

The Effect of Soil Moisture Content and Animal Manure Application on the Growth of Mendong (*Fimbristylis globulosa* (Retz.) Kunt)

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ABSTRACT

The objective of the research was to study the interaction between soil moisture content and animal manure application on the growth of Mendong (*Fimbristylis globulosa* (Retz.) Kunt). The experiment was conducted in May until September 2016 in Kampung Lembur Sawah, Kamulyan Village, Manonjaya Subdistrict, Tasikmalaya Regency. A pot experiment was performed using a factorial design consisting of two factors and three replicates. The factors were soil moisture content (K) consisting of four levels *i.e.* k_1 (100% field capacity (FC)), k_2 (150% FC), k_3 (200% FC), and k_4 (250% FC); and animal manure application (P) consisting of p_1 (cattle manure), p_2 (broiler chicken manure), and p_3 (sheep manure). The indicators of plant growth, *i.e.* plant height, number of tiller, fresh weight and dry weight of plant biomass, shoot/root ratio, percentage of the ≥ 75 cm-long stems, water consumption, and water use efficiency (WUE) were measured. The results showed that there was an interaction effect between the soil moisture content and animal manure application on the number of tiller at 45 days after planting (DAP), the percentage of the ≥ 75 cm-long stems, and the water consumption. The sheep manure application at any levels of soil moisture content resulted in better effect on the growth of Mendong, water use efficiency, and quality of stem (the percentage of the ≥ 75 cm-long stems). The soil moisture content above the field capacity resulted in better effect on the growth of Mendong, indicating that Mendong is more suitable to grow on the land with the soil moisture content above the field capacity or saturated soil during the whole growing period.

Keywords: Manure, Mendong, soil moisture content

ABSTRAK

Tujuan penelitian adalah untuk mengetahui interaksi antara kelembaban tanah dan pupuk kandang terhadap pertumbuhan tanaman Mendong (*Fimbristylis globulosa* (Retz.) Kunt). Percobaan dilakukan pada bulan Mei sampai September 2016 di Kampung Lembur Sawah, Desa Kamulyan, Kecamatan Manonjaya, Kabupaten Tasikmalaya. Percobaan pot dilakukan di dalam rumah plastik dengan menggunakan rancangan acak kelompok yang disusun dalam pola faktorial terdiri dari dua faktor dan tiga ulangan. Faktor pertama adalah kelembaban tanah (K) terdiri dari empat taraf, yaitu k_1 (100% kapasitas lapang (FC)), k_2 (150% FC), k_3 (200% FC), dan k_4 (250% FC); dan faktor kedua adalah pupuk kandang (P) terdiri dari p_1 (pupuk kandang sapi), p_2 (pupuk kandang ayam), dan p_3 (pupuk kandang domba). Variabel yang diamati adalah komponen pertumbuhan (tinggi tanaman, jumlah anakan, bobot basah dan bobot kering tanaman, nisbah pupus akar, persentase batang dengan panjang ≥ 75 cm), penggunaan air, dan efisiensi penggunaan air (EPA). Hasil penelitian menunjukkan bahwa terjadi interaksi antara kelembaban tanah dengan aplikasi pupuk kandang terhadap jumlah anakan pada 45 hari setelah tanam (HST), persentase batang dengan panjang ≥ 75 cm, dan penggunaan air. Aplikasi pupuk kandang domba pada berbagai taraf kelembaban tanah memberikan pengaruh yang lebih baik terhadap pertumbuhan tanaman Mendong, kualitas batang (persentase batang dengan panjang ≥ 75 cm), penggunaan air, dan efisiensi penggunaan air. Kelembaban tanah di atas kapasitas lapang memberikan pengaruh yang lebih baik terhadap pertumbuhan Mendong yang menunjukkan bahwa Mendong lebih cocok ditanam pada lahan dengan kelembaban di atas kapasitas lapang atau pada lahan yang jenuh air selama periode pertumbuhannya.

Kata kunci: Kelembaban tanah, Mendong, pupuk kandang

INTRODUCTION

Mendong (*Fimbristylis globulosa* (Retz.) Kunt) is an aquatic plant that can be used as raw materials for handicrafts (mats, bag, lamp-shades, hats etc.). The demand of Mendong as raw materials in Tasikmalaya is increasing. However, the increasing demand of mendong has not been met by the local farmers because of low productivity of local Mendong and the decrease of irrigated land area due to the conversion of wetland area into housing, roads, etc. (Rudianto and Lelono 2015). Based on the statistical data of Agriculture, Fishery and Forestry of Tasikmalaya Municipality 2013, the production of Mendong decreased from 1,269.74 Mg in 2012 to 988.30 Mg in 2013, or in other words the production decreased by 281.44 Mg.

Management of water and fertilizer is still a challenge for the farmers in Tasikmalaya in cultivating Mendong. In general, farmers cultivate Mendong in the lowland with continuous irrigation (Hatta 2004) for one to two consecutive years, resulting in three to eight harvesting times. In rainfed area or non irrigated area, the farmers rarely cultivate Mendong. The idea to increase Mendong productivity through extensification is by cultivating Mendong in rainfed area or non irrigated land accompanied by the incorporation of organic matter.

Soil organic matter content affects the biological, chemical and physical properties of soil. Physically, the soil organic matter content affects the soil structure and porosity, water infiltration, and soil water holding capacity (Sarief 1989; Bot and Benites 2005). Manure, which can be used as a source of organic matter, is an animal waste in the form of solid or liquid, or solid mixed with urine originated from cattle, goat/sheep, horse, poultry, and pig. The manure itself can be as fresh manure or decomposed manure. The quality of manure varies depending on the diet and age of the animals (Syahrudin dan Nuraini 1999). Nutrient exchange between organic matter, water, and soil is essential for soil fertility and needs to be maintained for sustainable production purposes (Bot and Benites 2005).

The objective of the research was to study the effect of soil moisture content and animal manure application on the growth of Mendong. In addition, the feasibility to cultivate Mendong on rainfed area or non irrigated area was evaluated based on the data of water use efficiency.

MATERIALS AND METHODS

Study Site

A pot experiment was carried out in May until September 2016 in a plastic house in Kampung

Lembur Sawah, Kamulyan Village, Manonjaya Subdistrict, Tasikmalaya Regency at the altitude of about 400 m above sea level. Latosol soil from Cibeureum was used in this experiment. The soil sample was air dried and sieved using 5 mm-diameter sieve. Then, the characteristics of soil sample were analysed at the Laboratory of Soil Science, Faculty of Agriculture, Universitas Padjajaran. The pH of the soil is 6.0, and the contents of organic-C, total-N, total-P, and total- K are 1.76%, 0.14%, 23 mg 100 g⁻¹, and 11.56 mg 100 g⁻¹, respectively. Mendong seedlings were obtained from Kampung Lembur Sawah, Kamulyan Village, Manonjaya Subdistrict, Tasikmalaya Regency. Each pot was planted with about 3 g of root cutting containing of three initial tillers (Sadhu 1989).

Animal manures were taken from Manonjaya, Tasikmalaya. The manures consisted of cattle manure (pH 7.89, organic-C 24.92%, total-N 2.62%, P₂O₅ 2.62%, and K₂O 0.80%); broiler chicken manure (pH 8.03, organic-C 24.87%, total-N 2.24%, P₂O₅ 1.77%, and K₂O 1.25%); and sheep manure (pH 7.44, organic-C 23.70%, total-N 2.37%, P₂O₅ 1.27%, and K₂O 0.70%).

Experimental Setup

The pot experiment was arranged in a factorial design consisting of two factors and 3 replicates. The factors were soil moisture content (K) consisting of four levels *i.e.* k₁ (100% field capacity (FC)), k₂ (150% FC), k₃ (200% FC), and k₄ (250% FC); and animal manure application (P) consisting of p₁ (cattle manure), p₂ (broiler chicken manure), and p₃ (sheep manure). The treatment combinations were k₁p₁, k₁p₂, k₁p₃, k₂p₁, k₂p₂, k₂p₃, k₃p₁, k₃p₂, k₃p₃, k₄p₁, k₄p₂, k₄p₃. The weight of soil used in each pot was 5000g with the organic matter content of 5%. The weight of animal manure applied in each pot is calculated based on the soil organic-C content. The soil organic-C content of the soil is 1.76%. Therefore, the amount of animal manure added is 5% - 1.76% = 3.24%. The additional amount of animal manure is then multiplied with the factor of 1.72 and the weight of soil used in each pot (*i.e.* 3.24 % × 1.72 × 5000g = 279g) in order to get the weight of animal manure added in each pot (USDA 2009).

The field capacity was determined gravimetrically by watering 5000 g the mixture of soil and animal manure into a saturated condition and then letting the gravitation water drained during 24 hours. The difference between the weight of soil after 24 hours and the initial soil weight is the soil moisture content at field capacity. The field capacity for the mixtures of soil and cattle manure, soil and

broiler chicken manure, and soil and sheep manure were 32%, 33%, and 34%, respectively.

Until 2 weeks after planting, the water level was maintained at the level of soil surface to promote the initial growth of Mendong seedlings, and afterwards the soil moisture content was maintained according to the treatments applied.

Application of Treatments and Observation

To keep the soil moisture content according to the treatments applied, water was added everyday by means of gravimetric method. All the pots, except for the treatment of 100% FC, were weighed once a day in the morning, and the water loss was calculated and then added or replaced. The pots with 100% FC treatment were weighed two times a day, in the morning and afternoon, and accordingly added with water, to avoid period of water deficit during the day (Yaya Sunarya and Suyudi 2016). The indicators of plant growth, *i.e.* plant height, number of tiller, fresh weight and dry weight of plant biomass, shoot/root ratio, percentage of the ≥ 75 cm-long stems, water consumption, and water use efficiency were measured. Water use efficiency (WUE) is calculated using the following formula (Anyia and Herzog 2004 and Singh *et al.* 2012 in Sri Suryanti *et al.* 2015):

$$WUE = \frac{\text{Dry weight of total biomass}}{\text{Total water used}} \times 100\%$$

The data were analyzed statistically using analysis of variance followed by Duncan’s multiple range test at the significance level of 0.05 (Gomez and Gomez 1995).

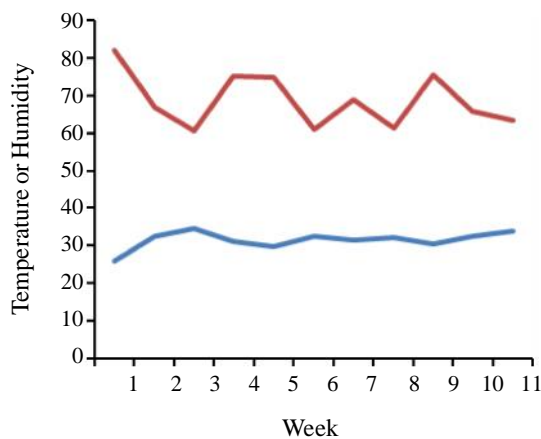


Figure 1. Weekly average temperature and relative humidity. — : temperature (°C), — : relative humidity (%).

RESULTS AND DISCUSSION

The weekly average temperature and relative humidity in the plastic house during the research periode were 31.4°C and 68.6%, respectively (Figure 1). This condition presumably affected the amount of water used and accordingly the growth of Mendong.

Plant Height

The effect of soil moisture content and animal manure application on the height of Mendong is presented in Table 1.

Table 1 indicates that there was no interaction effect between the soil moisture content and animal manure application on the height of plants at 30, 45, 60, and 75 days after planting (DAP). However, each of soil moisture content or animal manure application showed a significant effect on the plant height. The height of plant increased with the increase of age of Mendong until the final observation. The soil moisture content above the field capacity resulted in a better effect on the plant height. In addition, sheep manure application resulted in a better effect on the plant height than the applications of cattle manure and broiler chicken manure. The effect of animal manure application tends to exceed the effect of soil moisture content.

Number of Tiller

There was an interaction effect between the soil moisture content and animal manure application on the number of tiller at 45 DAP, and each of soil moisture content or manure application showed a significant effect on the number of tiller at 30, 60, dan 75 DAP. The number of tiller increased with the increase of age of Mendong until the final observation (Table 2). The sheep manure application resulted in more number of tiller at all levels of soil moisture content compared to other manure applications. On the other hand, application of any kinds of animal manures resulted in the same effect on the number of tiller at different level of soil moisture content. The effect of animal manure application exceeded the effect of soil moisture content.

Table 3 indicates that there was also no interaction effect between the soil moisture content and animal manure application on the number of tiller at 30, 60, and 75 DAP, and each of soil moisture content or manure application showed no significant effect on the number of tiller. The number of tiller increased with the increase of age of Mendong until

Table 1. Plant height at 30, 45, 60, and 75 DAP at various soil moisture content and animal manures.

Treatment	Plant height (cm)			
	30 dap	45 dap	60 dap	75 dap
Soil moisture content				
100% FC	24.33 a	32.67 c	44.58 a	50.25 b
150% FC	24.67 a	34.08bc	46.33 a	57.08 a
200% FC	27.00 a	36.00ab	47.00 a	55.58ab
250% FC	25.08 a	36.75a	49.08 a	57.67a
Animal manure				
Cattle	34.75 a	48.00 a	62.08 ab	73.50ab
Broiler	29.92 b	41.25b	57.00b	69.50 b
Sheep	36.42 a	50.25 a	67.92a	77.58a

Note: The values followed by the same lowercase are not significantly different according to Duncan's multiple range test at 5% significance level.

Table 2. The number of tiller at 45 DAP at various soil moisture content and animal manures.

Soil moisture content	Animal Manures		
	Cattle	Broiler	Sheep
	------(stem)-----		
100% FC	24.67 a B	20.00 a B	41.67 a A
150% FC	34.67 a AB	28.00 a B	43.33 a A
200% FC	34.33 a A	21.33 a B	40.00 a A
250% FC	32.67 a A	21.67 a B	39.67 a A

Note: The values followed by the same lowercase (vertical) and uppercase (horizontal) are not significantly different according to Duncan's multiple range test at 5% significance level.

Table 3. The number of tiller at 30, 60, and 75 DAP at various soil moisture content and animal manures.

Treatment	Tiller number		
	30 dap	60 dap	75 dap
Soil moisture content			
100% FC	10.08 a	21.42 a	42.42 a
150% FC	11.83 a	27.08 a	45.25 a
200% FC	11.08 a	23.58 a	41.83 a
250% FC	12.25 a	22.42 a	44.25 a
Animal manure			
Cattle	15.33 b	30.83b	53.17b
Broiler	11.08 c	24.50b	49.83b
Sheep	18.83 a	39.17 a	70.75 a

Note: The values followed by the same lowercase are not significantly different according to Duncan's multiple range test at 5% significance level.

Table 4. Fresh weight and dry weight of biomass, dry weight of shoots and roots, shoot/root ratio, total water added, water use efficiency, number of stems with 75 cm-long at various soil moisture content and animal manures.

Treatment	Fresh weight of biomass (g)	Dry weight of biomass (g)	Dry weight of shoots (g)	Dry weight of roots (g)	Shoot/root ratio	Water use efficiency (g L ⁻¹)	Number of stem with 75cm-long
Soil moisture content							
100% FC	103.83 b	23.16 a	14.45 a	8.72 a	1.28 a	2.30 a	17.67 b
150% FC	152.69 a	33.19 a	21.68 a	11.52 a	1.60 a	3.16 a	25.42 ab
200% FC	145.40 a	29.00 a	18.47 a	10.54 a	1.48 a	2.70 a	23.83 ab
250% FC	151.83 a	31.16 a	20.12 a	11.04 a	1.46 a	2.87 a	27.25 a
Animal manure							
Cattle	159.63 b	33.37 b	22.50 ab	10.86 b	2.15 a	3.18 b	28.33 b
Broiler	164.06 b	33.30 b	19.82 b	13.48 ab	1.67 a	3.25 b	21.08 c
Sheep	230.06 a	49.86 a	32.39 a	17.46 a	2.00 a	4.59 a	44.75 a

Note: The values followed by the same lowercase are not significantly different according to Duncan's multiple range test at 5% significance level.

the final observation. It is also observed that the effect of animal manure application tends to exceed the effect of soil moisture content.

Weight of Plant Biomass, Shoot/Root Ratio, Water Use Efficiency, Stem Quality, and Water Consumption

The effect of soil moisture content and animal manure application on the fresh weight and dry weight of biomass, dry weight of shoots and roots, shoot/root ratio, water use efficiency, number of stems with ≥75 cm-long, and water consumption was presented in Table 4.

Table 4 indicates that the fresh weight of biomass and number of stems with ≥75 cm-long of

Mendong grown at the soil moisture content above the field capacity were better than those at the field capacity, indicating that Mendong is more suitable to grow on the saturated soil during the whole growing period. The sheep manure application resulted in higher fresh weight and dry weight of biomass, water use efficiency, and number of stems with ≥ 75 cm-long than those of cattle manure and broiler chicken manure applications.

Post harvest handling of Mendong classifies Mendong fiber based on its length into 120-, 110-, 90-, 80-, and 75- cm long. The ≥75 cm-long stem is one of the parameters that indicates the quality of Mendong fiber selected for raw materials of handicrafts. Table 5 indicates that application of sheep manure and cattle manure resulted in better

Table 5. Percentage of stems with ≥75 cm-long at various soil moisture content and animal manures.

Soil moisture content	Animal Manures		
	Cattle	Broiler	Sheep
	------(%)-----		
100% FC	37.19 b B	27.95c B	54.05 a A
150% FC	47.52 b B	55.05 a AB	66.02 a A
200% FC	64.03 a A	40.97bc B	63.81 a A
250% FC	65.81 a A	49.31 ab B	66.33 a A

Note: The values followed by the same lowercase (vertical) and uppercase (horizontal) are not significantly different according to Duncan's multiple range test at 5% significance level.

Tabel 6. Water consumption at various soil moisture content and animal manures.

Soil moisture content	Animal Manures		
	Cattle	Broiler	Sheep
	------(ml)-----		
100% FC	9,869.00 b AB	9,736.33b B	10,310.67c A
150% FC	10,559.00a A	10,391.00 a A	10,667.00 bc A
200% FC	10,784.00 a A	10,228.00ab B	10,994.00ab A
250% FC	10,557.33 a A	10,278.67 a B	11,346.33 a A

Note: The values followed by the same lowercase (vertical) and uppercase (horizontal) are not significantly different according to Duncan's multiple range test at 5% significance level.

quality of Mendong than the application of broiler chicken manure based on the percentage of ≥ 75 cm-long stem.

The effect of soil moisture content and animal manure application on water consumption of Mendong is presented in Table 6.

Table 6 shows that the application of all types of animal manure at soil moisture content above the field capacity resulted in higher water consumption of Mendong, indicating that the consumption of water of Mendong depends on the availability of water in soil (Sri Suryanti *et al.* 2015). At all levels of soil moisture content, sheep manure and cattle manure applications resulted in higher water consumption of Mendong than that of broiler chicken manure application. Organic manure contributes to the stabilization and improvement of crop productivity and crop quality due to the multiple positive effects of manure application on the physical, chemical and biological soil properties (Adugna 2016).

CONCLUSIONS

It is concluded that there was an interaction effect between the soil moisture content and animal manure application on the tiller number at 45 DAP, percentage of number of stems with ≥ 75 cm-long, and water consumption of Mendong. The application of sheep manure at all levels of soil moisture content resulted in better effect on the growth of Mendong and the water use efficiency. At application of all kinds of animal manures, the soil moisture content above the field capacity resulted in better growth of Mendong, indicating that Mendong is more suitable to grow on the land with the soil moisture content above the field capacity or saturated soil during the whole growing period.

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