Forage production in saline soil treated with organic fertilizer used as feed for growing goats

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Abstract

The research was conducted (i) to evaluate the effect of application of organic fertilizer in saline soil on forage production of *Panicum maximum* and *Sesbania grandiflora*; and (ii) to evaluate the use *of Panicum maximum* and *Sesbania grandiflora* foliage for growing goats. The study was conducted during the dry season (June – October 2016) in saline soil (EC = 4.1 dS/m) in Kaliori sub-district area, Rembang Regency, Central Java Province, Indonesia. Experiment 1 was to measure production of *P. maximum* and *S. grandiflora* at different dosages of organic fertilizer (0, 10 tonnes/ha and 20 tonnes/ha) planted solely or inter-planted. Experiment 2 was the use of the forages for growing goats: native grass and *Leucaena leucocephala* (80 % : 20%) and *P. maximum* and *S. grandiflora* (80% : 20% and 60% : 40%).

Organic fertilizer (cow dung) application on saline soil increased dry matter production of *P. maximum* and *S. grandiflora* planted solely or inter-planted. There were increases in DM intake of 60%, in live weight gain of 100%, and improvements in DM feed conversion of 23%, for combinations of *P. maximum : S. grandiflora* (80 : 20) and *(*60 : 40) compared with Native grass : *L. leucocephala* (80 : 20)*.*

Key words: *cow dung, DM intake, FCR, live weight gain, Panicum maximum, Sesbania grandiflora*

Introduction

One of the major problems in Indonesia is soil salinity. Saline soil is identified by excess salt, especially sodium chloride (NaCl), on the soil and in the root zone (Abrol et al 1988). Sodium (Na^+) and chloride (Cl^-) ions result when ionized by water. The excessive amounts of NaCl causes both ionic (chemical) and osmotic stress which limits growth and production of crops (Xiong et al 2002). Osmotic stress will reduce the ability of plants to take up water causing drought stress. The effect of drought stress on the plant is to reduce chlorophyll content, number of tillers, stover yield and grain yield of rice (Purbajanti et al 2017). The widespread areas of saline soil in Indonesia can not be used as agricultural land.

Many attempts are being made to make these saline soils productive again by utilizing salt-tolerant plants, micro climate modification, using chemical agents and organic matter. Kusmiyati et al (2012) reported that *Panicum maximum* was the most tolerant grass compared to *Setaria sphacelata, Euchlaena mexicana, Brachiaria brizantha* and *Cynodon plectostachyus*. Among legume forages, *Sesbania grandiflora* produced high biomass on moderately saline soil (Qadir et al 2008). Kusmiyati

et al (2016) reported that micro climate modification by using mulch to reduce evaporation from the soil surface will help to control soil salinity in the root zone. Application of 3 – 6 tonnes/ha rice straw mulch in highly saline soil (EC 8.7 dS/m) increased forage production and feed quality of *P. maximum* and *S. grandiflora*. Gypsum and organic matter as chemical and phytoremediation procedures have been implemented worldwide (Sharma and Minhas 2005). The aplication of organic matter improves physical, chemical and biological properties of saline soil (Diacono and Montemurro 2015). Organic fertilizer as source of organic matter and nutrients for soil and plants is important for sustainable land use and crop productivity on saline soil. Purbajanti et al (2016) reported manure as organic fertilizer (5 tonnes/ha) increased chlorophyll content, plant height, crop growth rate, forage yield, dry matter yield and dry matter content of *Brachiaria brizantha.*

Saline soil in Indonesia is mostly located along the coast. Farmers in this location usually have growing goats. Feed is from native grasses such as *Axonopus compressus, Cyperus rotundus* and *Cynodon dactylon*. Native grasses are fodders that grow wild and comprised of a diverse mix of grasses that grow naturally. These grasses can grow in all kinds of soil and are easy to find on the edge of the road. The production is quite low as well as nutritional quality.

The objectives of the present study were: (i) to evaluate the effect of organic fertilizer in saline soil on forage production of *Panicum maximum* and *Sesbania grandiflora; and* (ii) to evaluate the use of *Panicum maximum* and *Sesbania grandiflora* as feed for growing goats.

Materials and Methods

Study area

This study was conducted during the dry season (June – October 2016) on saline soil in the Kaliori sub-district area, Rembang Regency, Central Java Province, Indonesia. Rembang regency is located on the northeast coast of Central Java Province where annual rainfall is 1140 mm/year. The soil type is alluvial with silt loam texture. Organic C, total nitrogen and cation exchange capacity were 1.08%, 0.13% and 12.0 C-mol/kg. Soil pH was 7.8 and the electrical conductivity (EC) was 4.1 dS/m. According to saline soil classification by Abrol et al (1988), saline soil in the area is classified as moderately saline.

Experiment 1 : Production of forage crops

Design and treatments

The design was a randomized complete block design (RCBD) with three blocks. The experimental treatments were *P. maximum* and *S. grandiflora* planted solely or inter-planted, with different dosages of organic fertilizer (0, 10 and 20 tonnes/ha). Organic fertilizer was manure from cow dung. There were 27 plots, the size of each plot was 6 x 7m.

As sole crop *P. maximum* or *S. grandiflora* was planted at 100x75 cm. In inter-planted crop, *P. maximum* was planted at 100x75cm and *S. grandiflora* was planted between *P. maximum* rows. These two forage crops were planted at the same time. The planting materials were tillers for *P. maximum* and seed for *S. grandiflora.* Recommended levels of nitrogen (60 kg N/ha/cutting), phosporus (150 kg P_2O_5/ha) and potassium (100 kg K_2O/ha) were applied using urea, SP-36 and potassium chloride (KCl), respectively. The first cut of *P. maximum* was done 4 weeks after planting. Growth and production of grass were not recorded during the first cut. The second cut of grass was done four weeks after the first cut and the third cut was done five weeks after the second cut. *S. grandiflora* was cut at 13 weeks after planting or at the same time with the third cut of grass. *P.*

maximum and *S. grandiflora* were cut at 10 and 30 cm above soil, respectively. One hundred grams of fresh forage was dried at 105^{o}C until the weight of sample was constant to measure dry matter percentage

Statistical analysis

Analysis of data of dry matter (DM) production was done using analysis of variance, followed by Duncan Multiple Range Test (DMRT) to compare the difference between treatments according to Steel and Torrie (1991).

Experiment 2 : Forage for growing goats

Experimental animals, treatments and design

Nine growing male goats (mean live weight 16,1 $\pm$ 1,9 kg) were hired from small-holder goat owners in the area for feeding trials. The goats were kept in individual pens and randomly allocated into 3 groups based on completely randomized design (CRD) with 3 treatments and 3 replications. The feeding treatments were:

NG-LL: Native grass and *Leucaena leucocephala* (80 % : 20%)

PM-SG (80-20)*: Panicum maximum* and *S. grandiflora* (80% : 20%)

PM-SG (60-40): *P. maximum* and *S. grandiflora* (60% : 40%)

Feeding and management

P. maximum and *S. grandiflora* were harvested daily from the saline soil in experiment 1, while native grass and *Leucaena leucocephala* were harvested from the land near experiment 1. The freshly chopped forages were given daily at 08:00 and 16:00 at 5% of goat body weight (DM basis). Experimental periods were 77 days; the first 7 days for adaptation of the goats. The goats were weighed every week. During the feeding trials, refusals were collected once daily and weighed. The parameters observed were dry matter (DM) intake, growth rate and feed conversion ratio (FCR).

Statistical analysis

Data were analysed by ANOVA, followed by Duncan Multiple Range Test (DMRT) to compare the differences between treatments according to Steel and Torrie (1991).

Results and Discussion

Experiment 1 : Production of forage crops

Figures 1 and 2 compare the dry matter yields of *P. maximum* at second and third cutting, when planted solely as well as when inter-planted with *S. grandiflora* with different dosages of organic fertilizer.

Figure 1. Dry matter yield of *P. maximum* at second cutting when planted solely and when inter-planted with *S. grandiflora* at different dosages of organic fertilizer

Figure 2. Dry matter yield of *P. maximum* at third cutting when planted solely and when inter-planted with *S. grandiflora* at different dosages of organic fertilizer

Aplication of organic fertilizer on saline soil increased dry matter yield of *P. maximum* at second and third cutting. There were no differences between application of 10 tonnes/ha and 20 tonnes/ha of organic fertilizer on dry matter yield of *P. maximum.* Dry matter yield of *P. maximum* when planted solely and when inter-planted with *S. grandiflora* at the same dosage of organic fertilizer did not differ (Table 1).

Table 1. Dry matter yield (kg/ha) of *P. maximum* when planted solely and when inter-planted with *S. grandiflora* at different dosage of organic fertilizer at second cutting and third cutting

Organic fertilizer		**Second cutting**	**Third cutting**
0 tonnes/ha	Planted solely	420[b]	2490[c]
	Interplanted	450[b]	1540[c]
10 tonnes/ha	Planted solely	1050[ab]	7150[ab]
	Interplanted	960 [ab]	6130[b]
20 tonnes/ha	Planted solely	1170[a]	8180[ab]
	Interplanted	1550[a]	8890[a]

A similar trend was also observed for the dry matter yield of *S. grandiflora* at first cutting (Table 2). No organic fertilizer decreased dry matter yield of *S. grandiflora* when planted solely and when interplanted with *P. maximum.* Dry matter yields of *S. grandiflora* at application of 10 tonnes/ha and 20 tonnes/ha of organic fertilizer were not different. There were no differences in yield of *S. grandiflora* when planted solely and when interplanted with *P. maximum* with the same dosage of organic fertilizer.

Table 2. Dry matter yield (kg /ha) of *S. grandiflora* when planted solely and when inter-planted with *P.maximum* at different dosage of organic fertilizer at first cutting

Organic fertilizer		First cutting
0 tonnes/ha	Planted solely	973[b]
	Interplanted	1080[b]
10 tonnes/ha	Planted solely	2150Â[a]
	Interplanted	2086Â[a]
20 tonnes/ha	Planted solely	2380Â[a]
	Interplanted	2590[a]

The positive effect of organic fertilizer on saline soil was obvious as the dry matter yields of *P. maximum* and *S. grandiflora* were enhanced both planted solely and inter-planted.

Organic fertilizer as soil amendment has several beneficial effects on saline soils such as slow release of nutrients, and soil biological and physical properties improvement (Diacono and Montemurro 2015). Organic amendments significantly reduced the salt content and improved the content of available N, P and K (Wang et al 2014). Potassium (K^+) is important to maintain plant turgor pressure under salinity stress. One of the characteristics of saline soil is low organic matter. C and N mineralization pattern to salinity stress depended on the type of animal manure incorporate to the soil such as cow dung, poultry manure and goat manure (Walpola and Arunakumara 2010) . Organic matter increased soil aggregates stability through the bonding or adhesion properties of waste products of bacteria and fungal and/or bacteria hyphae (Diacono and Montemurro 2015). Soil porosity, water infiltration and water holding capacity of soil are improved as a consequence of soil aggregate stability.

Experiment 2 : The use of Panicum and Sesbania forage for growing goats

S. grandiflora had the highest content of crude protein and lowest content of crude fibre (Table 3). *P. maximum* had higher content of CP and lower content of CF compared to native grass. *L. leucocephala* had lower content of CP and higher content of CF compared to *S. grandiflora.*

Table 3. Chemical composition of the experimental feeds

	DM	CP	CF	Ash
	g/kg		g/kg DM	
P. maximum	277	118	297	117
S. grandiflora	225	214	156	69
L. leucocephala	290	193	191	77
Native grass	210	44	305	130

Total DM intake was greatest *for P. maximum : S. grandiflora* (80 : 20) followed by treatments of *P. maximum : S. grandiflora* (60 : 40) with the lowest values on treatment of native grass : *L. leucocephala* (Table 4). Crude protein intake was greatest for treatments of *P. maximum : S. grandiflora* (60 : 40). The lowest CP intake was with treatment of native grass : *L. leucocephala.* The DM intake of *P. maximum* supplemented with *S. grandiflora* was increased as compared with native grass : *L. leucocephala*. *P. maximum* had higher palatability than native grass. Ash and Petaia (1992) reported *S. grandiflora* to be highly palatable and well digested by goats when fed as a major part of the diet.

Table 4. Mean values for feed intake, live weight gain and feed conversion for goats with different feeding treatments

	***NG-LL* (80-20)**	**PM-SG (80-20)**	**PM-SG (60-40)**	***p***
DMI, g/day				
P. maximum	-	757	558	
S. grandiflora	-	127	255	
Natve grass	450	-	-	

L. leucocephala	90	-	-	
Total	**540** [b]	**884** [a]	**813a**	**0.014**
DMI, % of LW	3.59[b]	5.31 [a]	4.98[ÂÂ a]	0.0003
CP, % DMI	5.04[c]	13.2[b]	14.8[ÂÂ a]	< 0.0001
Initial LW, kg	15.2	16.[7]	16.3	
Final LW, kg	17.8	21.8	21.8	
LW gain, g/day	38.1[b]	73.8[a]	78.6[ÂÂ a]	0.0006
DM conversion	14.3[a]	11.9[ab]	10.3[b]	0.0425

Live weight gains were similar for the different ratios of *P. maximum : S. grandiflora* (60 : 40 and 80: 20) and much better than for native grass : *L. leucocephala* (Figure 3). The high nutritional value for goats of *Sesbania grandiflora* has been documented in Vietnam when given as the sole feed (Nhan et al 1998) or as a supplement to sweet potato vines (Vo Lam and Inger Ledin 2004).

Figure 3. Live weight gain of goats fed grasses and tree legume forages

Conclusions

- Organic fertilizer (cow dung) application on saline soil increased dry matter production of *P. maximum* and *S. grandiflora* planted separately or inter-planted.

- DM intake and live weight gain were much higher, and DM conversion better, for combinations of *P. maximum : S. grandiflora* (80 : 20) and *(*60 : 40) than for Native grass : *L. leucocephala((80:20).*

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