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Composting Potato Crop Residues with Rumen Wastes

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Abstract: *This experiment was conducted in the field at Candikuning village, Tabanan regency, Bali, Indonesia, to investigate the rate of composting potato crop residues (pcr), added-soils (as) and cow rumen wastes (crw) and to analysis the nutrients of the mature compost. Composting was performed using Indore pit method. Six treatments imposed were 1) mixture of pcr+as(1:3 v/v) (R_0ka); 2) mixture of pcr+as(2:2 v/v) (R_0kb); 3) mixture of pcr + as (3:1 v/v) (R_0kc); 4) mixture of pcr + as (1:3 v/v) + crw (R_1ka); 5) mixture of pcr + as (2:2 v/v) + crw (R_1kb); 6) mixture of pcr + as (3:1 v/v) + crw (R_1kc). Treatments were arranged in a randomized complete block design with four replications. Results of the experiment indicated that adding cow rumen wastes into mixture of pcr + added-soils (3:1 v/v) (R_1kc) resulted in the fastest composting as 9.0% higher media weight loss observed at 58.0 DAD (days after decomposition started) compared control(R_0kc). Adding cow rumen wastes and added-soils increased important nutrients (C-organic, total-N, total-K), except available-P in mature compost produced. The R_1kc treatment gave the highest content of those nutrients in composts, suggesting it is effective to apply particularly in potato farming.*

Keywords: *Composting, Potato Crop Residues, Rumen Wastes*

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I. Introduction

Potatocropresiduesare partsofpotato plants thoseareusuallyneglectedafter the tubers areharvested. Those parts includeupperleaves and stems, roots and remaining (non economic) tubers. In potatofarming area at Candikuningvillage, Tabananregencyof Bali province the availabilityofpotatocropresiduesincluding remaining tubers is huge (±24.35 tonnes ha^{-1}) (perscomm). These parts of the crop, which are in fact absorbed and used soil nutrients, eventually are not economically counted. Composting, therefore, is an alternative way to make use of those neglegted potato crop residues, although it needs time and energy. Depending on C/N ratio of biomass the microbes may take longer time to decompose the organic materials, therefore addition of microbial inoculums is needed to decrease duration of composting process as well as to improve quality of mature compost[1].Rumen is part of digestion system in ruminant where the microbial fermentation occurs[2]. In Indonesia and other developing countries, these slaughterhouse wastes (especially cow rumens) are frequently disposed into drainage system that can cause environmental pollutions due to pathogens and excess nutrients introduced into surface and ground water[3,4]. On the other hand, rumen wastes may be useful as an activator in organic decomposition for compost or biogas production through anaerobic fermentation. Cow rumen wastes are known as one of potential compost activator sources[5] in producing compost from *Leucaenaleucocephala* leaves[6]. Composts produced from sugar palm with cow rumen activator was also reported as an effective treatment for sweet corn cultivation in coastal sandy soil of Samas Beach, Bantul, Indonesia[7]. Concentrations of N, Mg, and S in leaves, as well as the relative chlorophyll content were increased and the yield of corn plants were boosted after application of organic compost derived from wastes of the breeding and slaughter of small ruminants[8]. Higher content of organic-C, total-N, available P, and total-K were found in mature composts, derived from mixture of cow rumen wastes and potato crop residues compared to without rumen wastes[9]. In cow's rumen, bacteria, protozoa, and fungi are exist together with bacteria handle more than half of the rumen's digestive work. Therefore, due to microbe functions and their rich nutrition contents, cow rumen wastes, are expected to increase the rate of composting. In Indore pit method[10] an amount of soils has to be added into organic compost materials to increase volume and to reduce moisture content as well as humidity for better texture of mature compost produced. In addition, added-soil may contain nutrients and microbes that could function as starter in decomposition of compost media. Humus formations and activities of earthworms are also facilitated by added-soils[11]. However, information on the amount of added-soils needed to produce better quality composts is limited. The use of rumen wastes have been studied on composting plant residues[6,7] however limited study was done on potato crop residues. The objective of this experiment was to investigate the effects of adding cow rumen wastes (crw) into mixed potato crop residues (pcr) and added-soils (as) on rate of composting and the nutrients of the mature compost produced.

II. Material And Methods

ExperimentLocation andTreatments

A field experiment was conducted in Pemuteran village, district of Baturiti, Tabanan regency, Bali province from April until July 2017. The location was ± 1287 m asl at $8^0 28' 81''$SL and $115^0 15' 39''$ ELPotato crop residues (leaves and stems, roots and the remaining tubers) of Granola variety, added soils and cow rumen wastes (collected from the slaughter house of Sudimaravillage,Tabanan, Bali) were prepared as experiment materials.The experimentwasdesigned as randomizedcompleteblock with four replications. The treatments were 1) mixture of potato crop residues (pcr)+added-soil (as) (1 : 3v/v) (R_0ka); 2) mixture of pcr+as(2 : 2v/v) (R_0kb); 3) mixture of pcr+as(3 : 1v/v) (R_0kc); 4) mixture of pcr +as (1 : 3v/v)+cow rumen wastes (crw) (R_1ka); 5) mixture of pcr+as(2 : 2v/v)+crw (R_1kb); 6) mixture of pcr+as(3 : 1v/v)+crw (R_1kc). Notes: pcr (potato crop residues); as (added-soils); crw (cow rumen wastes).

Composting

Composting was conducted using Indore pit method[10]. Chopped of potato crop residues at 10 cm long were put into composting holes of 150 cm length, 100 cm width and 100 cm depth with six divisions of inside-compartments of 50 cm length, 50 cm width and 100 cm depth.The position of holes were kept secure from any possible waterlogging. The material composition for each treatment were prepared as follows: for R_0ka (10 kg pcr+ 30 kg as); R_0kb (0 kg pcr+ 20 kg as); R_0kc (30 kg pcr+ 10 kg as); R_1ka (10 kgpcr+ 30 kg as + 5 kg crw; R_1kb (20 kg pcr+ 20 kg as + 5 kgcrw; R_1kc (30 kg pcr + 10 kg as+ 5 kgcrw). All components were mixed thoroughly in each compartment according to the treatments.

Observation and measurements

Compost is considered mature if it has solid texture and dark brown color. During the process pattern of temperature and pH was observed at 20 cm depth inside the compost pile (respectively using digital thermometer and pH meter calibrated in potentiometricmethod) daily until mature compost was produced (when temperature of compost was equal to air temperature and pH was neutral)[11]. The rate of decomposition was indicated by percentage of media weight loss, calculated using the following equation:

A–B = C/B x 100 %............................... 1)

where A= initial weightof composting media; B = weight of mature compost ;C = different of A-B. Lignin and cellulose, polyphenol and carbohydrates, proteins, fats of potato crop residues as well as of cow rumen wastes were analyzed in the laboratories (Table 1, Table 2). Total bacteria and fungi population were counted using plate count method with dilution of NA and PDA media[12] (Table 5). The measurement was conducted at time when maximum temperature of composting media was achieved. Chemical properties of added soils (Table 3) and those of compost were also analyzed (Table 6).

Statistical Analysis

Datawere collected and statisticallyanalyzed in ANOVA usingCOSTAT computer software(COHORT, Monterey, California). Mean comparisons for significant effects of individual treatment factor were calculated using 5% Duncan Multiple Range Test.

III. Result

Properties of potato crop residues, cow rumen wastes and added soils

The remaining tubers contained the highest contents of organic-C, C/N ratio; organic matters and carbohydrates, while leaf biomass contained the highest total-N, lignin, proteins, fats and ashes. Stem biomass had the highest celluloses, while the highest polyphenol contents was found in the roots (Table 1). Carbohydrates was the primary content in cow rumens (Table 2), while varied nutrients and microbes (with fungi dominant) were recorded in the added soil (Table 3).

Table 1. Properties of potato crop residues

Properties	Potato crop residues			
(%)	leave	stem	root	Remaining tuber
Organic-C	15.4	25.2	25.0	32.4
Total-N	2.1	1.3	1.5	1.3
C/N Ratio	7.0	20.0	16.0	25.0
Lignins	15.4	10.3	13.7	7.1
Polyphenols	3.3	2.5	5.3	4.3
Celluloses	29.8	39.7	34.8	5.6

Proteins	13.7	6.2	10.2	7.5
Carbohydrates	33.6	57.8	65.6	78.4

Sources: Soil Chemical Lab., Soil Biology Lab., Quality Evaluation and Food Security BrawijayaUniversity, Indonesia.

Table 2. Chemical properties of cow rumen wastes

Properties (%)	values
Proteins	9.9
Fats	2.3
Carbohydrates	54.7

Source: Service Lab. Unit, Fac. of Agricultural Technology, Udayana University, Indonesia.

Table 3. Properties of added-soils

Properties	Values
Organic-C (%)	1.8
Total-N(%)	0.2
Available- P (ppm)	2.9
Available-K	0.9
Total Bacteria (Cfu/g)	9.10^4
Total Fungi (Cfu/g)	13.10^4

Source: Testing Lab., Balittro, Bogor, Indonesia andMicrobiology Lab., MIPA Udayana University,Indonesia.

Effects of treatments on the rate of composting and quality of composts

Compost's max temperature, Duration to achieve max temperature, Duration to produce mature compost, Temperature andpH of mature composts, and Percentage of media weight loss

The highest maximum temperature of composts (57.6^{0}C) was recorded at treatment of adding cow rumen wastes into mixture of pcr + as (3:1 v/v) (R_1kc) (Table 4). That was achieved for 10.7 DAD (days after decomposition started), which was two days earlier than that under treatment without cow rumen wastes (R_0kc) and maximum temperature of composts was lower (48.2^{0}C). At the time when mature composts was achieved, the pH of composts (± 7.0) was not different among all treatments. Mature compost was determined by percentage of media weight loss. The highest percentage of media weight loss was recorded at treatment of adding cow rumen wastes into the mixture of pcr+as (3:1 v/v) (R_1kc) (55.2%), which occurred at 58.0 DAD. That weight loss of media was9.0% higher than those without adding cow rumen wastes at the same mixture of media (pcr+as) (R_0kc) (Table 4).

Table 4. Effect of treatments on maximum temperature, duration to achieve max temp and duration to produce mature compost, and percentage of media weight loss

Treatments	Max. temp. of compost (^{o}C)	Duration to achieve max temp. (*DAD)	Duration to produce mature compost (*DAD)	% of media wt loss(%)
R_0ka	44.7 e	8.7 c	39.5 d	14.4 f
R_0kb	46.2 d	9.5 c	46.2 c	33.7 d
R_0kc	48.2 c	12.7 a	64.5 a	50.6 b
R_1ka	48.5 c	7.2 d	36.2 e	20.3 e
R_1kb	53.3 b	8.5 c	44.5 c	38.1 c
R_1kc	57.6 a	10.7 b	58.0 b	55.2 a

Notes: Numbers in column followed by the same letter (s) are not significantly different at 5% DMRT. *DAD: days after decomposition started.
Treatments: 1) R_0ka: pcr (potato crop residues) + added-soil (as) (1:3 v/v); 2) R_0kb: pcr + as (2:2 v/v); 3) R_0kc:pcr + as (3:1 v/v); 4) R_1kapcr + as (1:3 v/v) + cwr (cow rumen wastes); 5) R_1kbpcr + as (2:2 v/v) +cwr; 6) R_1kc:pcr + as (3:1 v/v) +cwr.

Total bacteria and fungi at the highest temperature of composting media

The highesttotal bacteria as well as fungi were found at the treatment of adding cow rumen wastes into mixture of pcr+as (3:1 v/v) (R_1kc) (Table 5).

Table 5. Effect of treatments on total bacteria and fungi at the highest temperature

Treatments	Total bacteria (Cfu/g) x10^6	Total fungi (Cfu/g) x 10^6
R_0ka	0.10 b	0.02 b
R_0kb	1.40 b	0.70 b
R_0kc	2.33 b	3.00 b

R_1ka	4.33 b	7.00 b
R_1kb	47.33 b	19.00 b
R_1kc	240.67 a	99.67 a

Notes: Numbers in column followed by the same letter (s) are not significantly different at 5% DMRT.
Treatments: 1) R_0ka: pcr (potato crop residues) + added-soil (as) (1:3 v/v); 2) R_0kb: pcr + as (2:2 v/v); 3) R_0kc:pcr + as (3:1 v/v); 4) R_1kapcr + as (1:3 v/v) + cwr (cow rumen wastes); 5) R_1kbpcr + as (2:2 v/v) +cwr; 6) R_1kc:pcr + as (3:1 v/v) +cwr.

Chemical properties of composts

Treatment of mixture of pcr+as (3:1 v/v) (R_1kc) significantly gave the highest content of organic-C, Total-N and total-K compared to the other treatments. C/N ratio under this treatment was slightly higher than in treatment with no rumen wastes (R_0kc) (Table 6). There was no significant difference in available-P of composts among treatments.

Table 6. EffectoftreatmentsonOrganic-C,total-N, C/N ratioof composts, available-P andtotal-K of composts

Treatments	Organic-C (%)	Total-N (%)	C/N ratio	Available-P- (ppm)	Total-K (%)
R_0ka	2.9 d	0.3 d	8.3 a	12.2 a	5.4 c
R_0kb	3.0 d	0.5 c	6.7 b	12.6 a	8.5bc
R_0kc	3.8 c	0.6 b	6.7 b	14.6 a	10.8bc
R_1ka	3.6 c	0.4 d	9.3 a	14.2 a	10.8bc
R_1kb	4.5 b	0.5 c	8.7 a	19.1 a	18.2ab
R_1kc	6.0 a	0.7 a	9.0 a	21.7a	26.1 a

Notes: Numbers in column followed by the same letter (s) are not significantly different at 5% DMRT.
Treatments: 1) R_0ka: pcr (potato crop residues) + added-soil (as) (1:3 v/v); 2) R_0kb: pcr + as (2:2 v/v); 3) R_0kc:pcr + as (3:1 v/v); 4) R_1kapcr + as (1:3 v/v) + cwr (cow rumen wastes); 5) R_1kbpcr + as (2:2 v/v) +cwr; 6) R_1kc:pcr + as (3:1 v/v) +cwr.

IV. Discussion

Addition of cow rumen wastes (crw) and added-soils (as) into composting media of potato crop residues (pcr) was significantly ($p<0.05$) effective to increase the rate of composting. This was indicated by the highest (55.2%) reduction of composting media occured at 58.0 DAD (days after decomposition started) as showed by treatment of R_1kc [pcr +as (3 : 1 v/v)] + cow rumen wastescompared to the other teratments (Table 4). The ruminal content of cattle was reported rich in microbes[13]. In the present experiment, high population of bacteria and fungi recorded in the treatment of R_1kc at the highest temperature of composting (Table 5) may contribute to the decomposition. The amount of pcr, which was 3 times of added soils, in R_1kcavailableto the microbes. High population of bacteria and fungi need organic materials for their energy and foods[14] andtheir activities were determined by the amount of nutrients in organic materials[15]. Potato crop residues provided high amount of materials (such as organic-C, proteins, carbohydates, celluloses, polyphenols and lignins) (Table 1). Although there were some lignins and polyphenols, pcr had relatively low C/N ratio i.e 20 (in stems) and 25 (in the remaining tubers) (Table 1), which resulted in faster decomposition by microbes. It is well known that celluloses and lignin, have substances that are more difficult to decompose[16,17]. The optimum C/N ratio at the start of composting process should be below 30:1[18]. Cow rumen wastes themselves contained 54.7% of carbohydrates, besides small amounts of proteins and fats (Table 2), which may also increase the amount of organic materials of media.

Adding cow rumen wastes and added-soils into potato crop residues also significantly resulted in higher amount of nutrients in compost produced than non- rumen wastes and added-soils. C-organic content increased by 19.5%; 33.5% and 35.7% in R_1ka, R_1kb, R_1kc treatments(Table 6). Total-N and total-K of R_1kc were 16.2 % and 58.7 % respectively higher than those of R_0kc.The treatment of mixture of pcr + as (3 : 1 v/v) + cwr (R_1kc) released the highest amount of important nutrients than the other treatments (Table 6). Those higher amounts of nutrients were associated with high qualities of properties of potato crop residues (Table 1), added-soils (Table 3) as well as cow rumen wastes (Table 2). Although C/N ratio under this treatment was slightly higher than in treatment with no rumen wastes (R_0kc) (Table 6), the ratio was less than 10.0.That was due to higher organic–C as well as total-N in R_1kctreatment.High organic-C and N supplied by potato crop residues (Table 1) and added-soils (Table 3) were needed by microorganisms as energy sources and to form proteins respectively. Carbohydrates, proteins, fats, lignin, celluloses and polyphenols contained in the composting media (Table 1) were broken down into higher C and N (Table 6), K and P elements (Table 7). In the early stage, carbohydrates and proteins were degraded faster followed by lignin, fats, celluloses and polyphenol[19]. Some nutrients contained in added-soils (N, P and K) (Table 3) may also contribute to higher nutrients in compost resulted from adding cow rumen wastes and added-soils.

Increased nutrient content in matured composts resulted from adding cow rumen wastes into potato crop residues was also reported[9]. In the present experiment, however, adding cow rumen wastes did not gave any significant different effect on available-P of compost (Table 7). That may be associated with small amount of phosphorus contained in cow rumen wastes due to low utilization efficiency of dietary P in cow, which resulted in around 80% of the P consumed to be excreted[20]. In addition, phosphorus forms, availability and quantities as well as changes in phosphorus fraction during organic composting were determined by types of animal sources[21].

V. Conclusion

Cow rumen wastes and added-soils significantly ($p<0.05$) increased the rate of composting of potato crop residues. Treatment of adding cow rumen wastes into mixture of potato crop residues + added-soils (3:1 v/v) (R1kc) resulted in the fastest composting indicated by 9.0% higher media weight loss observed at 58.0 DAD compared to those without cow rumen wastes at the same mixture of media (pcr+as) (R0kc). Adding cow rumen wastes and added soils also significantly ($p<0.05$) increased important nutrients (C-organic, total-N, total-K), except available-P, in mature compost produced.

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