Effect of Seed Density and Nutrient Source on Production and Quality of Greenhouse Fodder as Dairy Cattle Feed

Idat Galih Permana,* Despal, Dara Melisa

Department of Animal Nutrition and Feed Science, Faculty of Animal Science,
Bogor Agricultural University, Bogor, 16680, Indonesia
Corresponding author: permana@ipb.ac.id

Abstract

This study examined the effect of seed density (D) and bio-slurry (N) on production and quality of corn greenhouse fodder (CGF) in a 3 x 3 completely randomized factorial experimental design. Corn seed were grown in 28 x 35 cm tray for 9 days in a greenhouse under hydroponic system. The density of corn seed were D1 (350 g/tray or 36 g/100 cm^2), D2 (450 g/tray or 46 g/100 cm^2) and D3 (500 g/100 cm^2). Nutrient solution (N) used were N1 = 100% commercial nutrient solution (CNS), N2 = 25% bio-slurry + 75% CNS and N3 = 50% bio-slurry + 50% CNS. Plant height, fresh biomass corn produced, proximate composition (water, ash, crudes protein, lipid and fiber contents), *in vitro* fermentability (VFA and NH_3) and digestibility (IVDMD and IVOMD) of the CGF have been observed. The result showed that there were no interaction between factors have been observed. Seed density significantly improved fresh fodder production and its digestibility but reduced ash content. Seed density did not influence other factors. Utilization of 25% bio-slurry as CNS substitution did not significantly reduced plant height and water contents. Increasing bio-slurry level reduced significantly plant height and water content. The IVDMD and IVOMD parameters improved by the substitution. There were no effect of bio-slurry on proximate composition, biomass production and fermentability of the fodder. It can be concluded that utilization bio-slurry could be used as CNS substitution up to 25% and seed density up to 51 g/100 cm2 did not produce competition between seed in getting nutrient, space and light.

Keywords *bio-slurry, corn, dairy, density, hydroponics,*

1. Introduction

Increasing population of Indonesian resulted massive agricultural land conversion which leads to decreasing land availability for fodder productions that are needed to maintain ruminant healthy life [1]. Land intensity with vertical farming such as hydroponic system could be used as an alternative to solve the problem. Hydroponic is a method of growing plants in nutrient solutions without soil [2]. Fodders produced from hydroponic system have better protein, highly digested and metabolizable energy [3]. One fodder that could be grown in the system is corn.

Corn is a C4 plant which well adaptive to several productions constrain [4]. The corn has advantage for fast growing and highly nutritious. The maximum corn production will be reached at optimum seed density [5] which related to the ability of the seed to compete in uptake nutrient, water and light [6]. Providing sufficient space and nutrient source will reduce the competition.

Biogas is a method to produce renewable energy from biomass such as cattle dung. The system is less popular among Indonesian smallholder dairy farmer due to lack of benefit to cost ratio. An effort to increase farmer benefit through utilizing the biogas byproduct such as bio-slurry will stimulate the farmer. Bio-slurry contained effective nitrogen and mineral that could be used as nutrient source in hydroponic system.

The research is aimed at finding corn seed density and level of bio-slurry application to produce the best corn green house fodder production for dairy cattle.

2. Materials and Methods

The research has been carried out in IPB University Farm (UF) green house facilities and Dairy Nutrition Laboratory. Combination of seed density (D) and nutrient solution (N) have been studied. Factor seed density D1 (350 g/tray or 36 g/100 cm^2), D2 (450 g/tray or 46 g/100 cm^2) and D3 (500 g/100 cm^2) and factor nutrient solution N1 = 100% commercial nutrient solution (CNS), N2 = 25% bio-slurry + 75% CNS and N3 = 50% bio-slurry + 50% CNS have been studied in a completely randomized factorial (3 x 3) design with 3 replications.

Corn seed from local market were used. The seed were washed and soaked (24 h) prior to incubation. The seed were spread in a 28 x 35 cm tray and incubated for 8 d. The trays were watered every 1 – 2 h to wet the seed surface. Plant growth was observed daily. Harvest was conducted at day 9. The fresh fodder production were weighted and dried to obtained fresh biomass and DM production. Nutrient content and utilization for animal were tested after drying the sample in a 60^oC oven for 48 h. The dried samples were ground and analyzed for proximate composition (DM, ash, CP, lipid, and CF) according to Naumann and Bassler (1997) procedure [7], rumen fermentability and digestibility followed one- and two-stage methods of Tilley and Terry (1963) [8], VFA concentration used steam distillation method, while NH_3 concentration followed Conway micro diffusion method from General Laboratory Procedure Dept. Dairy Science Wisconsin University (1969) [9].

The impact of seed density (D) and nutrients source (N) on parameters were tested using ANOVA followed by Duncan Multiple Range Test.

3. Results and Discussions

The yield and quality of sprouts produced in hydroponic fodder system is influenced by temperature, humidity, grain quality, grain variety and treatments, soaking time, nutrient supply, depth and density of grain in troughs and the incidence of mould [10]. Corn growth, production and its nutrient content in this experiment are shown in Table 1. There was no effect of seed density on corn height. Nutrient source however, did influence the corn height. Utilization of bio-slurry for up to 25% did not significantly reduced corn height. It showed that density of seed used in this experiment gave enough space for seed to germinate and growth and no significant competition have been occurred.

In this experiment, fresh fodder productions were influenced by seed density and nutrient sources. Utilization up to 25% bio-slurry tent to increase fresh fodder weight from 884 g to 901 g but the production then significantly decreased if bio-slurry level were added. Bio-slurry is a good nutrient source for the fodder growth. However, if it is used too much, the slurry will covered leaf stomata, prevented CO_2 passed into internal space within the leaf and diffused into mesophyll cell which will inhibit photosynthesis. The dirt in the slurry becomes pollutant to the plant. Beside pollutant, stomata are also influenced by several environmental variables such as quantum flux density, relative humidity, temperature, carbon dioxide concentration and media moisture [11]. Decreasing CO_2 concentration passed into internal space within the leaf, decreased photosynthesis rate on the N3 treatment which leads to less biomass production.

Increasing seed density produced more weight on fresh fodder because more space area of the seed to absorb nutrient from media and photosynthesis conducted. Up to 51 g seed per 100 cm^2 were adequate and there were no competition between seed in getting nutrient, water and light were observed by mean of decreasing biomass production and germination rate.

Table 1. Plant height, fresh and dry matter fodder production and nutrition quality

Seed density		Nutrient source			Average ± STD
		N1	N2	N3	
Plant Height (cm)	D1	28.37 ± 6.40	29.13 ± 6.76	19.60 ± 6.26	25.72 ± 7.26
	D2	28.80 ± 4.69	24.90 ± 5.07	25.50 ± 5.07	26.40 ± 4.65
	D3	30.5.09 ± 1.75	25.70 ± 4.66	21.37 ± 1.93	25.73 ± 5.22
	AVG ± STD	29.10 ± 0.92^{a}	26.60 ± 2.29^{a}	22.16 ± 3.03^{b}	
Fresh fodder weight (g)	D1	674 ± 140.87	862.33 ± 127.25	610 ± 143.72	715.44 ± 164.55^{b}
	D2	923.67 ± 81.13	929.33 ± 159	712 ± 251.17	855 ± 187.74^{a}
	D3	1055.67 ± 113.17	912.33 ± 86.03	830.33 ± 39.40	932.78 ± 123.27^{a}
	AVG ± STD	884.44 ± 193.83^{a}	901.33 ± 34.83^{a}	717.44 ± 110.27^{b}	
Water contents (%)	D1	74.94 ± 0.32	70.11 ± 0.33	69.81 ± 0.18	71.62 ± 2.50
	D2	75.45 ± 0.20	69.80 ± 0.41	69.89 ± 0.26	71.72 ± 2.82
	D3	74.70 ± 0.51	70.00 ± 0.22	70.15 ± 0.19	71.62 ± 2.33
	AVG ± STD	75.03 ± 0.38^{b}	69.97 ± 0.16^{a}	69.95 ± 0.18^{a}	
Ash content (% DM)	D1	7.93 ± 2.89	5.11 ± 2.50	4.47 ± 0.19	5.84 ± 2.49^{a}
	D2	5.11 ± 3.47	5.99 ± 0.71	5.38 ± 2.36	5.49 ± 2.16^{a}
	D3	4.75 ± 1.46	2.77 ± 0.24	2.64 ± 0.25	3.39 ± 1.27^{b}
	AVG ± STD	5.93 ± 1.74	4.62 ± 1.67	4.16 ± 1.39	
Protein content (% DM)	D1	14.09 ± 1.52	12.94 ± 0.88	12.68 ± 0.91	13.24 ± 1.18
	D2	14.57 ± 1.58	13.97 ± 2.43	14.76 ± 0.40	14.43 ± 1.50
	D3	13.83 ± 0.46	14.12 ± 1.89	13.74 ± 1.39	13.90 ± 1.21
	AVG ± STD	14.16 ± 0.38	13.68 ± 0.64	13.73± 1.04	
Crude fibre content (% DM)	D1	3.92 ± 1.89	4.21 ± 1.63	4.69 ± 0.83	4.27 ± 1.36
	D2	5.39 ± 0.82	5.54 ± 1.13	4.97 ± 1.45	5.30 ± 1.04
	D3	4.48 ± 0.22	4.59 ± 1.61	2.84 ± 0.19	3.97 ± 1.18
	AVG ± STD	4.60 ± 0.74	4.78 ± 0.68	4.17 ± 1.16	
Crude lipid content (% DM)	D1	5.40 ± 1.45	3.36 ± 1.76	4.29 ± 0.30	4.35 ± 1.45
	D2	4.70 ± 0.18	4.47 ± 0.52	2.99 ± 1.29	4.05 ± 1.07
	D3	3.94 ± 0.31	3.80 ± 0.15	3.86 ± 0.05	3.87 ± 0.19
	AVG ± STD	4.68 ± 0.73	3.88 ± 0.56	3.72 ± 0.66	
VFA (mM)	D1	160.51 ± 27.91	147.96 ± 21.48	131.38 ± 32.16	146.62 ± 27.00
	D2	152.41 ± 23.94	132.44 ±32.39	130.91 ± 25.08	138.59 ± 25.90
	D3	193.81 ± 74.90	153.79 ± 16.84	167.73 ± 94.24	171.78 ± 63.27
	AVG ± STD	168.91 ± 21.94	144.73 ± 11.03	143.34 ± 21.12	
NH_3 (mM)	D1	5.29 ± 0.37	4.23 ± 0.24	4.82 ± 0.46	4.78 ± 0.56
	D2	5.19 ± 0.99	5.21 ± 2.78	5.57 ± 2.37	5.32 ± 1.90
	D3	3.79 ± 0.22	4.70 ± 0.36	4.39 ± 2.23	4.29 ± 1.20
	AVG ± STD	4.76 ± 0.84	4.71 ± 0.49	4.93 ± 0.59	
IVDMD (%)	D1	77.51 ± 2.18	85.24 ± 3.28	76.39 ± 1.28	79.71 ± 4.66^{b}
	D2	74.28 ± 0.55	84.62 ± 1.64	85.53 ± 2.39	81.48 ± 5.61^{b}
	D3	85.92 ± 2.71	84.59 ± 1.89	87.05 ± 1.16	85.86 ± 2.05^{a}
	AVG ± STD	79.24 ± 6.01^{b}	84.82 ± 0.37^{a}	82.99± 5.76^{a}	
IVOMD (%)	D1	78.99 ± 1.46	85.80 ± 3.23	78.58 ± 1.52	81.12 ± 4.01^{b}
	D2	76.54 ± 0.75	84.99 ± 1.12	85.77 ± 2.54	82.43 ± 4.66^{b}
	D3	86.25 ± 2.99	85.01 ± 1.63	87.48 ± 1.10	86.25 ± 2.09^{a}
	AVG ± STD	80.60 ± 5.05^{b}	85.26 ± 0.46^{a}	83.94 ± 4.73^{a}	

Water contents of corn fodder decreased by inclusion of bio-slurry (N2 and N3) but did not influence by seed density. It might caused by water content of N2 and N3 were lower than N1. It can be also seen from the cleanliness of the media solutions. AB mix solution (N1) was cleaner than bio-slurry (N2 and N3). Ash content in the green fodder was lower for higher density seed application. Which might show that the mineral content in bio-slurry contained media was less available for plant to uptake. There were no effects of treatments on protein and crude fiber contents of the fodder as well as to the fodder fermentability as have been measured from VFA and NH_3 parameters. The treatments influenced both IVDMD and IVOMD in the same patterns. IVDMD and IVOMD increased in line with increasing seed density and level of bio-slurry.

It can be concluded that application of corn seed at density 51 g/100 cm^2 tray did not produce competition between the seeds in getting nutrient, light and water. Utilization of bio-slurry however is only effective up to 25% as nutrient source to replace commercial nutrient solution ABmix.

3. References

[1] Sofyan, A. 2010. Pedoman Teknis Perluasan Areal Kebun Hijauan Makanan Ternak. Jakarta (ID): Kementerian Pertanian.

[2] Mugundhan, M R., M. Soundaria, V. Maheswari, P. Santhakumari and V. Gopal. 2011. “Hydroponics”- a novel alternative for geoponic cultivation of medicinal plants and food crops. International Journal of Pharma and Bio Sciences 2(2): 286 – 296.

[3] Mooney, J. 2002. Growing Cattle Feed Hydroponically. Australian Nuffield Farming Scholars Association. Meat and Livestock Australia.

[4] Goldsworthy, PR and N.M. Fisher. 1980. Fisiologi Tanaman Budidaya Tropik. Yogyakarta (ID): Universitas Gadjah Mada Press.

[5] Mayadewi, NNA. 2007. Pengaruh jenis pupuk kandang dan jarak tanam terhadap pertumbuhan gulma dan hasil jagung manis. Agritrop 26 (4) : 153 – 159.

[6] Gonggo B, E. Turmidi dan W. Brata. 2003. Respon pertumbuhan dan hasil ubi jalar pada sistem tumpangsari ubi jalar jagung manis di lahan bekas alang-alang. *Jurnal* Ilmu-Ilmu Pertanian Indonesia. 5(1): 34-39.

[7] Naumann, C. and R. Bassler. 1997. VDLUFA-Methodenbuch Band III, Die chemische Untersuchung von Futtermitteln. 3rd ed. VDLUFA-Verlag, Darmstadt, Germany.

[8] Tilley JMA and R.A.Terry. 1963. A two stage technique for the *in vitro* digestion of forage crop. *J of British Grassland*. 18:104-111.

[9] General Laboratory Procedure. 1966. *Report of Dairy Science*. Madison (USA): University of Wisconsin.

[10] Sneath, R. and McIntosh, F. 2003. Review of Hydroponic Fodder Production for Beef Cattle. Project Report no. NBP 322. Meat & Livestock Australia Limited. Locked Bag 991 North Sydney NSW

[11] Turner, N.C. 1991. Measurement and influence of environmental and plant factors on stomatal conductance in the field. Agricultural and Forest Meteorology 54 (2 – 4): 137–154