J I T A A
Journal of the Indonesian Tropical Animal Agriculture
Accredited by Ditjen Penguatan Risbang No. 60/E/KPT/2016

J. Indonesian Trop. Anim. Agric.
pISSN 2087-8273 eISSN 2460-6278
http://ejournal.undip.ac.id/index.php/jitaa
44(3):303-313, September 2019
DOI: 10.14710/jitaa.44.3.303-313

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

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Received June 11, 2019; Accepted August 26, 2019

ABSTRAK

Penelitian ini bertujuan untuk mengkaji pengaruh pupuk kandang pada tanah salin terhadap produksi hijauan, kualitas dan daya tampung ternak dari *P. maximum* dan *S. grandiflora*. Penelitian dilaksanakan pada tanah salin dengan tingkat salinitas sedang di Kabupaten Rembang, Provinsi Jawa Tengah, Indonesia. Rancangan yang digunakan adalah rancangan acak kelompok. Perlakuan adalah dosis pupuk kandang yaitu 0 ton/ha, 10 ton/ha dan 20 ton/ha. Tanaman pakan dalam penelitian ini adalah rumput benggala (*Panicum maximum*) dan legum turi (*Sesbania grandiflora*) yang ditanam secara monokultur dan tumpangsari. Parameter yang diukur adalah produksi bahan kering (BK) hijauan, abu, protein kasar (PK), serat kasar (SK), lemak kasar (LK) dan *total digestibe nutrients* (TDN). *P. maximum* dipotong 8 kali, sedangkan *S. grandiflora* dipotong 6 kali selama satu tahun. Hasil penelitian menunjukkan bahwa produksi bahan kering tertinggi pada perlakuan tumpangsari *P. maximum* dan *S. grandiflora* dengan aplikasi pupuk kandang 20 ton/ha. Produksi BK, produksi PK dan produksi TDN tersedia pada perlakuan aplikasi pupuk kandang 20 ton/ha berturut-turut adalah 29.131 kg/ha/tahun; 3.722 kg/ha/tahun dan 17.718 kg/ha/tahun. Daya tampung ternak berdasarkan BK, PK dan TDN berturut-turut adalah 10,8 ST/ha/tahun; 13,6 ST/ha/tahun dan 11,3 ST/ha/tahun. Kesimpulan, peningkatan pupuk kandang sampai dosis 20 ton/ha di tanah salin meningkatkan produksi, protein kasar hijauan serta daya tampung ternak,

Kata kunci: monokultur, protein kasar, satuan ternak, TDN, tumpangsari

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 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 absorp 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 tolerence 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 negatif 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. Olanite *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). Rinduwati *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'u *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 Kaliori, 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, 30ºC 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_2O_5, K_2O, 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_2O_5, K_2O 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_2O_5/ha and 100 kg K_2O/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*a*/S*a* + M*b*/S*b*, 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} = The observation at i^th^ treatment and j^th^ block

μ = Overall mean

T_i = Effect of i^{th} treatment (i = 1, 2, 3, 4, 5, 6, 7, 8 and 9)

B_j = Effect of j^{th} block (j = 1, 2 and 3)

ε_{ij} = 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) : (1) 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.,* 2017). (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 aplication 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 Olanite *et al.* (2009) . Ojo *et al* (2013) planted *P. maximum* at soil of sandy clay. While, Olanite *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, Olanite *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 Olanite *et al.* (2009).

Application of manure at saline soil also significantly improved DM production of *S. grandiflora* (Table 2). *S. grandiflora* production at manure aplication of 20 ton/ha was significantly higher than at manure aplication 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 aplication 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

Cutting	Dosage of Manure at Monoculture			Dosage of Manure at Mixed Cropping		
	0 ton/ha	10 ton/ha	20 ton/ha	0 ton/ha	10 ton/ha	20 ton/ha
4rd	1088.0±305.3^{c}	6196.4±244.0^{b}	7495.1± 237.5^{a}	684.7±148.5^{c}	5447.1± 849.8^{b}	7038.2±746.7^{a}
5th	2086.7±775.7^{d}	3616.7±655.8^{bc}	4531.1± 804.6^{ab}	747.8±207.6^{e}	2712.2± 941.8^{cd}	4933.3±600.4^{a}
6th	1724.4±486.1^{c}	5039.8±751.3^{a}	5717.2± 837.9^{a}	684.6±244.4^{d}	2276.6± 244.4^{c}	3346.1±605.4^{b}
7th	1066.2±204.0^{c}	1942.2±138.5^{b}	2696.4± 149.8^{a}	410.2± 25.5^{d}	1176.4± 100.4^{c}	2183.1±355.1^{b}
8th	377.7 ± 39.7^{d}	1440.0±347.0^{b}	2354.2± 204.0^{a}	423.1±_85.4^{d}	875.1± 274.6^{c}	1714.2±161.3^{b}
Total	6343.01±683.6^{d}	18235.1±147.1^{b}	22794.2±1139.7^{a}	2950.4±459.1^{e}	12487.6±1434.9^{c}	19215.0±901.1^{b}

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

Cutting	Dosage of Manure at Mixed Cropping			Dosage of Manure at Mixed Cropping		
	0 ton/ha	10 ton/ha	20 ton/ha	0 ton/ha	10 ton/ha	20 ton/ha
2nd	1027.6± 56.6^{c}	1536.0±175.9^{b}	2261.4±113.6^{a}	882.2±328.2^{c}	1639.1±131.1^{b}	2381.3±295.1^{a}
3rd	1276.8±215.4^{d}	2408.9±337.7^{b}	3360.0±385.7^{a}	912.2±103.3^{d}	1776.0±227.1^{c}	1986.4±82.8^{bc}
4th	736.7± 65.7^{cd}	1738.4±182.0^{b}	2311.8±202.6^{a}	369.5± 48.2^{d}	823.4±143.9^{c}	1735.8±363.4^{b}
5th	394.2± 84.2^{d}	1106.3±110.3^{c}	2731.8±315.9^{a}	333.1± 27.8^{d}	817.2±142.6^{c}	1672.2±309.7^{b}
6th	378.1± 64.6^{c}	806.2±139.8^{b}	1335.3±246.9^{a}	309.7± 54.5^{c}	872.9±163.5^{b}	1590.2±240.9^{a}
Total	3813.4±140.2^{e}	7595.8±171.4^{c}	12000.3±1071.4^{a}	2806.7±371.8^{e}	5928.6±132.8^{d}	9366.0±861.7^{b}

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 aplication 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 conductity (EC) and exchange sodium percentage (ESP), increase infiltration and holding capacity of water, increase agregate 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*

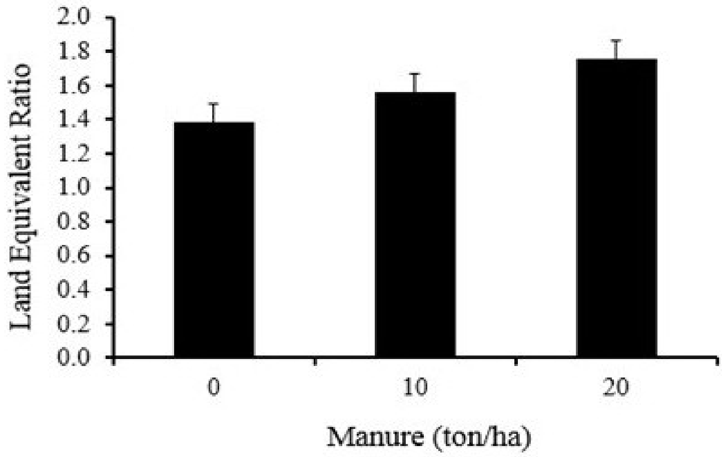

Figure 1. Land Equivalent Ratio (LER) at Different Dosage of Manure

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

	Dosage of Manure at Mixed Cropping			Dosage of Manure at Mixed Cropping		
	0 ton/ha	10 ton/ha	20 ton/ha	0 ton/ha	10 ton/ha	20 ton/ha
P. maximum						
CP	7.2±1.1 [bc]	7.8±0.6 [abc]	9.3±0.4 [a]	6.2±0.4 [c]	7.1±0.9 [bc]	8.3±1.6 [ab]
CF	26.8±0.5	26.7±0.6	27.0±0.1	27.6±0.5	28.1±1.3	27.4±2.4
EE	1.8±0.4	2.0±0.4	1.9±0.2	1.8±0.3	2.0±0.7	1.8±0.4
S. grandiflora						
CP	17.7±0.7 [c]	21.0±0.6 [b]	23.9±1.8 [a]	20.5±0.9 [b]	19.1±0.6 [bc]	23.8±2.2 [a]
CF	12.2±0.1	13.1±0.7	13.5±0.3	12.7±0.9	13.5±1.6	12.2±0.1
EE	3.6±0.5	3.5±1.2	3.7±0.4	3.7±0.4	3.8±0.9	3.8±0.1

Different superscript in the same row indicates significantly different (P<0.05); N = 3

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 an 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 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

Item		Dosage of Manure at Mixed Cropping		
		0 ton/ha	10 ton/ha	20 ton/ha
DM	Production (kg/ha/year)	6183.1±513.3	19312.9±1107.7	29131.7±856.0
	Carrying Capacity (AU/ha/year)	2.3± 0.2	7.2± 0.4	10.8± 0.3
CP	Production (kg/ha/year)	771.2± 91.9	2048.9± 67.3	3722.0± 67.2
	Carrying Capacity (AU/ha/year)	2.8± 0.3	7.5± 0.2	13.6± 0.2
TDN	Production (kg/ha/year)	3826.2±338.8	11429.1±587.4	17718.3±396.9
	Carrying Capacity (AU/ha/year)	2.4± 0.2	7.3± 0.4	11.3±0.3

N = 3

bacteria responsible for digestion can not sustain adequate level to process forage.

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 amount of 765 g DM/day, 109 g CP/day and 530 g TDN/day, respectively. Based on those DM, CP and TDN intake recommendation, mixed cropping *P. maximum* and *S. grandiflora* with manure application 20 ton/ha could accomadated 104.3 sheeps based on DM, 93.6 sheeps based on CP and 91.6 sheeps based on TDN.

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.

ACKNOWLEDGEMENT

The authors would like to express gratitude to the Directorate General of Research and Community Service, Ministry of Research, Technology and Higher Education for its financial support through Institution Nasional Strategic grant 2016-2017 (contract number : 700-79/UN7.5.1/PP/2017). An expression gratitude is also conveyed to the Research and Community Service Institute - Diponegoro University.

REFERENCES

Ahmad, M.S.A., M. Ashraf and Q. Ali. 2010. Soil salinity as a selection pressure is a key determinant for the evolution of salt tolerance in Blue Panic grass (*Panicum antidotale* Retz.). Flora 205(1):37-45.

Andrade CMS de; Farinatti LHE; Nascimento HLB do; Abreu AQ; Jank L; Assis GML de. 2013. Animal production from new *Panicum maximum* genotypes in the Amazon biome, Brazil. Trop. Grassl. 1(1):36-38.

Badan Pusat Statistik Kabupaten Rembang. 2017. Kabupaten Rembang dalam Angka. Badan Pusat Statistik Kabupaten Rembang.

Association of Official Analytical Chemists (AOAC). 2005. Official Methods of Analysis. AOAC Inc., Virginia.

Ates, S., H. Cicek, L.W. Bell, H.C. Norman, D.E. Mayberry, S. Kassam, D.B. Hannaway and M.Louhaichi. 2018. Sustainable development of smallholder crop-livestock farming in developing countries. IOP Conf. Ser. : Earth Environ. Sci. 142 : 012076

Bano, A and M.Fatima. 2009. Salt tolerance in Zea mays (L). following inoculation with Rhizobium and Pseudomonas. Biol. Fertility of Soils. 45(4):405-413.

Diaz, F.J., S.R. Grattan, J.A. Reyes, B. de la Roza-Delgado, S.E. benes, C. Jimenez, M. Dorta and M. Tejedor. 2018. Using saline soil and marginal quality water to produce alfalfa in arid climates. Agric. Water Manag. 199(1):11-21.

Fadiyimu, A.A., J.A. Alokan and A. N. Fajemisin. 2010. Digestibility, nitrogen balance and haematological profile of west African dwarf sheep fed dietary levels of *Moringa oleifera* as supplement to *Panicum maximum*. J. American Sci. 6(10):634-643.

Fang, S., H. Li, Q. Sun and L. Chen. 2010. Biomass production and carbon stocks in poplar-crop intercropping systems: a case study in northwestern Jiangsu, China. Agrofor. Syst. 79(2):213-222.

Ginting, S.P., K. Simanihuruk, Antonius and A. Tarigan. 2017. Growth and feed utilization of boer x kacang crossbred goats offered total mixed rations of different protein and energy levels. JITV. 22(4):188-195.

Hartadi, H., S. Reksohadiprodjo, S. Lebdosukojo, A.D. Tillman, L.C. Kearl and L.E. Harris.

1980. Table of Feed Composition for Indonesia. IFI., Utah Agricultural Experiment Station, Utah State University, Logan, UT., USA., pp : 12.

Hong Chin, N. and K. Thi Hue. 2012. Supplementing *Tithonia diversifolia* with Guinea grass or tree foliages: effects on feed intake and live weight gain of growing goats. Livest. Res. Rural Dev. 24:Article # 188.

Jayanegara, A., M. Ridla, D.A. Astuti, K.G. Wiryawan, E.B. Laconi and Nahrowi. 2017. Determination of energy and protein requirements of sheep in Indonesia using a meta-analytical approach. Med. Pet. 40(2):118-127.

Kavana, P.Y., J.B. Kizima, Y.N. Msanga, N.B. Kilongozi, B.S.J. Msangi, L.A. Kadeng'uka, S. Mgulu and P.K. Shimba. 2005. Potential of pasture and forage for ruminant production in Eastern zone of Tanzania. Livest. Res. Rural Dev. 17. Article # 144.

Kearl, L.C. 1982. Nutrient Requirements of Ruminants in Developing Countries. International Feedstuffs Institute, Utah State University, Logan.

Kebede, G., G. Assefa, F.Feyissa and A. Mengistu. 2016. Forage legumes in crop-livestock mixed farming systems – a review. International J. Livest. Res. 6(4):1-18.

Kimura, E., S. C. Fransen, H. P. Collins, B.J. Stanton, A. Himes, J. Smith, S.O. Guy, W.J. Johnston. 2018. Effect of intercropping hybrid poplar and switchgrass on biomass yield,forage quality, and land use efficiency for bioenergy production. Biomass Bioenergy . 111:31-38.

Kumar, U., H.N.N. Murthy, K.C. Singh, M.D. Gouri, Y.B. Rajeshwari, N.C. Siddeshawara, A. Mateen and R. Guruprasad. 2017. Biomass yield and chemical composition of Sesbania grandiflora and Moringa oleifera. Int. J. Sci. Environ. 6:3264-3269.

Kusmiyati, F. Sumarsono, Karno and E. Pangestu. 2012. Mineral concentration of forage grasses at different salinity levels of soil. Proceedings. The 2nd International Seminar on Animal Industry, Bogor Agricultural Institute, Jakarta, Indonesia, July 5-July 6, 2012. P. 171-177

Kusmiyati, F., Sumarsono, Karno and E. Pangestu. 2016. Influence of rice straw mulch on saline soil : forage production, feed quality and feed intake by sheep. J. Int. Soc. Southeast Asian Agric. Sci. 22(1):42-51.

Kusmiyati, F., E.D. Purbajanti, Surahmanto and Sumarsono. 2017. Forage production in saline soil treated with organic fertilizer used as feed for growing goats. Livest. Res. Rural Dev. 29:Article # 195.

Kusmiyati, F., E.D. Purbajanti and Surahmanto. 2018. The effects of manure at saline soil on growth, dry matter production an crude protein of *S. grandiflora.* IOP Conf. Ser. : Earth Environ. Sci. 119 :012023.

Lam, V. and I. Ledin. 2004. Effect of feeding different proportions of sweet potato vines (*Ipomoea batatas* L. (Lam)) and *Sesbania grandiflora* foliage in the diet on feed intake and growth of goats. Livest. Res. Rural Dev. 16, Article #77

Lee, M.A., A.P. Davis, M.G.G. Chagunda and P. Manning. 2017. Forage quality declines with rising temperatures, with implications for livestock production and methane emissions. Biogeosci. 14:1403-1417.

Mbarki, S., A. Cerda, M.Zivcak, M.Brestic,M. Rabhi, M.Mezni, N. Jedidi,C. Abdelly and J.A. Pascual . 2018. Alfalfa crop amended with MSW compost can compensate the effect of salty water irrigation depending on the soil texture. Process Safety and Environ. Protect. 115:8-16.

Nhan, N. T. H .1998. Utilization of some forages as a protein source for growing goats by smallholder farmers. Livest. Res. Rural Dev. 10:Article #23.

Ojo, V.O.A., P.A. Dele, T.A. Amole, U.Y. Anele, S.A. Adeoye, O.A. Hassan, J.A. Olonite and O.J. Idowu. 2013. Effect of intercropping *Panicum maximum* var. Ntchisi and *Lablab purpureus* on the growth, herbage yield and chemical composition of *Panicum maximum* var Ntchisi at different harvesting times. Pak. J. Biol. Sci. 16 (22):1605-1608.

Olonite, J.A., S.A. Tarawali and M.E. Ake'ova. 2009. Dry matter yields and botanical composition of three grasses and two legume mixtures grazed by cattle in a derived savanna area of Nigeria. J. Agric. Sci. Env. 9(1):28-38.

Qureshi, A.S. and A. Al-Falahi. 2015. Extent, characterization and causes of soil salinity in central and southern Iraq and possible

recklamation strategies. Int. J. Engineering Res. Applications. 5(1):1-11.
Rinduwati., S. Hasan, J.A. Syamsu and D. Useng. 2016. Carrying capacity and botanical diversity of pastoral range in Gowa Regency. Int. J. Sci. Basic and Appl. Res. 29(3):105-111.
Rui-dong, H. 2018. Research progress on plant tolerance to soil salinity and alkalinity in sorghum. J. Integrative Agric. 17(4):739-746.
Sarvade, S., Y.S.Parmar and Nauni. 2014. *Sesbania grandiflora* (L.) Poiret : A potential agroforestry tree species. Popular Kheti. 2(3):204-207.
Sastre-Conde, I., Carmen Lobo, M., Icela Beltran-Hernandez, R. And H.M. Poggi-Varaldo. 2015. Remediation of saline soils by a two-step process: Washing and amendment with sludge. Geoderma. 247:140-150
Se'u, V.E., P.D.M.H. Karti and L. Abdullah. 2015. Botanical composition, grass production, and carrying capacity of pasture in Timor Tengah Selatan District. Med. Pet. 38(3):176-182.
Shrivastava ,P and R. Kumar.2015. Soil salinity : a serius environmental issue and plant growth promoting bacteria as one of tools for its alleviation. Saudi J. Biol. Sci. 22(2):123-131.
Tahuk, P.K., S.P.S. Budhi, Panjono, N. Ngadiyono, R. Utomo, C.T. Noviandi and E. Baliarti. 2017. Growth performance of male Bali cattle fattening fed ration with different protein levels in smallholder farms, West Timor, Indonesia. Asian J. Anim. Sci. 11(2):65-73.
Tahuk, P.K., S.P.S. Budhi, Panjono and. E. Baliarti. 2018. Carcass and meat characteristics of male Bali cattle in Indonesian smallholder farms fed ration with different protein levels. Trop. Anim. Sci. J. 41(3):215-223.
Vargas, R., E.S. Pankova, S.A. Balyuk, P.V.Krasilnikov and G.M. Khasankhanova. 2018. Handbook for Saline Soil Management. FAO of the United Nations.

Wu, H. 2018. Plant salt tolerance and Na^+ sensing and transport. The Crop J. 6(3): 215-225.
Wu, Y., Y. Li, C. Zheng, Y. Zhang and Z. Sun. 2013. Organic amendment application influence soil organism abundance in saline alkali soil. European J. Soil Biology. 54:32-40.
Wu, H., L. Shabala, X. Liu, E. Azzarello, M. Zhou, C. Pandolfi, Z.H. Chen, J. Bose, S. Mancuso and S. Shabala. 2015. Linking salinity stress tolerance with tissue-specific Na+ sequestration in wheat roots. Front. Plant Sci. 6:1-13.
Wu, Y., L. Yufei, Z.Yi., B.I. Yanmeng and S. Zhenjun. 2018. Response of saline soil properties and cotton growth to different organic amendments. Pedosphere. 28(3):521- 529
Yoottasanong, C., S. Pholsen and D.E.B. Higgs. 2015. Dry matter yields and forage quality of grass alone and grass plus legume mixture in relation to cattle manure rates and production methods. Pakistan J. Biol. Sci. 18(7):324-332