Animal Production

Utility, significance and benefits of cattle dung in rural Bhutan

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ABSTRACT

The study was carried out to determine dung production from dairy cattle and its economic value in Sarpang *dzongkhag* (district). Thirty Jersey cross (JX) cattle with stall feeding system and 40 households were randomly selected for the study. Same diet comprising of straw and concentrate was fed to animals. The mean fresh dung output per day from JX cow was 14kg and faecal dry matter output was 2.50kg. The mean N output per day was 0.10kg. There was a significant relationship between feed intake and dung output per day. However, the dung output was negatively correlated with live body weight of the animal. The dietary nutrient intake and dung output were major factors affecting faecal N output. The amount of fresh dung used as fertilizer and for biogas production in Sarpang *dzongkhag* were 12,117kg and 12,912kg per annum, respectively. Cow dung as fertilizer and for biogas production had benefitted dairy farmers in the *dzongkhag* in terms of reducing cost. By replacing commercial fertilizer with the use of cow dung, the annual cost saved was Nu. 10,071, whereas the annual cost saved by replacing Liquefied Petroleum Gas (LPG) was Nu. 2,664. The study concluded that cow dung has economic value in the lives of rural Bhutanese.

INTRODUCTION

Sustainable development encompasses intervention that is socially acceptable, economically viable and environmentally friendly and, offers great prospects for future development, without leaving any environmental footprints (Kushid 2009). Countries that have adopted sustainable development agenda are in fact on the right path towards achieving their national development objectives. Development and utilization of renewable resources is an excellent means to sustainable development. It can replace the fossil fuels and chemical fertilizers with cheap alternative source of energy and organic manure. Cow dung is one of the essential components of the animal manure that is widely used.

Cattle manure contains a variety of plant nutrients that are recycled in agronomic systems (Zhang et al. 2002). Therefore, animal manure has been an important fertilizer and soil conditioner. Dairy cows return significant quantities of nutrients to pastures through dung and urine. Haynes and Williams (1993) reported that, up to 65% of phosphorus (P) eaten in the diet is returned in faeces while approximately 11% and 79% of the consumed potassium (K) is returned in dung and urine, respectively. Most agricultural farms do not require commercial fertilizer if they use manure properly. In most cases, manure can supply all the nitrogen, phosphorus, potassium, and several other nutrients needed for crop production (Hart et al. 1997). Manure increases organic matter content, water holding capacity, plant nutrients and increases the efficiency of mineral fertilizer by improving the physical properties of the soil (Giller 2002). Vanlauwe et al. (2001) also reported that soil incorporated with cow dung supplies nitrogen, sulphur, phosphorus, and potassium to the plant.

Bhutan is an agrarian country with about 69% of population residing in the rural areas with majority of them engaged in subsistence farming (MoA 2009). Livestock rearing remains an important activity in this subsistence farming (MoA 2009). Besides economic benefits, livestock enterprise is critical to renewing the productive capacity of agriculture land resources. Traditionally, ruminants are an asset to the society by converting biomass from vast grazing areas into products useful for humans (Schiere et al. 2001).

Manure for field crops is one of the important reasons for Bhutanese farmers to continue rearing cattle despite their low productivity. However, manure production and draught power utilization from animals are ignored when animals are valued in economic terms for their production. The importance of animal manure will only increase as the country strives to go organic in agriculture production. Cow dung is also used for production of biogas in some parts of the country leading to reduced dependence on firewood and Liquefied Petroleum Gas (LPG). These utilities of animal wastes are not considered in the valuation of animals. Also, despite substantial quantity of manure produced, studies have not been conducted on contribution of livestock manure in terms of economic benefits. Therefore, a study was conducted with the objective to estimate dung production from dairy cattle and its economic value.

MATERIALS AND METHOD

Study sites

The study was conducted in Sarpang *dzongkhag* (district). Sarpang *dzongkhag* is situated in the southern foothills of Bhutan bordering the Indian state of Assam. Shompangkha and

Gakeling *gewogs* were selected for the study. In addition to Shompangkha and Gakeling *gewogs*, Chusegang, Dekiling and Gelephu *gewogs* were identified for the field survey.

Selection of dairy farms and animals

The list of all dairy farms with stall feeding system in Gakeling and Shompangkha *gewogs* was collected from records maintained with the Livestock Extension Centres (LECs) in two *gewogs*.

Thirty Jersey cross (JX) cows were randomly selected from eight farms with stall feeding system and numbers were assigned to all animals. The daily fresh dung output from each cow was collected and weighed for seven consecutive days. The ration for the experimental animals consisted of straw, fodder tree leaves, and concentrate feed that were provided based on body weight. Each of these feeds was weighed before feeding to the cows and same ration was included for thirty Jersey cross cows. Data was recorded daily for feed intake, dung output and number of defecation per cow per day.

Measurement of dung output

To quantify the dung output, the dung voided was collected from 30 dairy cows. The dung output estimation was carried out in the month of January and February 2013. The daily fresh dung output from each cow was collected and weighed for seven consecutive days. Dung, voided was weighed using a spring balance and plastic bucket. To estimate the defecation rate, the number of defecations per day from each cow was recorded for one week.

Laboratory analysis

About 10gm of fresh faecal samples were collected from 30 JX cows in clean sample vials with air tight cap. The samples were stored in cool pack in order to ensure that moisture content and volatile contents are not lost during transportation. The samples were analysed at the laboratory of the College of Natural Resources, Lobesa, Wangdue *dzongkhag*.

Dry matter and nutrient analysis

Proximate analysis (Henneberg and Stohmann 1865) was used to estimate the dry matter (DM) and ash contents. The DM and ash percentages were calculated as follows:

$$\mathrm{DM\%} = \frac{(\mathrm{B}-\mathrm{A})}{\mathrm{C}} \times 100$$

Where, A = Pan weight, B = Pan plus sample weight (after drying), C = Sample dry weight

$$\mathrm{Ash\%} = \frac{(\mathrm{B}-\mathrm{A})}{\mathrm{C}} \times 100$$

Where, A = Pan weight, B = Pan plus sample weight (after ashing), C = Sample dry weight

Nitrogen content determination

For determination of nitrogen content in dung, Kjeldahl method (Kjedahl 1883) was used. Nitrogen percentage was calculated using the following formula.

$$\mathrm{N\%} = \frac{1.401 \times (\mathrm{ml\ tritant} - \mathrm{ml\ blank}) \times (\mathrm{M(mol/L)HCl})}{\mathrm{Sample\ dry\ weigh} = \mathrm{t}}$$

The nitrogen output per year was estimated based on mean nitrogen output per day multiplied by 365 days.

Estimation of cow dung used for manure and biogas production

To estimate the annual use of cow dung by livestock farmers in Chuzagang, Dekiling, Gakeling, Gelephu and Shompangkha *gewogs*, a survey was conducted in the month of December 2012. For this purpose, 40 households owning improved breeds of cattle with stall feeding system were selected. Individual households were interviewed using a structured questionnaire. Prior to carrying out field survey, the questionnaire was pretested with two farmers in Shompangkha *gewog* for feasibility, applicability and consistency of the questions. The survey questions focused on the quantity of cow dung used as manure and for biogas production. Accordingly, the questions also focussed on cost saved annually for commercial fertilizers and LPG.

Determination of economic value of cow dung

After determining the dung and nitrogen output from the experimental animals, the quantity of nitrogen used annually by farmers from cow dung was calculated. The data on annual use of cow dung by livestock farmers was obtained from the survey carried out with 40 households in Sarpang *dzongkhag*. The economic value was calculated based on economic benefits derived by not having to spend on equivalent quantity of commercial nitrogen fertilizer and LPG gas.

Data analysis

The data obtained from field were processed in Microsoft Excel and analysed using the Statistical Package for Social Science (SPSS) version 16. Descriptive statistics was used to estimate the mean of dung output, nitrogen output, faecal dry matter content, live body weight of the animal and quantity of dung used by farmers. Pearson's correlation coefficient test was used to find the correlation among variables such as faecal nitrogen output, dung output, and feed intake.

RESULTS AND DISCUSSION

Dung output

The mean fresh dung output per day from one JX cow was 14.57±3.16kg (Table 1). On an average, one cow defecated 5±0.55 times a day and the fresh dung output per defecation was 2.90±0.42kg. The faecal dry matter content per day was 2.49±0.65kg. The total annual fresh dung output from a JX cow was estimated about 5318kg. However, Knowlton et al. (2010) reported that the fresh faecal or dung evacuation rate (dung production per day) and faecal dry matter output per day from a Jersey cow were 33.6 and 5.67kg, respectively, which is two times higher than the finding of this study. Weiss (2004) also reported higher wet faeces (43.1±9.50kg) and faecal dry matter (7.10±1.50kg) excretion by Holstein cows. While the higher dung output in Holstein cows can be attributed to their relatively bigger body size, lower faecal output from JX cows in our study could be due to limited fodder availability as the study was conducted during the winter season. According to Dikshit and Birthal (2010), dung evacuation rates varied considerably across species, age-groups and functional classification of bovine.

There was a significant correlation between dung output and feed intake ($r=0.81$, $p\leq0.01$) (Table 2). The dung output per defecation and feed intake were also significantly correlated ($r=0.57$, $p\leq0.05$). The current finding is in line with the findings of Rodriguez and Weiss (n.d.) that increasing Dry Matter Intake (DMI) increases manure production. Van Dorland et al. (2007) also reported that when diets contain grasses and clover that have very high concentrations of crude protein (usually high potassium concentrations), manure output may increase even more. Therefore, the availability of adequate fodder and feed supplement is important for optimum dung production.

Nutrient content in cow dung

The dairy manure contains all 13 of the plant nutrients required for agricultural crop production. These include nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg), sulphur (S), manganese (Mn), copper (Cu), zinc (Zn), chlorine (Cl), boron (B), iron (Fe), and molybdenum (Mo). However, in this study, only N content was considered. The mean N content in the dung of 30 JX cows was 2.22±1.4% of faecal dry matter and faecal N output per day was 0.10 ±0.04kg (Table 3). The mean N output per year was estimated to be 36.5kg. According to Nennich et al. (2005), the average N content in faeces per day of Holstein Fresian breed were 0.43kg for lactating cow, 0.057kg for heifer, and 0.023kg for calf. Knowlton et al. (2010) reported that the average faecal N excreted per day by Jersey cow was 0.16kg and Holstein Friesian cow 0.24kg (Table 4). However, the N output per day from JX cows in this study was lower than the finding of Knowlton et al. (2010). The variation in N output may be attributed to differences in feeding and management practices. The diet in the study of Knowlton et al. (2010) constituted fodder and cotton seed (17.7% CP), whereas JX cows in this study were fed with paddy straw and concentrate feed (Karma feed with 14% CP). The reason could be due to difference in N content in the feed. Nennich et al. (2005) observed that the increase in CP intake resulted in greater N excretion. Tomlinson et al. (1996) also reported that the variation in nutrient intake by animals is the single most important contributor to variation in nutrient excretions.

Table 1 The dung output (mean ± standard deviation) measured from 30 jersey cross cows for seven days.

Parameters	Mean
Defecation per day (no.)	5.00 ± 0.55
Fresh dung output per defecation (kg)	2.90 ± 0.42
Fresh dung output per day (kg)	14.6 ± 3.16
Faecal dry matter output per day (kg)	2.49 ± 0.65
Feed intake per day (kg)	24.8 ± 4.47

Table 2 Pearson correlation coefficient of dung output.

Parameters	Live body Weight (kg)	Defecation per day (No)	Dung output per defecation kg)	Dung output per day (kg)	Feed intake per day (kg)
Live body weight (kg)	1	-0.302	-0.066	-0.151	-0.254
Defecation per day (No)		1	0.485*	0.785 **	0.653**
Dung output per defecation (kg)			1	0.766**	0.566*
Dung output per day (kg)				1	0.807**
Feed intake per day (kg)					1

*p≤0.05, **p≤0.01

Table 3 Daily and annual N output from cow dung.

Parameters	Mean
Faecal N content (%)	2.20 ± 1.40
Faecal N output per day (kg)	0.10 ± 0.04
Faecal N output per year (kg)	20.6 ± 14.0

Table 4 N intake and excretion by lactating Jersey and Holstein cow.

Parameters	Holstein	Jersey
Faecal N excretion per day (kg)	0.24	0.16
Urinary N excretion per day (kg)	0.21	0.16
Total manure N excretion per day (kg)	0.45	0.32

Adopted from Knowlton et al. (2010)

Manure nutrient concentration can vary substantially and is affected by many factors, such as species, age, and diet of the animal (Wilkerson et al. 1997). Yan et al. (2006) reported that the manure N output is also positively and significantly correlated with live weight, milk yield, dietary crude protein (CP) concentration, DMI, and N intake. In this study, the faecal N output was significantly correlated with N content (%) in the faecal DM (where r=0.90, p≤0.01) (Table 5). There was a significant correlation between dung output per day and N output (r=0.55, p≤0.05). Therefore, the current study also revealed that faecal N content (%) and dung output per day were the major factors affecting faecal N output from the cow.

Utilization of cow dung

Of the 40 dairy farmers interviewed, all households used cow dung as manure for agriculture production such as in orchards, kitchen garden and fishery ponds. In addition, 37% percent of the respondents also used dung for biogas production (Figure 1). The quantity of dung used annually were 12118±4818kg and 12913±5295kg for fertilizer and biogas production, respectively (Table 6).

At present, chemical fertilizers are the major components of modern farming and approximately 50% of the world's crop production depends on fertilizer use and this trend is increasing throughout the world (Bockman et al. 1990). It is estimated that by 2020, the sources of plant nutrients will be 21% from soil, 9% from manure and 70% from fertilizers and data also indicate that crop production supported by fertilizer use will continue to dominate future agricultural productivity, especially in developing countries with associated soil degradation (FAO 2001).This is a vicious circle in poorer countries since the continued nutrient exhaustion of soils leads to an increasing dependence on fertilizers to maintain crop yields, which in turn degrades the soil further. Increased crop production can be sustained by the balanced use of organic manures and chemical fertilizers (Lal and Singh 1998). However, the finding of this study indicates that none of the respondents from Sarpang *dzongkhag* used chemical fertilizer. They are totally dependent on farmyard manure for crop production and cow dung is the main component. This reveals that there is limited use of chemical fertilizer in Sarpang *dzongkhag* and cattle play a crucial role in producing farmyard manure. It was also found that many fishery farmers in the *dzongkhag* are using cow dung for manuring their fish ponds. The organic fertilizer (manure), such as cow dung manure is cheap and available and these manures are frequently used for the growth of aquatic microphytes (phyto-zooplankton), which in turn are used as food for the fish. Further, it also helps to regulate water quality characters of fishponds (Mirza et al. 1990).

Table 5 Pearson correlation coefficient of Nitrogen output from Jersey cows.

Parameters	Live body wt. (kg)	Feed intake per day (kg)	Av. Dung output/ day (kg)	N content (%)	N output/day (kg)
Live body weight (kg)	1	-0.254	-0.159	-0.136	-0.143
Feed intake per day (kg)		1	0.806**	0.066	0.347
Average dung output per/day (kg)			1	0.084	0.551*
Nitrogen content (%)				1	0.901**
Nitrogen output per day (kg)					1

*p≤0.05, **p≤0.01

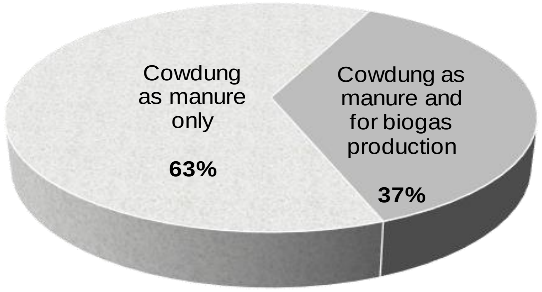

Figure 1 Dung utilization

Javed et al. (1992) also reported that the application of cow-dung enhanced the growth performance of fish species significantly. Similarly, farmers in the study area make good use of cow dung for fertilizing fishery ponds as the manure is easily available from their cattle and cost incurred is very minimum. Apart from using cow dung for crop and vegetable production, substantial quantity of cow dung is used for manuring orchards (orange and areca nut) and pasture fields.

The current study found that cow dung is also used for biogas production by livestock farmers in Sarpang *dzongkhag* and biogas generated from the cow dung are mainly used for cooking purposes (Table 6). In many parts of the developing world, cow dung is used as a fuel, insect repellent, thermal insulator and as sealant for smoke boxes on steam locomotives and in recent times, the dung is collected and used to produce biogas to generate electricity and heat (Ajayi and Adefila 2012). Panchal et al. (2011) also reported that the cow dung is used as an optional ingredient in the manufacture of adobe mud brick housing depending on the availability of materials. However, this study found that the use of cow dung is restricted to manure and biogas production only.

Economic benefit

The economic benefits from the use of cow dung had been calculated based on actual quantity of fertilizer replaced by cow dung manure and genuine cost saved by farmers for not having to spend on purchasing chemical fertilizer (urea) and LPG cooking gas (replaced by biogas). The mean expenditure and cost saved annually through the use of cow dung were Nu. 10071±4004 and 2664±925, for fertilizer and LPG, respectively (Table 7). Kushid (2009) reported that the economic benefit of biogas production to rural family (with an average seven to 10 members) is a saving on buying LPG, fuel-wood, cow dung cakes, and cost of chemical fertilizer. Such saving is a big economic gain for a rural family and can help in poverty reduction in rural areas. In similar manner, the farmers owning dairy cows in the present study area were benefited financially as they need not have to spend on purchasing inorganic fertilizer for their various agricultural activities. The use of cow dung for the production of biogas had reduced dependency on LPG cylinder and firewood. However, Hernandez and Schmitt (2012) reported that the basic economic value of manure is calculated by the cost of commercial fertilizer that will be replaced by nutrients in manure minus the costs of manure application. The authors also state that the economic value should not be based on all the nutrients contained in the manure but should be calculated based on the amount of needed nutrients that are being replaced. In the current study, the cost saved from the use of manure for agriculture production was also calculated based on the actual quantity of manure used for replacing fertilizer.

Table 6 Cow dung used for manure and biogas production in Sarpang *dzongkhag*.

Parameters	Mean
Dung as fertilizer (kg)	12118 ± 4818
Dung use for biogas production (kg)	12913 ± 5295

Table 7 Cost saving from use of cow dung by dairy farmers (n=40) in Sarpang *dzongkhag*.

Parameters	Mean
Cost saved from fertilizer (Nu)	10071 ± 4004
Cost saved from Biogas (Nu)	2664 ± 925

Social and environmental benefit

Besides economic benefits, the farmers in the present study area benefited from adoption of biogas technology as they could maintain cleanliness through the reduction of firewood usage. The time saved from not having to collect firewood from forest was devoted to other productive works. The use of biogas had immensely helped women to carryout household chores conveniently and reduced their exposure to smoke, which is indoor health hazard.

The use of firewood has many negative effects, both social and environmental. Mostly women and children collect firewood and this can take several hours in a day, which leaves them less time for education, employment and recreation. Gautam et al. (2009) reported that the use of firewood and other forms of biomass as cooking fuel is also directly related to exposures to hazardous particles of the smoke. Dagnachew et al. (2003) reported that biogas produced from cow dung can additionally reduce the use of forest resources for household energy purposes. Replacing biomass energy with biogas could help to solve several problems that are typically associated with using biomass fuels. The indoor air quality of homes can be improved as a result of using biogas instead of burning firewood. This innovation could benefit rural society in terms of improved cleanliness, health, and hygiene (Kushid 2009).

Conclusions

Jersey cows can produce substantial quantity of manure, which is an important source of major nutrients required for agricultural purposes. Farmers in Sarpang *dzongkhag* used considerable quantity of cow dung in crop production, orchard, kitchen garden, fishery pond, and for production of biogas. The contribution from cow dung was significant in terms of replacing chemical fertilizer and providing cheap alternative source of energy in the form of biogas, which had replaced the use of LPG gas. This signifies that, apart from contributing to livelihood of rural community, dairy farming also generates useful non-consumable product (cow dung). The use of cow dung for manure and biogas production has environmental benefits to the community as it reduces the use of chemical fertilizer and dependency on firewood from forest. The use of biogas from cow dung could also improve health and hygiene of the households due to minimum exposure to hazardous smoke. Therefore, the utilities of cattle manure should be considered in valuation of animals in addition to estimating economic value of consumable products from dairy farming. However, similar study is needed at the national level and with different breeds of cattle.

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