value of forage production. The production value with a mixed cropping pattern system is IDR. 19,312,533.3 / ha, while in the
monoculture cropping pattern only produces Rp. 18,851,986.7 / ha. Mixed cropping patterns that involve several types of plants on the same land produce a variety of harvested commodities obtained. Each commodity has a different selling value so that it can increase the production value of the mixed cropping system. Mixed cropping systems minimize external inputs thanks to synergies between components particularly fertilizer. Diversification allows mixed cropping systems to be less sensitive to inputs and sales price fluctuations [10].

4. Conclusion

Based on the results and discussion it can be concluded that the existence of a mixed cropping system on dry land can increase the production of dry matter, organic matter, digestible dry matter, digestible organic matter, and economics income compared to the monoculture cropping system.

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