Effect of Feed and Draught on Carbon Dioxide Emission from the Rumen of He-Buffalo

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A B S T R A C T

The bacteria in ruminant animals help to digest the food and produce copious amounts of carbon dioxide and methane in the process. So, to know the effect of feed on CO₂ emission from rumen of he-buffalo the study was conducted at 4 different feed concentration at two different draught levels at 3 hour of exercise on treadmill having speed of 2 km/h and 3 hour of rest period under maintained environment controlled chamber. The environment temperature and relative humidity was maintained according to the average temperature and relative humidity of the area which was 25°C and 90%. Two draught levels of 10% and 12% of body weight were selected. The study shows decreasing CO₂ concentration in exhaled air of test he-buffalo with increase in duration of exercise and also with increase in level of draught and it shows increasing trend with the increase of berseem percentage in feed. The maximum concentration of CO₂ is 75.60% at 10% draught level and at 75% berseem concentrated feed on dry matter basis during initial hour (0 h) of exercise. Minimum concentration observed is 69.77% at 12% draught level after 3rd hour of exercise and when 100% wheat bhusa on dry matter basis was used as feed. CO₂ concentration of test he-buffalo shows increasing trend with increase in duration of rest. The maximum concentration of carbon dioxide is 76.59% which is at 10% draught (at 3rd hour of rest period) and at 75% berseem concentrated feed on dry matter basis. Minimum concentration observed is 72.26% at 12% draught level after 1st hour (initial hour) of rest and at 100% wheat bhusa on dry matter basis was used as feed.

Keywords

Trifolium Alexandrinum (Berseem), Treadmill, He-buffalo, CO₂ concentration, Bhusa, Draught

Introduction

Global warming has attracted the attention of the world communities in the recent years due to occurrence of the numerous abnormal weather events, rise in sea level, displacement of communities, and drop in agricultural productivity and its effect on livestock and farming. The effects of the global livestock industry on global warming have been studied for more than three decades and its effects were well documented. Different studies show that the feeding habits of cattle – cows, buffaloes and all ruminant creatures contributes to climate change. A buffalo is a ruminant animal, which means it extracts nutrition from the food that it eats by fermentation process. Agriculture sector accounts for highest anthropogenic GHGs emissions. The United Nations Environment
Programme (UNEP) analysis that the world’s cattle contributed to more greenhouse gas emissions than global transport report was released in 2006. It was estimated that 21-25% of carbon dioxide (CO₂) from agriculture activities contributes to the anthropogenic GHGs emissions (Angela et al., 2000). The animal emits CO₂ per day because of bacterial digesting cellulose in the Rumen mainly herbivores. Buffaloes contribute to nearly 21.23% (108.7 million) of the total livestock population in India with its population growth of 4.18% in rural areas (Shown in the below chart). Total buffaloes population in India is 108.7 million. In Uttarakhand, buffaloes numbered at 9, 87,775 as per 2012 Census.

Nearly 60% of its population is dependent on agriculture and allied activities and the draught animal are primary source of power in India in particular and developing countries in general. Hence, the present study was designed to evaluate carbon dioxide emission from rumen of he-buffalo with the effect of feed and draught levels at different exercise and rest periods.

Materials and Methods

The present study has been conducted from October 2016 to April 2017 in the Department of Farm Machinery and Power Engineering, College of Technology, G.B. Pant University of Agriculture and Technology, Pantnagar. The study fully based on the guidelines of the Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA, 2006). The he-buffalo was maintained on wheat bhusa, berseem (length= 3-4 cm), concentrate and water. Wheat straw has an average of 8.5 to 15% lignin and 70 to 80% fiber, its dry matter content was 92.11g per 100g of wheat straw. In 100g of berseem total 60-65% digestible nutrient, 17% crude protein and 25.9% crude fiber and its dry matter content was 8.85g -12.65g. Amount of concentrate was fixed as 2.5kg on daily basis for each trial.

The dietary treatment was given in different composition of threshed wheat straw (length=1.5-3.2cm), berseem (length= 3-4 cm), concentrate and water. Wheat straw has an average of 8.5 to 15% lignin and 70 to 80% fiber, its dry matter content was 92.11g per 100g of wheat straw. In 100g of berseem total 60-65% digestible nutrient, 17% crude protein and 25.9% crude fiber and its dry matter content was 8.85g -12.65g. Amount of concentrate was fixed as 2.5kg on daily basis for each trial. Feed were weighed on dry matter intake (DMI) before the experiment. Body weights were measured every seven days.
Daily feed for different trials conducted

Berseem and wheat bhusa was used as feed. Berseem is a highly palatable fodder. Different amount of feed is selected for different trials. The wheat bhusa and berseem diets were offered twice daily at 08:00am and 06:00pm.

\[ T_1 = 2.5 \text{ kg concentrate} + 16 \text{ kg wheat straw per day.} \]

\[ T_2 = 2.5 \text{ kg concentrate} + 12 \text{ kg wheat straw} + 28 \text{ kg berseem per day.} \]

\[ T_3 = 2.5 \text{ kg concentrate} + 8 \text{ kg wheat straw} + 56 \text{ kg berseem per day.} \]

\[ T_4 = 2.5 \text{ kg concentrate} + 4 \text{ kg wheat straw} + 75 \text{ kg berseem per day.} \]

Feeding was done on dry matter basis during the period of 14 days continuously and then the buffalo was made to exercise on treadmill for four numbers of days.

Buffalo on treadmill exercise

The he-buffalo were exercised on treadmill from morning 10:00 am to afternoon 01:00 pm, for a period of three hours or up to the he-buffalo reached a stage of fatigue (fatigues score card was referred to diagnose). After that the buffalo kept for rest for three hours from 01:00 pm to 04:00 pm in controlled chamber. For the analysis CO\(_2\) production by he-buffalo the exhaled gas samples were taken on hourly basis during exercise and rest periods of 3 hours for four no of days in each trial.

Carbon dioxide measurement technique

Samples was collected by placing an air tight face mask on the mouth of he-buffalo which was connected with the leak proof Douglas bag as shown in figure 1 to collect and store the exhaled gas. A 22 mm diameter anti-static corrugated rubber tube and a three way non return valve used to connect the face mask with Douglas bag. Sample for analysis were collected with the help of 20 ml disposable syringes. The collected sample was analyzed through Gas Chromatograph technique. Sample was analyzed using propaq Q column in Thermal Conductivity Detector of Nucon 5700 Gas Chromatograph in Bio-Mechanics lab of Farm Machinery and Power Engineering Department. Hydrogen gas was used as carrier gas for the analysis. Volume of sample used for analysis was 2 ml.

Experimental design and data analysis

The Design Expert 10 Software was used for the data analysis. The experiment was designed in factorial, multilevel categorical method completely randomized design. For the analysis of data ANOVA technique using F-test at 1%, 5% and 10% level of significance was used. For each dependent parameters with different combinations of independent variables at constant temperature, humidity, speed and inclination of treadmill the linear regression analysis technique was used to develop mathematical modelling using Design Expert 10 software.

Results and Discussion

Effect of different influencing factors i.e. different type of feeds, draughts and duration of exercise on the presence of carbon dioxide gas concentration in the collected exhaled air of he-buffalo was estimated and statistically analysed.

Figure 3.1 to 3.6 shows the average CO\(_2\) concentration observed during the treadmill exercise at two draught levels, 4 feed levels at 3 h of exercise and 3 h of rest period at constant treadmill speed and maintained
environment controlled chamber. Increase and decrease was measured with respect to 0 hr.

**CO₂ concentrations observed during exercise**

The maximum concentration of CO₂ is 75.60 % at 10% draught level and at 75% berseem on dry matter basis during initial hour (0 h) of exercise. Minimum concentration observed is 69.77% at 12% draught level after 3rd h of exercise and at 100% wheat bhusa on dry matter basis was used as feed. It was observed that maximum percentage decrease in CO₂ concentration is 4.03 which were at 12% draught and at feed proportion of 100 % bhusa on dry matter basis. The minimum percentage decrease found is 1.32% at 10% draught level and 75% berseem proportion on dry matter basis was used for feeding purpose. Decrease in CO₂ concentration was found 2.71 and 4.03 percent at 10% and 12% draught levels respectively when 100% wheat bhusa on dry matter basis was used as feed. When addition of 25% berseem was done on dry matter basis the percentage decrease in CO₂ concentration was observed is 2.54 and 3.87 percent at 10% and 12% draught. Similarly, 1.72 and 2.85 percent decrease was observed at 10% and 12% draught when 50% berseem on dry matter basis was added in feed. Percentage decrease of 1.32 and 2.14 percent is observed at 10% and 12% draught respectively when 75% berseem on dry matter basis used in feed.

**CO₂ concentrations observed during rest**

The maximum concentration of carbon dioxide is 76.59% which is at 10% draught and having 75% berseem concentration on dry matter basis at 3rd h of rest period. Minimum concentration observed is 72.26% at 12% draught level after 1st hour (initial hour) of rest and when 100% wheat bhusa on dry matter basis was used as feed. During the study the maximum CO₂ concentration was found 75.60% during initial hour and 76.59% at 3rd h of rest which was slightly higher than the 65.5% which was found by Sniffen and Herdt (1991) during investigation on dairy cattle.

It is observed that maximum percentage increase in CO₂ concentration is 2.32% after third hour of rest from the initial (0 hour) which is at 10% draught level and at feed level of 100 % bhusa on dry matter basis. The minimum percentage increase found is 0.88% from the initial (0 h) at 12% draught level, 75% berseem on dry matter basis was used for feeding purpose. Percentage increase in CO₂ was found 2.32 and 1.86 percent from initial at 10% and 12% draught level respectively at 100% bhusa on dry matter basis used as feed. At addition of 25% berseem in feed on dry matter basis the percentage increase observed is 1.30 and 1.03 percent at 10% and 12% draught level. Similarly, increase of 1.40 and 1.39 percent from initial was observed at 10% and 12% draught at the addition of 50% berseem in feed on dry matter basis. Percentage increase of 1.31 and 0.88 percent from initial is observed at 10% and 12% draught respectively when 75% berseem on dry matter basis was used in feed.

Average percentage increase from 3rd hour of exercise to the first hour rest period was found between 1 to 4 %. The maximum percentage increase in CO₂ concentration after exercise and at first hour of rest was 3.44 at feed level of 100% bhusa on dry matter basis at 12% draught and minimum was 1.58 at feed concentration of 75% berseem on dry matter basis at 10% level of draught.

The concentration of CO₂ at 3rd h of rest period after exercise was higher than the initial (0 h). The relationship between CO₂ concentration with different feed level,
duration of exercise, duration of rest period after exercise, two draught levels at constant level of temperature, humidity, inclination of treadmill and speed is depicted in Figure 3.1–3.6 represent the average relation between different feed concentration and CO$_2$ emission at different duration of exercise and rest period at 10% and 12% draught.

**Results of regression analysis of data obtained during exercise**

The regression analysis of the experimental variables for carbon dioxide was done using multilevel categorical design in Factorial method of Design expert 10. Thirty two experiments were carried out with the combinations of three variables and there different levels. The F-value of model obtained implies that the model was significant at 1% level (p< 0.01) of significance.

**Statistical analysis of CO$_2$ concentration during exercise**

In terms of linear, interactive and quadratic term the effect of different treatment on CO$_2$ emission was done through Analysis of Variance (ANOVA). F-value indicate that linear terms of independent variables significantly affected CO$_2$ concentration (P<0.01) at 1% level of significance. F-value of individual independent parameters indicate that effect of draught, feed, duration of exercise was highly significant at 1% level of significance (p<0.0001) (Table 1).

**Numerical analysis of CO$_2$ concentration in exhaled gas of buffalo during exercise**

Multiple linear regression analysis was done for the CO$_2$ concentration in exhaled gas. Regression analysis results that the coefficient of determination (R$^2$) for regression model is 0.9879, which conclude that the model was valid for 98.79 % data. The value of R$^2$ – adjusted was 98.37 which was observed to be close to R$^2$ (0.9879) value. It shows a relatively satisfactory adjustment to the model obtained from the experimental data.

The predicted R$^2$ (0.9796) is in reasonable agreement with the adjusted R$^2$ of 0.9837 i.e., the difference is less than 0.2. The Model obtained was highly significant (p<0.01) at F$_{cal}$ value of 205.00 which was greater than F$_{tab}$ value 9.23 at 1% level of significance.

The significant predicted quadratic regression equation for CO$_2$ emission in exiled gas of he-buffalo is as follows:

$$CO_2 \text{ concentration (\%)} \ Y = 73.62 - 0.29 A + 1.66 B - 0.99 C - 0.22 AC + 0.32 BC - 0.42 B^2$$

(3.1)

Where,

A= Draught
B = Feed (% DMB of berseem)
C = Duration of exercise and rest (h)

Positive terms of coefficient B, AB, BC indicate the increase in CO$_2$ concentration with increase in level of variables. Negative term of coefficient A, C, AC, B$^2$ indicate the decrease in CO$_2$ concentration with increase in level of variables.

**Graphical analysis of CO$_2$ concentration in exhaled gas during exercise**

The method used for the graphical analysis of data obtained during the experiment was Factorial method multi categorical design in Design Expert 10. Figure 3.7 gives the 3-Dimensional representation of the relationship between the independent variables and the CO$_2$ emission during exercise it was concluded from graph the decrease of CO$_2$ emission with increase in draught and
duration of exercise and increasing trend with increase in berseem percentage.

Results of regression analysis of data obtained during rest

The regression analysis of the experimental variables was done using multilevel categorical design with three variables in the Factorial method. Twenty four experiments were carried out with the combinations of three variables containing different levels. The model F-value implies the model was significant at 1% level (p< 0.01) of significance.

Statistical analysis of CO₂ concentration in exhaled gas during rest

Shows the effect of different treatment variables in linear, interactive and quadratic term on CO₂ emission during rest. In Table F-value (68.66) indicate that linear terms of independent variables significantly affected CO₂ concentration (P<0.01) at 1% level of significance. The interactive and quadratic term also affect CO₂ concentration at 1% level of significance. It was found that the effect of draught, feed, duration of exercise was highly significant at 1% level of significance (p<0.0001).

Numerical analysis of CO₂ concentration in exhaled gas of buffalo

Multiple linear regression analysis was done for the CO₂ concentration in exiled gas at rest. The Regression analysis results that the coefficient of determination (R²) for regression model is 0.9765, which conclude that the model was valid for 97.65 % data.

The value of R² –adjusted was 0.9639 which was observed to be close to R² (0.9765) value. It shows a relatively satisfactory adjustment to the model obtained from the experimental data. The predicted R² (0.9533) is in reasonable agreement with the adjusted R² of 0.9765 i.e., the difference is less than 0.2. The Model obtained was highly significant (p<0.01) at Fcal value of 68.66 which was greater than F tab value 3.89 at 1% level of significance.

The significant predicted quadratic regression equation developed for CO₂ emission in exiled gas of he- buffalo is given below.

CO₂ concentration (%) Y = 75.08 – 0.31 A + 1.19 B + 0.61 C – 0.19 BC– 0.18B² . ..(3.2)

Where,
A= Draught
B = Feed (kg)
C = Duration of exercise and rest (h)

Positive terms of coefficient B, C indicate the increase in CO₂ concentration with increase in level of variables. Negative term of coefficient A, BC, B², C² indicate the decrease in CO₂ concentration with increase in level of variables.

Graphical analysis of CO₂ concentration in exhaled gas during rest

The Factorial method multilevel categorical design in Design Expert 10 was used for the graphical analysis of data obtained during the experiment when buffalo was at rest after exercise.

Figure 3.8 gives the 3-Dimensional representation of the relationship between the independent variables and the CO₂ emission during rest period after exercise. It was concluded from graph the decrease of CO₂ emission with increase in draught and increase in emission with increase in duration of exercise and berseem percentage of feed.
Table 1 Dependent and independent variables

| Trial no. | Feed composition | Draught equivalent to % body weight | Sample collection at different hours of exercise | Sample collection at different hours of rest | Dependent variable |
|----------|------------------|------------------------------------|-----------------------------------------------|---------------------------------------------|---------------------|
|          | Wheat straw (%)  | Berseem (%)                        | Concentrate (fixed)                          | %    | %    | hour  | hour  | Percentage (%) |
| T1       | 100              | 0                                  | 2.5 kg                                        | 10   | 12   | 0th, 1st, 2nd and 3rd | 4th, 5th and 6th   | CO₂ production    |
| T2       | 75               | 25                                 | 2.5 kg                                        | 10   | 12   | 0th, 1st, 2nd and 3rd | 4th, 5th and 6th   | CO₂ production    |
| T3       | 50               | 50                                 | 2.5 kg                                        | 10   | 12   | 0th, 1st, 2nd and 3rd | 4th, 5th and 6th   | CO₂ production    |
| T4       | 25               | 75                                 | 2.5 kg                                        | 10   | 12   | 0th, 1st, 2nd and 3rd | 4th, 5th and 6th   | CO₂ production    |

Fig.1.1 Distributions of all India Livestock census-2012

![Fig.1.1 Distributions of all India Livestock census-2012](image)

Fig.2 View of three way air valve and face mask connected with Douglas bag

![Fig.2 View of three way air valve and face mask connected with Douglas bag](image)
**Fig. 3.1** Relationship between CO$_2$ concentrations in the exhaled gas during exercise and rest at two draught levels and at 100% wheat bhusa on DMB as feed

**Fig. 3.2** Relationship between CO$_2$ concentrations in the exhaled gas during exercise and rest at two draught levels and at 25% berseem on DMB as feed

**Fig. 3.3** Relationship between CO$_2$ concentrations in the exhaled gas during exercise and rest at two draught levels and at 50% berseem on DMB as feed
Fig. 3.4 Relationship between CO₂ concentrations in the exhaled gas during exercise and rest at two draught levels and at 75% berseem on DMB as feed

![Diagram showing CO₂ concentration over duration of exercise and rest at two draught levels.]

Fig. 3.5 Carbon dioxide emission at 10% draught level and different feed proportions at exercise and rest period

![Bar chart showing CO₂ concentration at different feed proportions and exercise/rest periods at 10% draught level.]

Fig. 3.6 Carbon dioxide emission at 12% draught level and different feed proportions at exercise and rest period

![Bar chart showing CO₂ concentration at different feed proportions and exercise/rest periods at 12% draught level.]

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Fig. 3.7 Effect of draught, feed, duration of rest on CO₂ emission

Conclusions of the study are as follows:

- The dietary dependence has effect on the CO₂ emission. It shows increasing trend with the increase of berseem percentage in feed.
- The CO₂ concentration in exhaled air of test he-buffalo shows decreasing trend with increase in duration of exercise and also with increase in level of draught.
- The maximum concentration of CO₂ during exercise is 75.60 % at 10 % draught level and at 75 % berseem on dry matter basis during initial hour (1h) of exercise.
- CO₂ concentration in exhaled gas was found increasing with the increase in duration of rest period after exercise.
- The maximum concentration of CO₂ during rest was 76.59 % at 10 % draught level during 3rd hour of rest.
and when 75 % berseem on dry matter basis used during feeding.

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