IOP Conf. Series: Earth and Environmental Science **119** (2018) 012014 doi:10.1088/1755-1315/119/1/012014

Quality and Quantity of Sorghum Hydroponic Fodder from Different Varieties and Harvest Time

R. Chrisdiana[1]*

[1]The student of Master of Animal Sciences, Faculty of Animal and Agricultural Sciences, Diponegoro University, Semarang, Central Java Indonesia

*Corresponding E-mail: freya.rasheesa@gmail.com

Abstract

This experiment was designed to compare different varieties and harvest time of sorghum hydroponic fodder based on nutrient content and biomass production. Experimental design for fodder productivity was completely randomized design with 2 x 3 factorial, i.e., sorghum varieties (KD 4 and Super-1) and time of harvesting the sorghum hydroponic fodder (8,12 and 16 d). Total biomass and DM production, were affected significantly ($p<0.05$) on harvest time. Total biomass and nutrient content were increased in longer harvest time. The nutrient content were increased with decreasing total value of DM. Super-1 varieties produce larger biomass and nutrient content higher than KD4 ($p<0.05$). Based on sorghum hidroponic fodder quality and quantity, sorghum hidroponic fodder with Super-1 varieties harvested at 12 d had a good quality of fodder and it can be alternative of technology providing quality forage and land saving with a short time planting period and continous production.

1. Introduction

Forage is the main source of ruminant feed to supply the maintenance, production and reproduction requirements of livestock. Therefore, methods and technologies were required to improved productivity of forage like hydroponic system with continuously production without season-influenced and can be applied without requiring extensive land. Forage development technology that can be applied is hydroponic fodder system.

Hydroponic fodder system was hydroponics forage production with a short time harvest by using cereal plants. Moisture and nutrients were needed to enable germination and growth of plants. Germination process will produce green shoots and root-shaped mats to be harvested as animal feed [5]. The basic principle of a hydroponic fodder system is that cereal plants respond to water supplies and nutrients to germinate, grow, and then produce green plants in short time. The development of this system allows the production of fresh forages from grains produced with high yields of 15 to 30 cm with a production rate of 7 to 9 kg of fresh forage (depending on grain varieties) with 0.9-1.1 kg of dry matter of 1 kg of seeds within 6 to 8 days [7].

Various cereals can be used as animal feed, including barley, wheat, corn, and sorghum. Sorghum is an adaptive and suitable food crop developed in the tropics and efficient in producing high photosynthetic products. The optimum temperature for the growth of sorghum plants ranges from 21-35°C. Sorghum has advantages, including drought tolerance, high salt content, and extensive adaptability, and easier maintenance than sugar cane and other cereals. Sorghum has a greater biomass than maize [8]. Among the species of sorghum that can be developed as animal feed is Sorghum bicolor KD4 and Super-1 varieties.

The process of growing plants hydroponically will cause the chemical and structural changes that take place in the cereal grains through the germination process. Activation of enzymes in seeds during germination causes the hydrolysis of proteins, carbohydrates and fats to be simple components [6]. This hydrolysis increases the concentration of amino acids, soluble sugars and fatty acids in grains and produces sprout [4]. The growth or germination of the grains will affect the nutrient content by increasing fiber, fat, protein, but decreasing starch and total dry matter [7].

This study was designed to compare different varieties and harvest time of sorghum hydroponic fodder based on nutrient content and biomass production. The results of this study are expected to provide information about the technology of providing quality forage and land saving with a short time planting period.

2. Materials and Methods

2.1. Plants productivity Experiments

Six hundreds grams of Sorghum seeds were weighed and spread in 1 tray of 16 trays according to the treatment, then sorghum seeds soaked 20% sodium hypocloride solution 1 mL for 1 L of water for 20 minutes. The sorghum seed was washed again, then soaked with water for 24 hours. The water was drained and the seeds were spread on the tray. Sorghum seeds were sprayed two times a day until harvest time. Three replications of the experiments were observed for plant productivity including biomass, dry mater, crude protein production and subsequent proximate analysis. Harvested sorghum hydroponic fodder was dried in an oven at 60°C for 48 hours then ground for proximate analysis including Dry mater (DM), ash, crude protein (CP), extract ether (EE), crude fiber (CF), neutral detergent fiber (NDF), and acid detergent fiber (ADF). Proximate analysis using SNI (1995) method for DM, CF and Ash, AOAC (2005) method for CP, EE, ADF, and NDF.

2.2. Statistical Analysis

Experimental design for fodder productivity was completely randomized design with 2 x 3 factorial, i.e., sorghum varieties (KD4 and Super-1) and time of harvesting the sorghum hydroponic fodder (8,12 and 16 d). Data obtained were analyzed by using analysis of variance (ANOVA) and followed by Duncan's multiple range test.

3. Results and Discussion

The nutrient compositions of sorghum hydroponic fodder are presented in Table 1. Dry matter of the plant was reduced with a longer time of harvest, while CP, ash, NDF, and ADF were increased. In barley plant fodder, dry matter of the seeds is significantly reduced with increasing periods of 6-7 days. While CP, EE, ash, NDF, and ADF increased [7]. In hydroponic fodder plants, soaking seeds will increase the activity of enzymes that break down the seeds into simpler fractions such as starch into sugars, proteins into amino acids and fat into free fatty acids, while dry matter and total energy will decrease [10]. In a barley hydroponic, germination of barley plants have 18% loss in DM. CP, Ash, fiber content, NDF, and ADF increased in a 8 days of sprouting [9].

It has been known that loss of dry matter and total energy may be caused by oxidation of plants. During soaking and germination, the seeds lose dry matter because they use their own energy reserves for growth. Sprouts can regain their dry matter with effective mineral absorption and photosynthesis [10]. The lower dry matter value give the higher CP content. The increase in CP is probably due to the loss of carbohydrates in the dry matter because at the time of planting no source of nitrogen is externally added to the water used for irrigation [6].

The increase in NDF and ADF values occurs because of the synthesis and accumulation of lignin which usually occurs during the formation and thickening of secondary cell walls, therefore the rate of maturation and irrigation will affect the accumulation of lignin [3]. Furthermore, Dung et al [6] (2012) explains that the fiber content is mostly derived from root and seed husk due to the maturation process and endosperm formation. With the increasing value of ADF and NDF in plants, the organic matter content will decrease.

Table 1. Nutrient Composition of Sorghum Hydroponic Fodder

Composition	KD4			Super-1		
	8d	12d	16d	8d	12d	16d
			%			
DM	27.04	22.66	15.68	25.36	14.55	15.94
CP	13.94	18.04	18.68	17.27	26.94	26.68
EE	4.04	4.05	5.80	4.13	5.55	5.60
CF	15.17	16.06	19.66	25.55	31.62	36.57
Ash	2.25	3.25	3.69	1.56	2.10	2.41
NDF	22.57	35.70	39.04	23.18	32.68	33.41
ADF	8.99	10.9	15.36	9.96	17.65	18.26

Biomass Production of sorghum hydroponic fodder was significantly different ($p<0.05$) on harvest time and varieties (Table 2). Longer harvested time will produce higher biomass. At 16 d harvest time, biomass production tends to remain even decreased in Super-1 varieties. This is because plant growth depends on the availability of nutrients in the seeds. Without additional nutrients the plant will last only less than 16 days. As mentioned by Andriani and Isnaini [2], sorghum which grown with soil medium with age between 3-10 days after planting, its growth depends on nutrition and food reserves from seed. Shoots (coleoptile) appear on the soil after 3-4 days after planting, while the secondary roots will begin to growth 3-7 days after sprout.

Super-1 varieties produce higher biomass than KD4. Biomass production depend on plant species, varieties, and environmental conditions, 1 kg of grain will produce 15-25 kg of fodder with planting period of 8–10d [1]. The results and quality of the fodder are also influenced by many factors such as soaking time, seed quality, seed type and treatment, temperature, moisture, nutrient supply, and seed density [4]. Starch in cereal plants is a raw material that supports plant growth. Water Imbibition during the soaking process will activate enzymes in the seeds that hydrolyse starch into sugars that available for embryonic growth. Under conditions of optimum humidity, oxygen and warmth, the sugar will be used for cell wall synthesis and to provide energy for growth [5].

DM production of sorghum hydroponic fodder was significantly different ($p<0.05$) on harvest time but did not differ significantly in plant varieties (Table 2). This result is inverse if compare with biomass production. In this study, longer harvested time, biomass production plants will increase while dry matter production will decrease. Biomass production per kg of plants increased during the 6-7 day growing period caused by water absorption during seed germination resulting in a different percentage of DM [7]. Based on varieties, dry matter production is not significantly different between Super-1 and KD4. Yield and quality of the sprouts produced are influenced by many factors such as soaking time, seed quality, seed type and treatment, temperature, humidity, nutrient supply, and seed density to achieve maximum results [4].

Table 2. Biomass, DM and CP Production of Sorghum Hydroponic Fodder

Variables	Varieties	harvested time (d)			mean of sorghum varieties
		8	12	16	
Biomass (kg/m^2)	KD4	25.511	28.373	30.141	28.008^b
	Super-1	27.948	33.530	32.753	31.410^a
	mean of harvest time	26.730^b	30.951^a	31.447^a	
DM (kg/m^2)	KD4	6.893	6.439	4.725	6.019
	Super-1	7.070	4.877	5.229	5.974
	mean of harvest time	6.981^a	5.658^b	4.977^b	
CP (kg/m^2)	KD4	961	1.162	883	1.002^b
	Super-1	1.221	1.314	1.395	1.267^a
	mean of harvest time	1.091	1.238	1.139	

^{a,b}, means with different superscripts differ significantly (P<0.05).

In hydroponic fodder plants, soaking seeds will increase the activity of enzyme that breaks the seed into a simpler fraction. Dry matter and total energy will decrease due to plant oxidation [10]. When water imbibition occurs in the seed embryo, plant hormone (giberrelic acid) along with water will go to the aleuron layer. In the aleuron layer there will be DNA activation that converts amino acids into amylase enzymes. The amylase then goes to the endosperm layer to then catalyse the hydrolysis of starch into the glucose component. Glucose is then used for metabolic activity of newly grown plants. This oxidation will produce ATP and release CO_2 [6].

Crude protein production of fodder sorghum hydroponic value was significantly different ($p<0.05$) on plant varieties and did not differ significantly on harvest time. This explains that the increased CP percentage is proportional with DM percentage decrease, so the CP content does not actually occur in kilogram. Super-1 varieties CP (kg) is higher than KD4 because the content of CP seed in Super-1 varieties is higher than KD4. This result is consistent with statement that the percentage of proteins gives apparent increase as basically the total weight of the protein remains the same according to the dry matter [10]. The increase in the crude protein content derived from nitrate absorption, thus facilitating the metabolism of nitrogen compounds derived from carbohydrate reserves (Morgan et al., 1992) as cited by Saidi [9] (2015).

4. Conclusion

Based on sorghum hydroponic fodder quality and quantity studies, sorghum hydroponic fodder with Super-1 varieties harvested at 12 d had a good quality of fodder and it can be alternative of technology providing quality forage and land saving with a short time planting period and continuous production.

Acknowledgment

A sincere thanks was expressed to Animal Husbandry Training Center Batu for facilitating authors to conduct the experiment.

References

[1] Ghazi, N., Al-Karaki and M. Al-Hashimi. 2011. Greem Fodder Production and Water Use Efficiency of Some Forage Crops Under Hydroponic Conditions. ISRN Agronomy **1**. 15

[2] Andriani, A. and Isnaini M. 2012. Morfologi dan Fase Pertumbuhan Sorgum. Cereals Plant Research Institute.

[3] Carmi A, Aharoni Y, Edelstein M, Umiel N, Hagiladi A, Yosef E, Nikbachat M, Zenou A, & Miron J. 2006. Effects of Irrigation and Plant Density on Yield, Composition and In Vitro Digestibility of a New Forage Sorghum Variety, Tal at Two Maturity Stages. J. Anim. Feed Sci. Tech.**131**:121

[4] Chavan J and Kadam SS 1989 Nutritional Improvement of Cereal by Sprouting. Critical Rev. Food Sci. Nut. **28** (5) : 401.

[5] Cuddeford D. 1989. Hydroponic Grass In Practice **11**(5) 2

[6] Dung DD, Goodwin I R, Nolan JV 2010 Nutrient Content and *in sacco* Digestibility of Barley Grain and Sprouted Barley J. Anim. Vet. Advances **9** (19) 2485

[7] Fazaeli H, Golmohammadi HA,Tabatabayee SN, Tabrizi MA 2012 Productivity and Nutritive Value of Barley Green Fodder Yield in Hydroponic System. J World Appl Sci. **16** (4): 531.

[8] Rocateli AC, Raper RL, Balkcom KS, Arriaga FJ, Bransby DI 2012Biomass sorghum production and components under different irrigation/tillage systems for the southeastern US. Industrial Crops and Products **36** : 589.

[9] Saidi ARMA and Abo Omar J 2015 The Biological and Economical Feasibility of Feeding Barley Green Fodder to Lactating Awassi Ewes J. Anim. Sci., **5**, 99.

[10] Sneath R and McIntosh F 2003 Review of Hydroponic Fodder Production For Beef Cattle. Department of Primary Industries: Queensland Australia 84. McKeehen, pp: 54.