Production, quality and livestock carrying capacity of *Panicum maximum* and *Sesbania grandiflora* at saline soil with different manure application

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ABSTRACT

The objective of this study was to evaluate the effect of manure at saline soil on forage production, quality and livestock carrying capacity of *P. maximum* and *S. grandiflora*. The research was conducted on moderately saline soil at Rembang Regency, Central Java Province, Indonesia. Randomized complete block design was used as design experiment. The treatments were different dosage of manure as organic amendment (0, 10 and 20 tonnes/ha). Forage crops were *P. maximum* and *S. grandiflora* that planted monoculture or mixed-cropping. Parameters measured were dry matter (DM) production, ash, crude protein, crude fibre, ether extract, total digestible nutrients. *P. maximum* was cut eight times, *S. grandiflora* was cut six times during one year. The result showed that the highest total dry matter production of mixed cropping *P. maximum* and *S. grandiflora* was available at moderately saline soil with application 20 ton/ha manure. Total production of dry matter, crude protein and total digestible

Kata kunci: monokultur, protein kasar, satuan ternak, TDN, tumpangsari
nutrient available at application 20 ton/ha manure were 29131 kg/ha/year; 3722 kg/ha/year and 17718 kg/ha/year, respectively. Carrying capacity based on dry matter, crude protein and total digestible nutrients were 10.8 AU/ha/year; 13.6 AU/ha/year and 11.3 AU/ha/year, respectively. In conclusion, application of 20 ton/ha manure at saline soil increased production, crude protein and carrying capacity.

**Keywords:** animal unit, crude protein, mixed cropping, monoculture, Total Digestible Nutrient

### INTRODUCTION

One of the main problems that decreases crop production on agricultural land is salinity because most of crop are sensitive to high salt concentration. The area of salt affected is increasing year by year (Shrivastava and Kumar, 2015). Preliminary findings suggest that plants which grow at saline soil encounter osmotic stress, ion toxicity, nutrient deficiency and oxidative stress. Osmotic stress occurs because of the presence of salt in soil solution, consequently it reduces soil water potential and the plant ability to absorb water. The toxic ions found in saline soil are sodium (Na\(^+\)) and chloride (Cl\(^-\)) which have detrimental effects when accumulated in concentration over the tolerance threshold in plants (Bano and Fatima, 2009). The tolerance threshold of some plants is starting at electrical conductivity of 2 dS/m (Vargas et al., 2018).

Many studies have been undertaken to ameliorate saline soil so that it is suitable as agricultural land. Wu et al. (2018) stated that using organic amendment such as cattle dung, vermicompost and biofertilizer improved the soil organic matter content and soil organism at saline soil. While Mbarki et al. (2018) reported, compost application of municipal solid waste compensated salinity adverse effects on nutrient uptake and plant growth. Kusmiyati et al. (2018) reported, application of 20 ton/ha manure at saline soil increased growth and dry matter production of S. grandiflora at first and second cutting. Recording temporal and spatial changes of water quality and soil salinity was suggested by Qureshi and Al-Falahi (2015). Modification of micro climate using mulch at saline soil was another way to reduce salinity negative effect on plant growth (Kusmiyati et al., 2016). Other approach of using saline soil as agricultural land is utilizing salt tolerance plant (Rui-dong, 2018 and Diaz et al., 2018). Ahmad et al. (2010) stated that reduction of photosynthetic capacity was lower at salt-tolerant populations compared to salt-sensitive populations. Our previous studies showed that among 5 grasses (Panicum maximum, Euchlaena mexicana, Setaria sphacelata, Cynodon plectostachyus and Brachiaria brizantha), P. maximum showed the most tolerant grass based on mineral concentration at saline soil (Kusmiyati et al., 2012).

Panicum maximum and Sesbania grandiflora are usually used as forage crop in Indonesia. Forage crop could grown either in pastures as feed for grazing animal or in field as feed to livestock in confinement by cut and carry. Olaniye et al. (2009) reported dry matter production annually of P. maximum was 10.2 ton/ha at pasture in savanna area that has sandy soil with low in nitrogen and available phosphorus, fairly acidic. Dry matter production commonly was used to calculate the average number of cattle that an area supported safely for a season, it is called as carrying capacity. Carrying capacity of Panicum maximum in the Amazon biome – Brazil was 2.86 AU/ha for production of beef cattle (Andrade et al., 2013). Rindwati et al. (2016) reported carrying capacity of pasture that dominated with 15 species such as Cyperus rotundus, Calopogonium muconoides, Axonopus compressus, Crotalaria juncea and Desmodium intortum at Gowa Regency in Indonesia was 0.88 AU (Animal Unit)/ha/year. Meanwhile, Se’e et al. (2015) evaluated dry matter production of grass was 150 to 390 kg/ha/year that could support 0.24 to 0.63 AU/ha/year in Timor Tengah Selatan Regency in Indonesia.

Based on previous research, amelioration efforts on saline soil as agricultural land was only based on single methods (Wu et al., 2018). Combining two or more methods on using saline soil as agricultural land has not done yet. So, this research combines two methods, using plant tolerance and organic amendment. Plant tolerance at this research are P. maximum and S. grandiflora that are usually used as forage crop. Prior study did not reported the production, quality and carrying capacity of P. maximum and S. grandiflora at saline soil. Therefore, this experiment was conducted to evaluate the effect of manure as organic amendment on production, quality and livestock carrying capacity of P. maximum and S. grandiflora based on cut and carry at saline soil.
MATERIALS AND METHODS

Study Area
This research was conducted on moderately saline soil from June 2016 to July 2017 at Kaliiori, Rembang Regency, Province of Central Java, Indonesia. Rembang regency is located on the north coast of Java island at 3 m above sea level. The number of raindays, annual rainfall, average temperature and relative humidity were 72 days, 1716 mm, 30°C and 42 %, respectively (Badan Pusat Statistik Kabupaten Rembang, 2017). Type of soil was alluvial with pH 7.8 and texture of silt loam. Total nitrogen, P$_2$O$_5$, K$_2$O, organic C were 0.13%, 75.65 mg/100 g, 140.20 mg/100 g, 1.08 %, respectively. Sodium exchangeable and cation exchange capacity were 0.37 Cmol/kg and 11.99 Cmol/kg. The electrical conductivity (EC) was 3.8 dS/m during rainy season and 4.1 dS/m during dry season.

Design and Treatment
The design experiment used randomized complete block design. There were three blocks based on different soil salinity. The treatments were different dosage of manure as organic amendment (0, 10 and 20 tonnes/ha). The forage crops were _P. maximum_ and _S. grandiflora_ which planted monoculture or mixed-cropping. There were nine treatments with three blocks as replicates. Each treatment was used plot of 6 m x 7 m. Total plots were 27 plots. Soil tillage was done before planting. Application of manure was done after soil tillage and one week before planting. pH, C-organic, total N, P$_2$O$_5$, K$_2$O and C/N ratio of manure were 6.56; 30.64 %; 1.65 %; 9.27 %; 3.52 % and 18.55; respectively. Manure was produced by the fermentation of fresh cattle dung from farmers in the study area.

Crown splits of _P. maximum_ or seed of _S. grandiflora_ were planted at 75 cm x 100 cm at monoculture. While at mixed cropping, the second plant was planted between rows. Forage crops both at monoculture and mixed cropping were planted concurrently. Fertilizers were applied according to recommendation dosage (60 kg N/ha/cutting, 150 kg P$_2$O$_5$/ha and 100 kg K$_2$O/ha). First, _P. maximum_ was cut four weeks after planting. No parameter was measured at first cut. Following cutting of _P. maximum_ was carried out before generative stage. First, _S. grandiflora_ was cut thirteen weeks after planting. The next cut of _S. grandiflora_ was done every 7 weeks. Height of cutting of _P. maximum_ and _S. grandiflora_ were 10 cm and 30 cm above soil, respectively.

Parameter measured was dry matter (DM) production at every cutting. Crude protein, ash, crude fibre, ether extract and nitrogen free extract (NFE) were measured at eight cutting of _P. maximum_ and sixth cutting of _S. grandiflora_. Crude protein, ash, crude fibre and ether extract were analysed by proximate analysis according to AOAC (2005). Total digestible nutrient (TDN) was calculated based on proximate analysis (Hartadi et al., 1980). The formula for TDN calculation was:

TDN (%) = 37.937 – 1.018 (CF) – 4.886 (EE) + 0.173 (NFE) + 1.042 (CP) + 0.015 (CF)(CF) – 0.068 (EE)(EE) + 0.008 (CF)(NFE) + 0.119 (EE)(NFE) + 0.038 (EE)(CP) + 0.003 (EE)(EE)(CP)

Dry matter production was also utilized to calculate Land Equivalent Ratio (LER). In addition, land equivalent ratio (LER) was used to evaluate mixed cropping efficiencies with respect to monoculture/sole crop. It was expressed as LER = M/Sa + Mb/Sb, where M and S refer to mixed cropping and monoculture/sole crop yield respectively, and the subscripts a and b indicate the component crops in the mixture.

Analysis data
Dry matter (DM) production, crude protein, crude fibre and ether extract were analyzed using analysis of variance, followed by Duncan’s multiple range test. Statistical model was :

\[ Y_{ij} = \mu + T_i + B_j + \varepsilon_{ij} \]

Where :

- \[ Y_{ij} = \text{The observation at } i^{th} \text{ treatment and } j^{th} \text{ block} \]
- \[ \mu = \text{Overall mean} \]
- \[ T_i = \text{Effect of } i^{th} \text{ treatment} \]
- \[ B_j = \text{Effect of } j^{th} \text{ block} \]
- \[ \varepsilon_{ij} = \text{Effect of error} \]

Carrying capacity was calculated based on dry matter production, crude protein and total digestible nutrients. The procedure to calculate carrying capacity used the modification methods of Se’u et al. (2015) : 

- Calculation _P. maximum_ DM production (kg/ha/year) = sum of DM production from second cutting to eight cutting at mixed cropping. Total dry matter production of _P. maximum_ at second cutting and third cutting at 0 ton/ha, 10 ton/ha and 20 ton/ha manure application were 1996.5 kg/ha, 7087.3 kg/ha and 10444.2 kg/ha, respectively (Kusmiyati et al.,
(2) Calculation S. grandiflora DM production (kg/ha/year) = sum of DM production from first cutting to sixth cutting at mixed cropping. Dry matter production of S. grandiflora at first cutting at 0 ton/ha, 10 ton/ha and 20 ton/ha manure application were 1079.4 kg/ha, 2086.4 kg/ha and 2591.5 kg/ha, respectively (Kusmiyati et al., 2017). (3) Proper use factor (PUF) is 70%. (4) Calculation of Total DM production available at mixed cropping (kg/ha/year) = (P. maximum DM production x PUF) + (S. grandiflora DM production x PUF). (5) Daily DM forage requirement for 1 animal unit (AU) is 7.4 kg/day or 2701 kg/year (Kearl, 1982). Assumption used for definition of one animal unit is steer with body weight of 300 kg and 0.75 kg of average daily gain. (6) Calculation carrying capacity based on DM (AU/ha/year) = Total DM production available/DM requirement for one year. (7) Calculation carrying capacity based on crude protein production available (AU/ha/year) = Crude protein production available (kg/ha/year) / CP requirement (kg/AU/year). Crude protein requirement for one year (kg/AU/year) = 0.75 kg/day x 365 day = 273.75 kg/year (Kearl, 1982). Crude protein production available (kg/ha/year) = (Total DM production available of P. maximum x % CP of P. maximum) + ((Total DM production available of S. grandiflora x % CP of S. grandiflora). (8) Calculation carrying capacity based on total digestible nutrients production available (AU/ha/year) = total digestible nutrients production (kg/ha/year) / TDN requirement (kg/AU/year). Total digestible nutrients requirement for one year (kg/AU/year) = 4.3 kg/day x 365 day = 1569.5 kg/year (Kearl, 1982). Total digestible nutrients production available (kg/ha/year) = (Total DM production available of P. maximum x % TDN of P. maximum) + (Total DM production available of S. grandiflora x % TDN of S. grandiflora).

RESULTS AND DISCUSSION

Forage Production

The result showed that manure application affected DM production of P. maximum either at monoculture or mixed cropping from fourth cutting until eight cutting (Table 1). Kusmiyati et al. (2017) reported DM production of P. maximum at second cutting has no significant difference between manure application of 0 ton/ha and 10 ton/ha. However, manure application affected DM production at third cutting. Manure application impact at saline soil on DM production of P. maximum was obvious from third cutting until eight cutting which application of manure increased significantly grass production. Dry matter production was higher at manure application of 20 ton/ha than at 10 ton/ha at fourth cutting, fifth cutting, seven cutting and eight cutting. The highest total DM production of P. maximum was at manure application of 20 ton/ha and monoculture. Meanwhile, the lowest was at no manure application and mixed cropping with S. grandiflora.

The highest total DM production of P. maximum from fourth cutting to eight cutting was 22.8 ton/ha/year at application 20 ton/ha manure and monoculture (Table 1). The total DM production of P. maximum at saline soil in this study was higher than those reported by Ojo et al. (2013) and Olanie et al. (2009). Ojo et al (2013) planted P. maximum at soil of sandy clay. While, Olanie et al. (2009) reported DM annual production of P. maximum was 10.2 ton/ha. P. maximum production at this study was based on cut and carry systems. Meanwhile, Olanie et al. (2009) calculated production of P. Maximum in a derived savanna area in Nigeria based on cattle grazing. Grazing by cattle is noted to contribute the DM production decline of pasture over times, especially when grazing pressure or stocking rates are high. The lowest DM production of P. maximum from fourth cutting to eight cutting was 2.9 ton/ha at treatment with no manure application and mixed cropping with S. grandiflora. The DM production was lower with that reported by Olanie et al. (2009).

Application of manure at saline soil also significantly improved DM production of S. grandiflora (Table 2). S. grandiflora production at manure application of 20 ton/ha was significantly higher than at manure application of 10 ton/ha from second cutting to sixth cutting, either at monoculture or mixed cropping with P. maximum. Total DM production of S. grandiflora at manure application of 20 ton/ha was greater and significantly different than at manure application of 10 ton/ha and 0 ton/ha.

Dry matter production of S. grandiflora at saline was increased at treatment of 10 ton/ha and 20 ton/ha manure both at monoculture and mixed cropping with P. maximum. An increase in total DM yield of S. grandiflora at monoculture, from 3.8 ton/ha/year to 7.6 ton/ha/year and 12.0 ton/ha, as manure increased from 0 ton/ha to 10 ton/ha and 20 ton/ha. The yield of S. grandiflora at
Table 1. Dry Matter Production (kg/ha) of *P. maximum* at Monoculture and Mixed Cropping with *S. grandiflora* at Different Dosage of Manure

<table>
<thead>
<tr>
<th>Cutting</th>
<th>Dosage of Manure at Monoculture</th>
<th>Dosage of Manure at Mixed Cropping</th>
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<tr>
<td></td>
<td>0 ton/ha 10 ton/ha 20 ton/ha</td>
<td>0 ton/ha 10 ton/ha 20 ton/ha</td>
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<td>4&lt;sup&gt;th&lt;/sup&gt;</td>
<td>1088.0±305.3&lt;sup&gt;c&lt;/sup&gt; 6196.4±244.0&lt;sup&gt;b&lt;/sup&gt; 7495.1±237.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>684.7±148.5&lt;sup&gt;c&lt;/sup&gt; 5447.1±849.8&lt;sup&gt;b&lt;/sup&gt; 7038.2±746.7&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>5&lt;sup&gt;th&lt;/sup&gt;</td>
<td>2086.7±775.7&lt;sup&gt;d&lt;/sup&gt; 3616.7±655.8&lt;sup&gt;b&lt;/sup&gt; 4531.1±804.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>747.8±207.6&lt;sup&gt;c&lt;/sup&gt; 2712.2±941.8&lt;sup&gt;ad&lt;/sup&gt; 4933.3±600.4&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>6&lt;sup&gt;th&lt;/sup&gt;</td>
<td>1724.4±486.1&lt;sup&gt;c&lt;/sup&gt; 5039.8±751.3&lt;sup&gt;a&lt;/sup&gt; 5717.2±837.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>684.6±244.4&lt;sup&gt;d&lt;/sup&gt; 2276.6±244.4&lt;sup&gt;c&lt;/sup&gt; 3346.1±605.4&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>7&lt;sup&gt;th&lt;/sup&gt;</td>
<td>1066.2±204.0&lt;sup&gt;c&lt;/sup&gt; 1942.2±138.5&lt;sup&gt;b&lt;/sup&gt; 2696.4±149.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>410.2±25.5&lt;sup&gt;d&lt;/sup&gt; 1176.4±100.4&lt;sup&gt;c&lt;/sup&gt; 2183.1±355.1&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>8&lt;sup&gt;th&lt;/sup&gt;</td>
<td>377.7±39.7&lt;sup&gt;d&lt;/sup&gt; 1440.0±347.0&lt;sup&gt;b&lt;/sup&gt; 2354.2±204.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>423.1±85.4&lt;sup&gt;d&lt;/sup&gt; 875.1±274.6&lt;sup&gt;c&lt;/sup&gt; 1714.2±161.3&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>Total</td>
<td>6343.0±683.6&lt;sup&gt;d&lt;/sup&gt; 18235.1±147.1&lt;sup&gt;b&lt;/sup&gt; 22794.2±1139.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2950.4±459.1&lt;sup&gt;c&lt;/sup&gt; 12487.6±1434.9&lt;sup&gt;c&lt;/sup&gt; 19215.0±901.1&lt;sup&gt;b&lt;/sup&gt;</td>
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Different superscript in the same row indicates significantly different (P<0.05); N = 3

Table 2. Dry Matter Production (kg/ha) of *S. grandiflora* at Monoculture and Mixed Cropping with *P. maximum* at Different Dosage of Manure

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<tr>
<th>Cutting</th>
<th>Dosage of Manure at Mixed Cropping</th>
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<td>0 ton/ha 10 ton/ha 20 ton/ha</td>
<td>0 ton/ha 10 ton/ha 20 ton/ha</td>
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<td>882.2±328.2&lt;sup&gt;c&lt;/sup&gt; 1639.1±131.1&lt;sup&gt;b&lt;/sup&gt; 2381.3±295.1&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>369.5±48.2&lt;sup&gt;d&lt;/sup&gt; 823.4±143.9&lt;sup&gt;c&lt;/sup&gt; 1735.8±363.4&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>394.2±84.2&lt;sup&gt;d&lt;/sup&gt; 1106.3±110.3&lt;sup&gt;c&lt;/sup&gt; 2731.8±315.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>333.1±27.8&lt;sup&gt;d&lt;/sup&gt; 817.2±142.6&lt;sup&gt;c&lt;/sup&gt; 1672.2±309.7&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>6&lt;sup&gt;th&lt;/sup&gt;</td>
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<td>309.7±54.5&lt;sup&gt;c&lt;/sup&gt; 872.9±163.5&lt;sup&gt;b&lt;/sup&gt; 1590.2±240.9&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>Total</td>
<td>3813.4±140.2&lt;sup&gt;c&lt;/sup&gt; 7595.8±171.4&lt;sup&gt;c&lt;/sup&gt; 12000.3±1071.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2806.7±371.8&lt;sup&gt;c&lt;/sup&gt; 5928.6±132.8&lt;sup&gt;d&lt;/sup&gt; 9366.0±861.7&lt;sup&gt;b&lt;/sup&gt;</td>
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Different superscript in the same row indicates significantly different (P<0.05); N = 3
mixed cropping with *P. maximum* were 2.8; 5.9 and 9.4 ton DM/ha/year for manure application at 0, 10 and 20 ton/ha respectively. The DM production at manure application was lower than those reported by Sarvade *et al.* (2014) whose reported green material of *Sesbania grandiflora* was 5.5 ton/ha or 11 ton/ha DM in 6.5 months.

Application of manure gave significant increase for DM production of *P. maximum* and *S. grandiflora*. The total DM produced by *P. maximum* or *S. grandiflora* either monoculture or mixed cropping at 20 ton/ha of manure were significantly (*P* < 0.05) higher than the other treatment. Combining salt tolerant plant and organic amendent have more advantage in order to utilize saline soil as plant cultivation. *P. maximum* and *S. grandiflora* are tolerant forage crops at moderately saline soil (Kusmiyati *et al.*, 2012). Salt tolerant plant capability to buffer the Na⁺ increase in root meristem zone of cytosol cell is higher than salt-sensitive plants (Wu *et al.*, 2015). Mechanism of plant tolerance to Na in saline soil are Na⁺ exclusion, sequestration of vacuolar Na⁺, xylem Na⁺ loading and uploading control, recirculation of Na⁺ from shoot to root through phloem, Na⁺ secretion by specialized salt glands (Wu, 2018). The second methods to ammeliorate saline soil in our research is through application of organic amendment. Organic amendment such as manure at saline soil improve and increase organism and organic matter of soil (Wu *et al.*, 2018); accelerate Na leaching, decrease electrical conductivity (EC) and exchange sodium percentage (ESP), increase infiltration and holding capacity of water, increase aggregate stability (Wu *et al.*, 2013); increase content of N and P in soil (Sastre-Conde *et al.*, 2015). Our research finding suggests that plant production at moderately saline soil could be increased by using moderately tolerance plant such as *P. maximum* or *S. grandiflora* and organic amendment application. Organic amendment such as manure improve soil fertility including biological, physical and chemical properties of soil. Meanwhile, tolerant plant has better ability in enduring with overall salt stress effects. Combining two methods i.e. plant tolerance and organic amendment are better way in using saline soil as cultivation land.

Forage production of *P. maximum* and *S. grandiflora* at monoculture was greater than at mixed cropping in same dosage of manure. However, land use efficiency, calculated as land equivalent ratio (LER) was greater than one in all of manure treatment (Figure 1). The greatest LER (1.8) was achieved at mixed cropping of *P. maximum* and *S. grandiflora* with 20 ton/ha manure. This indicated that 80% more land would be needed in monoculture to yield the equal amount of dry matter production in mixed cropping. Land equivalent ratio at treatment no manure and 10 ton/ha manure were 1.4 and 1.6, respectively; it suggests that mixed cropping between *P. maximum* and *S. grandiflora* at moderately saline soil uses nutrient, water and air better than planted solely, and competition between those two plant is minimized. Our research explored the unique mixed cropping system between C4-grass (*P. maximum*) and C3-tree (*S. grandiflora*). Kimura *et al.* (2018) also evaluated mixed cropping system between C4-grass (*Panicum virgatum*) and C3-tree (*Populus

![Figure 1. Land Equivalent Ratio (LER) at Different Dosage of Manure](image-url)
spp) which has land equivalent ratio 1.4. Mixed cropping of forage crops improves C sequestration (Fang et al., 2010), feed quality and animal nutrition (Kebede et al., 2016). Forages in smallholder mixed farming systems have a crucial role in livestock nutrition, productivity and environmental sustainability (Ates et al., 2018).

**Forage Quality**

The result showed that crude protein of *P. maximum* at eight cutting and *S. grandiflora* at sixth cutting were affected significantly by dosage of manure. While, treatments were not affected crude fiber and ether extract of *P. maximum* and *S. grandiflora*. Crude protein of *P. maximum* at this research was varied between 6.2 – 9.3 % (Table 3). Yoottasanong et al. (2015) reported crude protein of *P. maximum* at mixed cropping with *Stylosanthes hamata* at application of 8 ton/ha and 16 ton/ha manure were 9.6 % and 9.4 %, respectively. Crude fiber content in *P. maximum* was lower to 40.4 % reported by Fadiyimu et al. (2010), Crude protein of *S. grandiflora* at saline soil was varied between 17.7 – 23.9 %. This value was equal to those reported by Kumar et al. (2017) whose recorded crude protein of *S. grandiflora* was 23.65 %.

Crude protein of *P. maximum* and *S. grandiflora* were increased significantly by adding manure at saline soil either at monoculture or mixed cropping (Table 3). The highest crude protein content of *S. grandiflora* was obtained by adding 20 ton/ha manure at saline soil. Manure application as organic amendment at saline soil increase N contents in soil (Sastre-Conde et al., 2015). Lee et al. (2017) stated forage nutritive value was increased by nitrogen fertilizer addition. Nitrogen addition to soil was positively related to crude protein, an increase of 100 kg N/ha/year associated with a 2 % increase in crude protein. Total nitrogen content of manure at this research was 1.65 %. Adding 20 ton/ha of manure indicated addition of 330 kg/ha total N to saline soil. It was stated by Lee et al. (2017), addition of high rate N (350 kg N/h/year) was correlated with a 7 % increase in crude protein. An increase of crude protein at *P. maximum* and *S. grandiflora* at saline soil by adding 20 ton/ha were 2 – 3 % and 3 – 6 %, respectively.

Forage quality such as crude protein, dry matter digestibility and palatability varied due to plant variety, maturity stages and management practices. Crude protein content decreases as forage moves from a vegetative stage to reproductive stage. Additionally, crude fiber increases during the same period. Crude fiber is an estimated measure of digestibility. Higher crude fiber means lower digestibility. Adding manure at saline soil will delay reproductive stage, so crude protein content of forage was still high and crude fiber was low. Crude protein levels of forages are essential for livestock. If the percentage of crude protein is low, intake and digestibility of livestock are reduced because the

### Table 3. Crude Protein (CP) (%), Crude Fibre (CF) (%) and Ether Extract (EE) (%) of *P. maximum* and *S. grandiflora* at Different Dosage of Manure

<table>
<thead>
<tr>
<th>Dosage of Manure at Mixed Cropping</th>
<th>Dosage of Manure at Mixed Cropping</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 ton/ha</td>
<td>10 ton/ha</td>
</tr>
<tr>
<td>0 ton/ha</td>
<td>10 ton/ha</td>
</tr>
<tr>
<td><em>P. maximum</em></td>
<td></td>
</tr>
<tr>
<td>CP</td>
<td>7.2±1.1 bc</td>
</tr>
<tr>
<td>CF</td>
<td>26.8±0.5</td>
</tr>
<tr>
<td>EE</td>
<td>1.8±0.4</td>
</tr>
<tr>
<td></td>
<td>6.2±0.4 c</td>
</tr>
<tr>
<td></td>
<td>27.6±0.5</td>
</tr>
<tr>
<td></td>
<td>1.8±0.3</td>
</tr>
<tr>
<td><em>S. grandiflora</em></td>
<td></td>
</tr>
<tr>
<td>CP</td>
<td>17.7±0.7 c</td>
</tr>
<tr>
<td>CF</td>
<td>12.2±0.1</td>
</tr>
<tr>
<td>EE</td>
<td>3.6±0.5</td>
</tr>
<tr>
<td></td>
<td>20.5±0.9 b</td>
</tr>
<tr>
<td></td>
<td>12.7±0.9</td>
</tr>
<tr>
<td></td>
<td>3.7±0.4</td>
</tr>
</tbody>
</table>

Different superscript in the same row indicates significantly different (P<0.05); N = 3
A proper proportion between protein and energy sufficiency is important to get high production of livestock. If farmers only used grass and legumes as feed, the availability of protein is sufficient. However, digestible energy availability is not sufficient (Tahuk et al., 2017). Feed which contain of 16 % crude protein and 2850 Kcal/kg DM metabolizable energy increase high rate of feed intake of goat (Ginting et al., 2017). Tahuk et al. (2018) reported feed with proportion between crude protein level of 12% and TDN of 17 % produced a higher-quality carcass and meat of male bali cattle.

**Carrying Capacity**

Based on Table 4, the highest total DM production of mixed cropping *P. maximum* and *S. grandiflora* was available at moderately saline soil with application 20 ton/ha manure as much as 29131 kg/ha/year that could accommodate 10.8 AU/ha/year. Total DM production available at application 10 ton/ha manure was 19312 kg/ha/year that could accommodate as many as 7.2 AU/ha/year, while total DM production available at no manure application was very low i.e. 6183 kg/ha/year that was only able to accomodate as many as 2.3 AU/ha/year. Carrying capacity based on crude protein was higher than based on dry matter production. Carrying capacity based on crude protein and total digestible nutrients at application 20 ton/ha manure were 13.6 AU/ha/year and 11.3 AU/ha/year, respectively.

Carrying capacity of *P. maximum* and *S. grandiflora* at saline soil in our research was higher than those reported from natural pasture at Gowa Regency – Indonesia (Rinduwati et al., 2016) and Timor Tengah Selatan Regency – Indonesia (Se’u et al., 2015). Forage crop at the natural pasture was dominated by native grasses which has genetically lower forage production. Potential pasture at Eastern Zone of Tanzania which consisted with 8 grasses and 7 legumes including *P. maximum* and *Sesbania sesban* was only able to support 0.2 TLU/ha/year (Kavana et al., 2005). Using plant tolerance and organic amendment at saline soil resulted in higher forage production and carrying capacity compare to natural pasture and potential pasture.

Carrying capacity based on DM production of *P. maximum* and *S. grandiflora* with application 20 ton/ha, 10 ton/ha and 0 ton/ha manure at moderately saline soil were 10.8 AU/ha/year, 7.2 AU/ha/year and 2.3 AU/ha/year, respectively. Based on the equivalent calculation, total DM production available at treatment 20 ton/ha, 10 ton/ha and 0 ton/ha manure was able to support sheep as many as 77.0 head/ha/year, 51.1 head/ha/year and 16.4 head/ha/year, respectively. Whereas, the DM production available was able to support goat as many as 67.4 head/ha/year, 44.7 head/ha/year and 14.3 head/ha/year, respectively.

Jayanegara et al. (2017) recommended dry matter, crude protein and total digestible energy (TDN) intake for local sheep in Indonesia for both maintenance and gain. Sheep with body weight (BW) 20 kg and average daily gain (ADG) 100 g/day required DM, CP and TDN intake in the

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**Table 4. Production Available of Dry Matter (DM), Crude Protein (CP), Total Digestible Nutrient (TDN) and Carrying Capacity of *P. maximum* and *S. grandiflora* at Different Dosage of Manure**

<table>
<thead>
<tr>
<th>Item</th>
<th>Dosage of Manure at Mixed Cropping</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 ton/ha</td>
</tr>
<tr>
<td>DM Production (kg/ha/year)</td>
<td>6183.1±513.3</td>
</tr>
<tr>
<td>Carrying Capacity (AU/ha/year)</td>
<td>2.3±0.2</td>
</tr>
<tr>
<td>CP Production (kg/ha/year)</td>
<td>771.2±91.9</td>
</tr>
<tr>
<td>Carrying Capacity (AU/ha/year)</td>
<td>2.8±0.3</td>
</tr>
<tr>
<td>TDN Production (kg/ha/year)</td>
<td>3826.2±338.8</td>
</tr>
<tr>
<td>Carrying Capacity (AU/ha/year)</td>
<td>2.4±0.2</td>
</tr>
</tbody>
</table>

N = 3
also conveyed to the Research and Community Service, Ministry of Research, Technology and Higher Education for its financial support through Institution Nasional Strategic Technology and Higher Education for its financial support through Institution Nasional Strategic Technology and Higher Education.

P. maximum and S. grandiflora are feed that has good quality and palatability for ruminant including small ruminant such as goat. P. maximum and S. grandiflora as feed can be used as a sole diet or supplemented with other forage.

Hong Chin and Thi Hue (2012) reported DM intake of P. maximum and Tithonia diversifolia were 339.6 g/day and 226 g/day, respectively which resulted in live weight gain of goat was 60.7 g/day. Dry matter intake and live weight gain of goat fed S. grandiflora as sole diet were 800 g/day and 114 g/day, respectively (Nhan, 1998). Meanwhile, Lam and Ledin (2004) reported goat fed S. grandiflora as sole diet resulted DM intake and live weight gain were 339 g/day and 63.5 g/day, respectively. Live weight gain of goat fed P. maximum and S. grandiflora at 60% : 40% proportion was 78.6 g/day, with DM intake of P. maximum and S. grandiflora were 558 g/day and 255 g/day, respectively (Kusmiyati et al., 2017).

CONCLUSION

Dry matter production, crude protein and carrying capacity of P. maximum and S. grandiflora were increased with application of 20 ton/ha manure at saline soil. Total production of dry matter, crude protein and total digestible nutrient of mixed cropping P. maximum and S. grandiflora at application 20 ton/ha manure were 29131 kg/ha/year; 3722 kg/ha/year and 17718 kg/ha/year, respectively. Carrying capacity based on dry matter, crude protein and total digestible nutrients were 10.8 AU/ha/year; 13.6 AU/ha/year and 11.3 AU/ha/year, respectively.

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