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ORIGINAL RESEARCH

Cow urine as an organic nutrient source for hydroponic vegetable production

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Abstract

Purpose: Fermented cow urine (cow bio urine) is used as an organic source of nutrients. This study aimed to determine the effect of various concentrations of cow bio urine as the organic nutrient source on the growth and yield of vegetable crops in hydroponic systems.

Method: Research was conducted in a greenhouse at the University Farm from November 2020 to January 2021 with a split plot in RCBD. The main plot consisted of 3 vegetables (bok choy, spinach, and water spinach). The subplot had 5 concentrations prepared by mixing cow bio urine with distilled water at C1: 10%, C2: 20%, C3: 30%, C4: 40%, and C5: 50%. These solutions were used as hydroponic nutrient solutions. All the treatment combinations were maintained in 4 replications.

Results: Cow urine analysis before and after fermentation revealed an increase in nutrient content. The highest plant growth and yield were obtained in all three vegetables at the concentration of 50% cow bio urine. Maximum leaf number, leaf area, foliage dry weight, root dry weight, total dry weight, and foliage fresh weight were significantly higher in the above treatment. The highest foliage fresh weight was observed in treatments with 50% cow bio urine, with values of 57.02 g (bok choy), 54.97 g (spinach), and 26.29 g (water spinach).

Conclusion: Cow bio urine could be effectively used as a hydroponic nutrient solution to grow organic vegetables. The regression showed that the optimal concentration of cow bio urine might be higher than the present levels

Keywords: Agricultural residues, Bio urine, Cow urine, Organic nutrients, Organic waste, Vegetables

Introduction

The current consumption of organic products tends to rise in Indonesia. However, the cultivation of organic plants, particularly organic vegetables, is still dominated by soil media. This cultivation frequently affected by inorganic waste from the surrounding environment. Maintaining the quality of the growth media is a new challenge in the cultivation system for organic crops. A novel concept is utilizing a hydroponic cultivation system using organic nutrients to ensure the quality of organic vegetables. Bok choy, water spinach and spinach are the most widely consumed vegetables in Indonesia. These three vegetables are widely cultivated hydroponically and organically. Hydroponic cultivation requires nutrients in the form of a solution. According to Upendri and Karunarathna (2021), a nu-

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trient solution is one of the most critical factors in determining the yield and quality of hydroponic products. Furthermore, organic hydroponic planting ensures the quality of organic products is maintained 100% organic. Highly efficient circular agriculture will be implemented by using organic fertilizers. The use of organic fertilizer in hydroponics can prevent soil-borne bacterial diseases (Ginting 2010), the consumption of agricultural chemicals can be reduced, and improve the quality of such vegetables (Kano et al. 2021).

Bio urine (fermented urine) is liquid organic fertilizer. Obtained from ruminants such as cows, buffalo, goats, and others through an anaerobic fermentation process. The fermentation process employs nitrogen-fixing microbes and other decomposer microbes, resulting in a greater nitrogen content after fermentation than urine without fermentation (Hidayati et al. 2011; Pramana et al. 2019). Previous research has shown that urine-derived fertilizers can be applied successfully in a hydroponics environment (El-Nakhel et al. 2021; Jurga et al. 2021; Van Gerrewey et al. 2021). Organic liquid fertilizer derived from cow bio urine is an alternative to replace nutrients in hydroponic cultivation.

Cow bio urine can boost the availability, adequacy, and efficiency of nutrient uptake for plants containing microorganisms to minimize the use of inorganic fertilizers (N, P, K) and maximize crop yields. The previous study demonstrated that cow bio urine contains beneficial macro and microelements such as Nitrogen (N) 0.52%, Phosphorus (P) 0.01% and Potassium (K) 0.56%, as well as humic acid, fulvic acid, and growth hormones to promote plant growth (Purwanto et al. 2015). Cow bio urine as an liquid organic fertilizer has previously been used on organic cultivation with soil media. It significantly affected plant growth and yield of shallots, Japanese spinach (*Spinacia oleracea*), gai lan (*Brassica oleracea*) (Suwardike et al. 2019; Tandi et al. 2015; Puspita et al. 2015).The provision of liquid organic fertilizers, such as cow bio urine, is one way to get healthier organic water spinach without adding inorganic fertilizers since the bio urine has adequate nutrients for plant growth (Dharmayanti et al. 2013). These nutrients are essential for plant growth, especially vegetable crops. Cow bio urine as an organic fertilizer provides advantages such as being relatively cheap, easy to obtain, and simple to apply. It is very easy to use by small farmers. Based on the description of the background above, research was conducted to determine the effect of the concentration of bio urine as a substitute for nutrients in the hydroponic system and determine the best concentration of bio urine for the growth and yield of bok choy, spinach, and water spinach.

Material and methods

The research was conducted in the greenhouse of the Faculty of Agriculture and Business, Mahasaraswati University, Denpasar, Indonesia. The hydroponic system was placed in a greenhouse with natural temperature and sunlight, using a split-plot in a randomized complete block design (RCBD) with 4 replications. The main plot consisted of 3 different vegetables: bok choy (V_1), spinach (V_2), and water spinach (V_3). There were 5 different concentrations of cow bio urine solutions in the subplot: 10% (C1), 20% (C2), 30% (C3), 40% (C4), and 50% (C5). In the hydrophonic nutrient solution, the formula for the concentration above was:

C1: 100 ml of cow bio urine + 900 ml distilled water
C2: 200 ml of cow bio urine + 800 ml distilled water
C3: 300 ml of cow bio urine + 700 ml distilled water
C4: 400 ml of cow bio urine + 600 ml distilled water
C5: 500 ml of cow bio urine + 500 ml distilled water

The vegetable seedlings at one week old were transferred to bottle media filled with different concentrations of cow bio urine as per the treatment. The seedlings with 4 leaves seedlings were used in the experiment. The cow bio urine were applied every 8 days until harvesting: first application (700 ml) and 8 day

after transplanting (DAT), 16 DAT, 24 DAT (100 ml) and TDS and pH was measured at 8 DAT, 16 DAT, 24 DAT and 32 DAT. The measurement aims to assess the quality of the hydroponic solution used during plant growth. The effects of each treatment on the growth of bok choy, spinach and water spinach were recorded by measuring plant growth parameters as follows: foliage number and leaf area, foliage dry weight, root dry weight, total fresh weight, total dry weight, foliage fresh weight. Foliage number is the number of leaves by counting all the leaves on the plant. Leaf area, the method used is by calculating the total area of plots (mm column) which is covered by the leaf area placed on the column millimeter sheet. Foliage and root dry weight is obtained by weighing plant leaves and root, which has been dried in the oven at 70°C until it, reaches constant weight. Foliage fresh weight is obtained by weighing plant leaves.

Cow Bio urine production

Cow bio urine was prepared using 20 liters of raw cow urine, 40 kg of cow feces, 2 liters enriched microbes (EM4), and 2 liters of molasses put in a drum containing 400 liters of water fermented for 10 days. EM4 is a bio-activator solution that includes several types of microorganisms and is applied to enhance organic matter decomposition during fermentation. The microbial consortia included *Lactobacillus sp* (decomposers), Cyanobacteria (photosynthetic bacteria), *Pseudomonas sp* (phosphorus solubilizing bacteria-PSB), and *Streptomyces* fungi (cellulose decomposing fungi).

The cow bio urine was analyzed at the Soil Laboratory facilities of Udayana University, and the raw cow urine and cow bio urine (fermented cow urine) properties are listed in Table 1. The nutritional content of cow urine was compared before and after the fermentation process. The analysis revealed that fermented cow urine (cow bio urine) contained more nutrients than raw cow urine. Nutrition is vital in hydroponic cultivation since it determines the success of plant growth and development. The result was in accordance with the analysis of cow bio urine applied to rubber seedlings by Sari et al. (2017). The nutritional value of cow bio urine is determined by the foods consumed and the ingredients added during fermentation.

Table 1 The results of the analysis of the nutritional content of cow urine before and after fermentation

Observed parameters	Before	After
N (%)	1.0	2.8
P (%)	0.5	2.4
K (%)	1.5	3.8
Ca (%)	1.2	5.8
Mg (%)	0.2	7.2
pH	7.2	8.2
Colour	Yellow	Black
Smell	Fishy/pungent	Less pungent

Design of the hydroponic system

A Wick based hydroponic system was used for the experiment (Fig. 1a, 1b and 1c). The flannel wick helped to absorb water and nutrients to the plant roots. The next step involved the preparation of rockwool measuring 30 cm x 10 cm as a seed-planting medium. Then, it was cut into a 2 cm x 2 cm square hole, and each box was perforated with a 1 cm depth. The steps were conducted to aid in the seeding process. Additionally, the seeds were inserted into the holes in the rockwool boxes, with each hole containing only one vegetable seed under study. The seeds were kept watered and moist in a dark location.

This research reused 1.5 l plastic mineral water bottles as containers for hydroponics. The bottles were painted black to prevent weed (moss) growth and avoid nutrient competition. The bottle was cut using a cutter to accommodate 800 ml solution. The treatment solutions were made by mixing the cow bio urine with distilled water as per the required concentrations, according to the tested treatment.

a b c

Fig. 1 a) The seedlings placed in the hydroponic systems; b) Growth of bok choy after 21 days of transplanting; c) General view of the top of hydroponic system along with the wick used for growing seedlings

Data analysis

Analysis of variance (ANOVA) was performed using Statistical Tools for Agricultural Research (STAR) software. The significance of the means was analyzed with Duncan's tests or LSD test between treatments at $p<0.05$, respectively. Regression analyses were made using Microsoft Excel.

Results and discussion

pH and TDS cow bio urine solution during growth

Seedlings were measured at eight days intervals until the end of the experiment at 32 days after planting (DAP). The concentration changes in bio urine solution during crop growth are shown in Table 2. The total dissolved solids (TDS) values of the cow bio urine solution were lowest at 1100.5 and highest at 1121.25 ppm, with a pH range of 6.4 to 7.1, as shown in Table 2. The C5 had the highest TDS in each observation. The TDS in C5 was between 1100 and 1150 ppm, allowing plants – mainly vegetables to absorb it, and its pH was 6.9-7.0 (Table 2). Adelia et al. (2013) reported that high TDS increases and accelerates nutrient absorption. The optimal TDS values vary between 1500 ppm and 2000 ppm. The enhancement and reduction in pH during growth indicate the change in the ratio of NH_4-N to NO_3-N in nutrient solutions (Jones 2005; Ezziddine et al. 2021). We have not observed any change of NH_4-N to NO_3-N in cow bio urine nutrient solution. The cow bio urine solution has met the requirements and can be used as a good hydroponic organic nutrient solution.

Table 2 Total Dissolved Solid (TDS) of cow bio urine during plant growth, pH of cow bio urine solution during growth

Treatment	TDS (ppm)				pH			
	8 DAT	16 DAT	24 DAT	32 DAT	8 DAT	16 DAT	24 DAP	32 DAT
C_1 – 10% cow bio urine	1001.50	1001.50	1001.50	1001.50	6.4	6.5	6.5	6.5
C_2– 20% cow bio urine	1003.25	1003.25	1003.25	1005.25	6.5	6.5	6.5	6.5
C_3– 30% cow bio urine	1004.82	1004.82	1006.82	1006.80	6.6	6.6	6.6	6.7
C_4– 40% cow bio urine	1007.25	1007.25	1007.25	1009.50	6.8	6.8	6.9	6.9
C_5– 50% cow bio urine	1112.45	1112.45	1112.50	1121.25	6.9	6.9	7.0	7.0

Growth of spinach, bok choy, and water spinach

According to Bustami et al. (2012), the dry weight of the plant reflects the nutrient status, the number of nutrients absorbed by the plant, and the photosynthesis rate. Lakitan (2012) mentioned that adequate nutrients available in plants would increase leaf area. Hence, the photosynthate allocated for forming vegetative organs such as leaves would increase. The C5 concentration significantly had the greatest fresh weight for all three vegetables 61.6 g of bok choy, 82.58 g of spinach, and 47.2 g of water spinach; and the highest dry weight 3.59 g of bok choy, 15.05 g of spinach, and 13.93 g of water spinach (Fig. 2a, 2b, 2c). Thus, increasing the concentration of the cow bio urine increases both the dry and fresh weight. However further research is required to determine the maximum concentration in each plant.

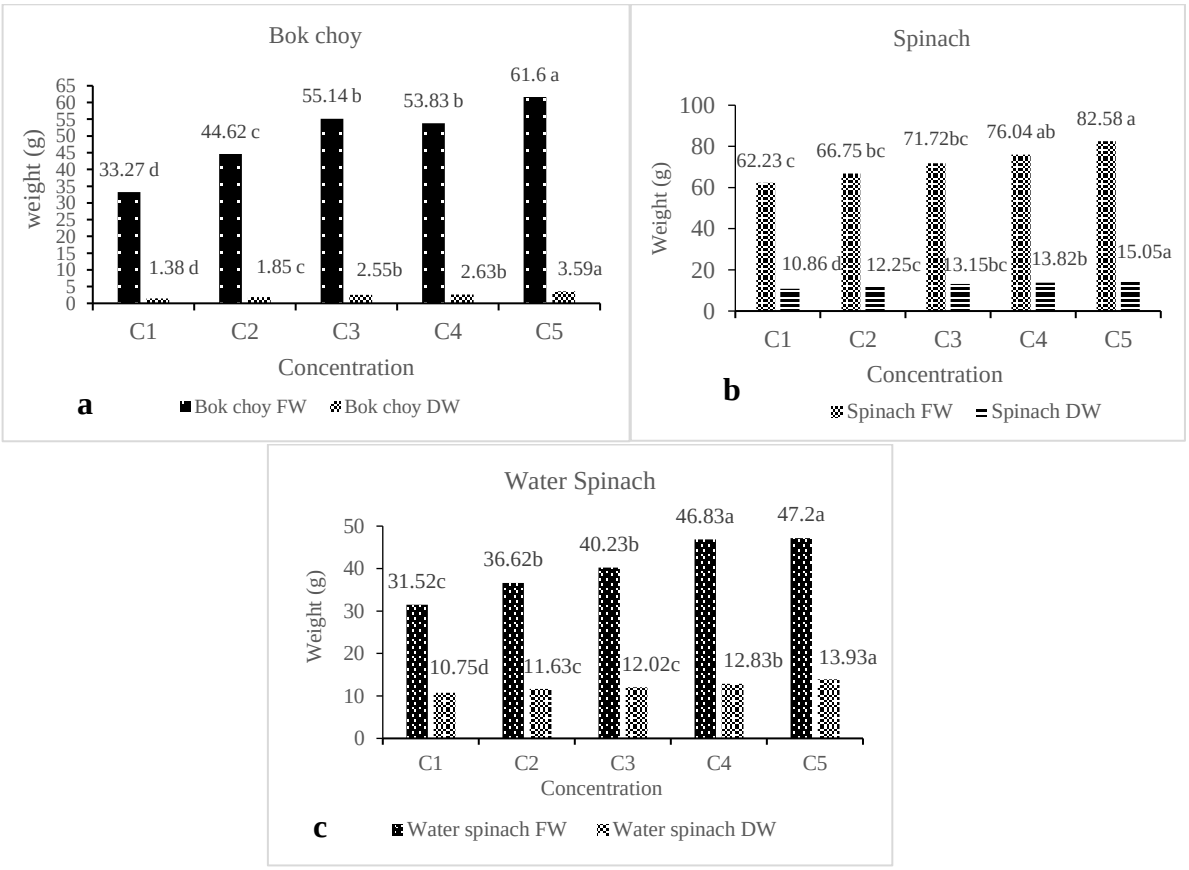

Fig. 2 The changes in total fresh weight (FW) and total dry weight (DW) of bok choy (a), spinach (b) and water spinach (c) at various concentrations based on LSD testat the 5% level

Table 3 demonstrates that the cow bio urine at a concentration of C5 significantly produced the highest number of leaves on bok choy, spinach, and water spinach, as well as the widest leaf area and the tallest plant for the three types of vegetables. The foliage number, leaf area, foliage dry weight, and root dry weight were measured once at the 32 DAP (Tables 3 and 4). The growth parameters increased proportionally to the concentration of cow bio urine in all three vegetables. The application of cow bio urine to mustard greens significantly affected the parameters of plant height, number of leaves, leaf area, root fresh weight, and foliage fresh weight (Setiawan et al. 2013; Sholikin et al. 2014; Siregar 2017).

Several other research on planting media also suggested that cow bio urine significantly affected bok choy and water spinach grown in hydroponic media (Septiani 2018).

Table 3 The effect of the nutrient concentration of cow bio urine with the type of vegetables on the foliage number and leaf area

Concentration	Variable											
	Foliage number						Leaf area (cm^2)					
	Bok choy		Spin-ach		Water spinach		Bok choy		Spin-ach		Water spinach	
C_1 – 10% cow bio urine	12.75	c	10.25	b	26.00	e	230.66	c	302.65	c	669.13	d
C_2– 20% cow bio urine	19.50	b	10.75	b	30.25	d	372.67	b	316.99	c	719.32	c d
C_3– 30% cow bio urine	19.00	b	12.25	ab	32.50	c	419.69	b a	418.33	b	772.81	c
C_4– 40% cow bio urine	19.50	b	13.25	ab	38.00	b	426.96	b a	584.18	a	851.42	b
C_5– 50% cow bio urine	21.50	a	14.00	a	42.50	a	458.19	a	644.61	a	966.92	a
Mean			21.47						543.63			
CV (%)			6.24						7.87			
Duncan (5%)			1.79						1830.89			

The numbers followed by the same letter are not significantly different in the DMRT test at the 5% level

Table 4 Foliage dry weight and root dry weight at different concentrations of cow bio urine

Concentration	Variable											
	Foliage dry weight (g)						Root dry weight (g)					
	Bok choy		Spin-ach		Water Spinach		Bok choy		Spin-ach		Water spinach	
C_1 – 10% cow bio urine	1.24	d	6.87	d	6.40	c	0.14	a	3.99	c	4.36	d
C_2– 20% cow bio urine	1.69	c	7.45	c	6.54	c	0.16	a	4.80	b	5.09	c
C_3– 30% cow bio urine	2.38	b	8.45	b	6.70	bc	0.17	a	4.71	b	5.32	c
C_4– 40% cow bio urine	2.46	b	8.72	b	6.98	bc	0.17	a	5.10	ab	5.85	b
C_5– 50% cow bio urine	3.42	a	9.61	a	7.61	a	0.18	a	5.45	a	6.32	a
Mean			5.77						29.98			
CV (%)			4.07						3.45			
Duncan (5%)			0.06						0.149			

The numbers followed by the same letter are not significantly different in the DMRT test at the 5% level

Fig. 3a and 3b shows that the three vegetables total dry weight and foliage fresh weight tended to increase. Fig. 3b depicts that bok choy was responsive to the increased concentration of cow bio urine in a steep regression line. Meanwhile, spinach and water spinach remained unchanged. The fresh weight of spinach and water spinach foliage, which were slightly stagnant, indicated that the solution concentration had not yet reached the saturation point.

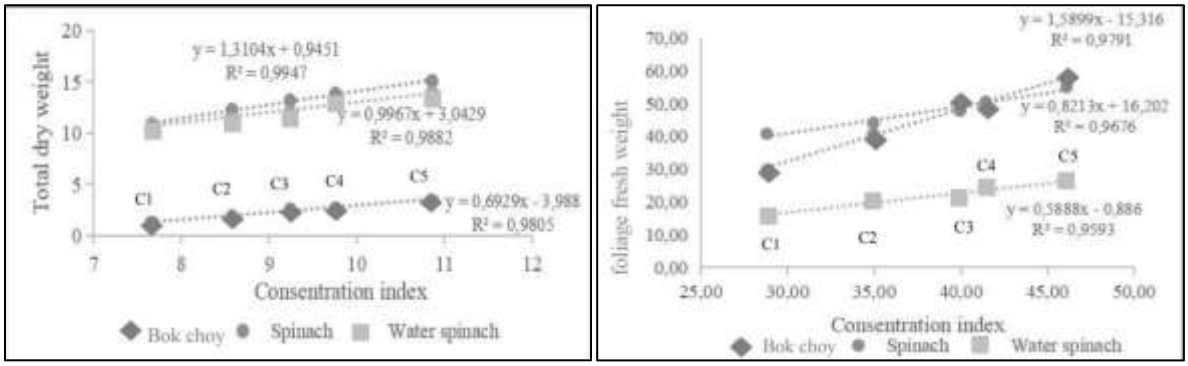

Fig. 3 Character slope curve (a) total dry weight and (b) foliage fresh weight (yield)

When growing the three types of vegetables with cow bio urine, the yield and quality were close to the reference commercial hydroponic fertilizer solution. There is still potential to improve foliage fresh weight in three vegetables by increasing the concentration of cow bio urine solution. Cow bio urine includes hormones that can stimulate plant growth and development, as well as more N, P, and K than solid cow manure (Sutari 2010; Yunita 2011; Aisyah et al. 2011; Rizki et al. 2014; Purwanto et al. 2015). The concentration of Indole Acetic Acid (IAA) in cow bio urine is 704.26 mg/l (Sutari 2010).

Organic nutrients derived from plants and animals cannot be absorbed directly by plants, unlike inorganic nutrients, and must undergo a microbial fermentation process to be converted into absorbable forms (Bi et al. 2010). This is a challenge in using organic fertilizers, where the rate of nutrient release may not match the nutritional needs of plants, necessitating continuous adjustment of the hydroponic system and substrate media to increase microbial activity and achieve an optimal decomposition of organic matter available for plant absorption (Burnett et al. 2016). This study's organic hydroponic cultivation technique is a simple hydroponic, suitable for small farmers and the community. The advantages of this organic hydroponic system are its simplicity, inexpensive, use of eco-friendly materials, easy to obtain, and independence from electricity.

Conclusion

The concentration of cow bio urine significantly affected all experimental parameters. The highest plant growth and yield were obtained at 50% cow bio urine (C5) concentration for all types of vegetables studied. There was an interaction between the concentration of bio urine and the types of vegetables on the parameters of maximum leaf number, leaf area, foliage dry weight, root dry weight, total dry weight, and foliage fresh weight. The highest fresh weight of foliage for each vegetable was 57.02 g (C5) for bok choy, 54.97 g (C5) for spinach, and 26.29 g (C5) for water spinach. The regression analysis revealed that the optimal concentration of cow bio urine for bok choy, spinach, and water spinach had not been found yet.

It is necessary to conduct further research using a wider range of cow bio urine concentrations and other cultivated plants to obtain the optimal concentration of

bio urine as a nutrient for organic hydroponic plants. In hydroponics, it is also required to assess the toxicity and pathogen content in cow bio urine solutions.Regarding the nutritional content of livestock bio urine, it would be interesting to conduct more studies on the content and effect of bio urine from various livestock urine ingredients.

Compliance with ethical standards

Conflict of interest: The authors declare that there are no conflicts of interest associated with this study.

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