Original Research Article

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 CO_2 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 $25^{o}C$ and 90%. Two draught levels of 10% and 12% of body weight were selected. The study shows decreasing CO_2 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 CO_2 is 75.60% at 10% draught level and at 75% berseem concentrated feed on dry matter basis during initial hour (o h) of exercise. Minimum concentration observed is 69.77% at 12% draught level after 3rd h of exercise and when 100% wheat bhusa on dry matter basis was used as feed. CO_2 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.

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 (CO_2) from agriculture activities contributes to the anthropogenic GHGs emissions (Angela *et al.,* 2000). The animal emits CO_2 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 and concentrate in different proportion for the present study.

Study site and experimental design

For the study, a psychometric chamber was developed. The site lies in Terai region of India at 283.8 m above mean sea level, 29°N latitude, 29.3°E longitude. The psychometric chamber was developed in the Department. The chamber having animal tread mill, humidifiers, air conditioners (split type), thermometer, etc. Temperature and humidity was maintained as $25\pm1^{o}C$ and $90\pm 1\%$ respectively. Two draught 10% and 12% of body weight of the he-buffalo were selected. The he-buffalo was put to exercise on treadmill for 3 hours continuously followed by 3 hours of rest. The samples were collected every hour starting from 0 hr in Douglas bag. Speed and inclination of the treadmill were fixed at 2 km/h and 0° respectively throughout the study. Pant adjustable single animal collar harness with U-shaped pipe frame for supporting draught used for harnessing of buffalo.

Selection of animal and fodder for the experiment

Two murrah he-buffaloes weighing 550 ± 18 Kg, age 5-6 year have been selected for the experiment and were maintained on wheat bhus, green fodder (berseem) at fixed rate of 3kg/100kg body weight per day on dry matter basis along with fixed concentrate amount of 2.5kg/day 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 kg concentrate + 16 kg wheat straw per day.

T_2 = 2.5 kg concentrate + 12 kg wheat straw + 28 kg berseem per day.

T_3 = 2.5 kg concentrate + 8 kg wheat straw + 56 kg berseem per day.

T_4 = 2.5 kg concentrate + 4 kg wheat straw + 75 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 tread mill 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.

CO_2 concentrations observed during exercise

The maximum concentration of CO_2 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 CO_2 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 CO_2 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 CO_2 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.

CO_2 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 hour 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 CO_2 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 CO_2 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 CO_2 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 CO_2 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 CO_2 at 3rd h of rest period after exercise was higher than the initial (0 h). The relationship between CO_2 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 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) 0f significance.

Statistical analysis of CO_2 concentration in exhaled gas during rest

Shows the effect of different treatment variables in linear, interactive and quadratic term on CO_2 emission during rest. In Table F-value (68.66) indicate that linear terms of independent variables significantly affected CO_2 concentration (P<0.01) at 1% level of significance. The interactive and quadratic term also affect CO_2 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 CO_2 concentration in exhaled gas of buffalo

Multiple linear regression analysis was done for the CO_2 concentration in exiled gas at rest. The Regression analysis results that the coefficient of determination (R^2) for regression model is 0.9765, which conclude that the model was valid for 97.65 % data.

The value of R^2 –adjusted was 0.9639 which was observed to be close to R^2 (0.9765) value. It shows a relatively satisfactory adjustment to the model obtained from the experimental

data. The predicted R^2 (0.9533) is in reasonable agreement with the adjusted R^2 of 0.9765 i.e., the difference is less than 0.2. The Model obtained was highly significant (p<0.01) at F_{cal} 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 CO_2 emission in exiled gas of he- buffalo is given below.

CO_2 concentration (%) Y = 75.08 – 0.31 A + 1.19 B + 0.61 C – 0.19 BC– 0.18B^2 . .. (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 CO_2 concentration with increase in level of variables. Negative term of coefficient A, BC, B^2, C^2 indicate the decrease in CO_2 concentration with increase in level of variables.

Graphical analysis of CO_2 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 CO_2 emission during rest period after exercise. It was concluded from graph the decrease of CO_2 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 (%)
T_1	100	0	2.5 kg	10	12	0th,1st, 2rd and 3rd	4th, 5th and 6th	CO_2 production
T_2	75	25	2.5 kg	10	12	0th,1st,2rd and 3rd	4th, 5th and 6th	CO_2 production
T_3	50	50	2.5 kg	10	12	0th, 1st, 2rd and 3rd	4th, 5th and 6th	CO_2 production
T_4	25	75	2.5 kg	10	12	0th, 1st, 2rd and 3rd	4th, 5th and 6th	CO_2 production

Fig.1.1 Distributions of all India Livestock census-2012
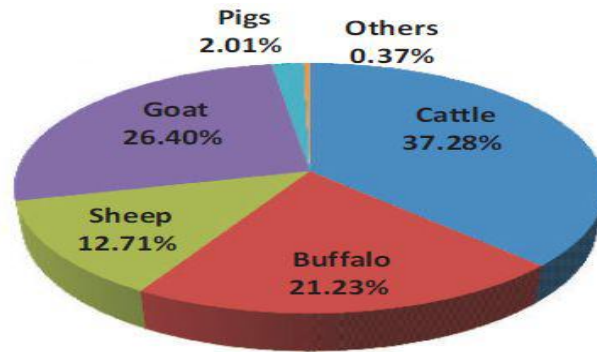
Fig.2 View of three way air valve and face mask connected with Douglas bag

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
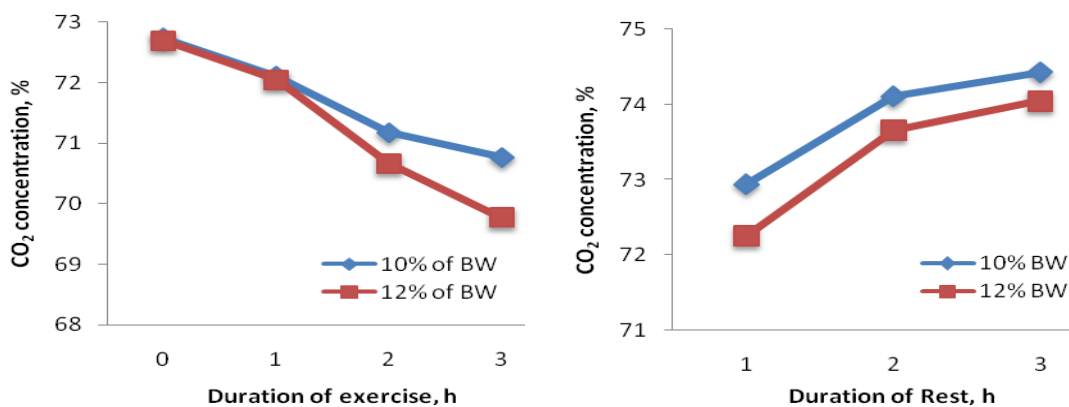
Fig.3.2 Relationship between CO_2 concentrations in the exhaled gas during exercise and rest at two draught levels and at 25% berseem on DMB as feed
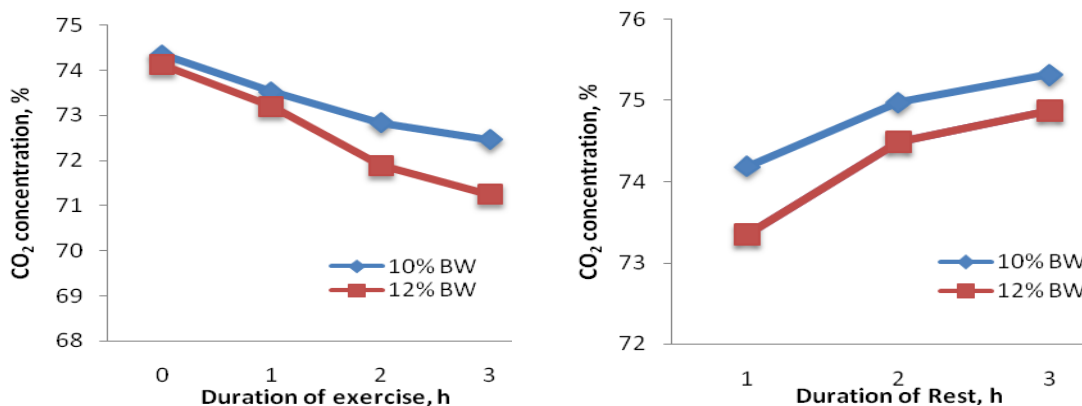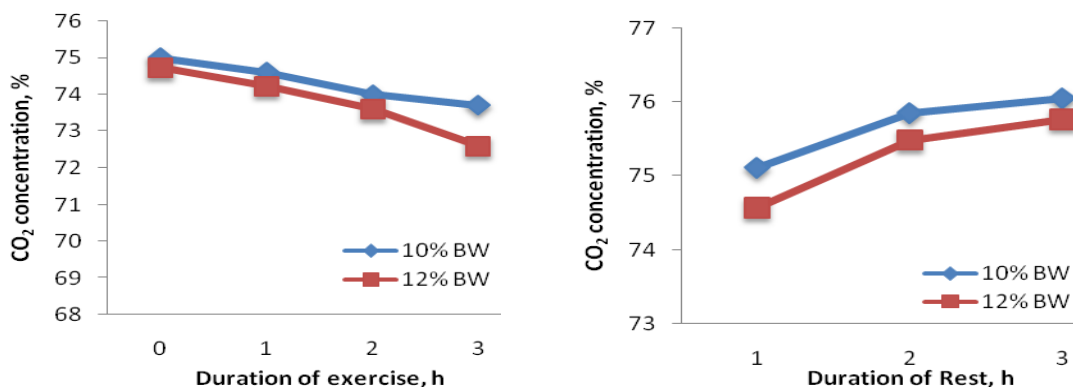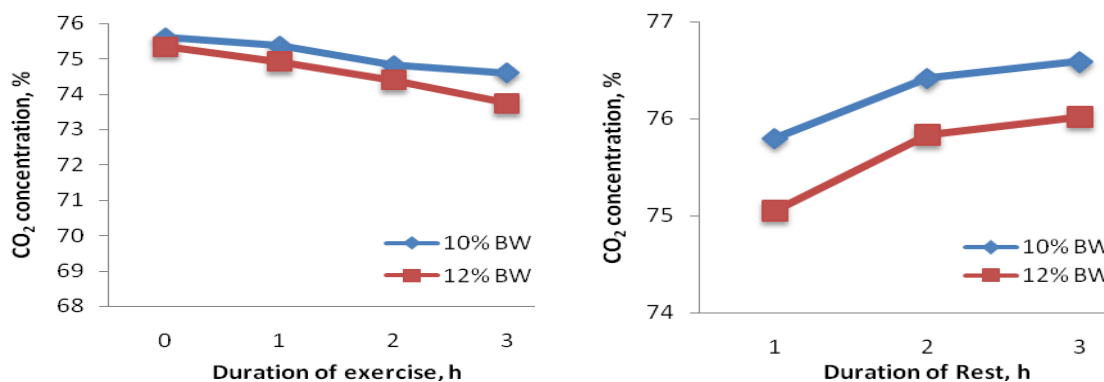

Fig.3.3 Relationship between CO_2 concentrations in the exhaled gas during exercise and rest at two draught levels and at 50% berseem on DMB as feed

Fig.3.4 Relationship between CO_2 concentrations in the exhaled gas during exercise and rest at two draught levels and at 75% berseem on DMB as feed

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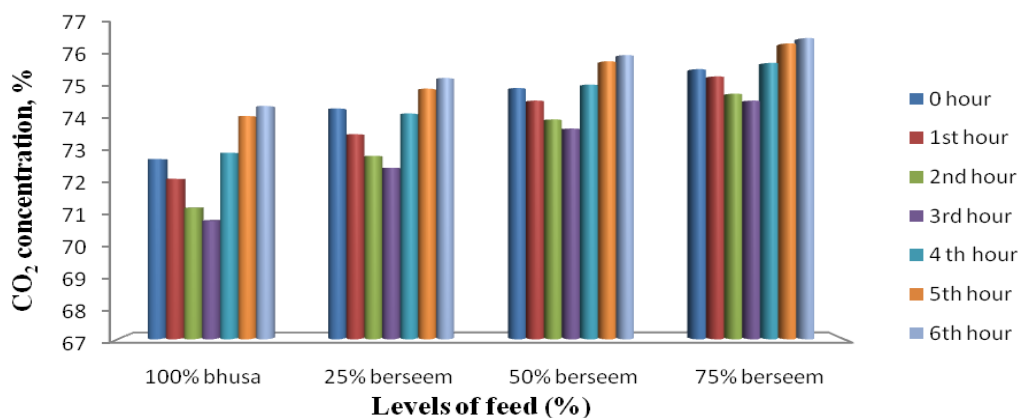

Fig.3.6 Carbon dioxide emission at 12% draught level and different feed proportions at exercise and rest period
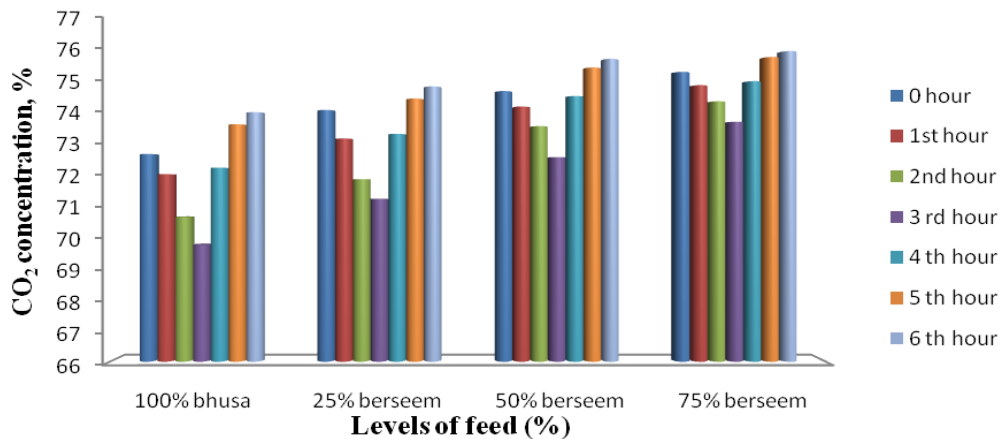
Fig.3.7 Effect of draught, feed, duration of rest on CO_2 emission
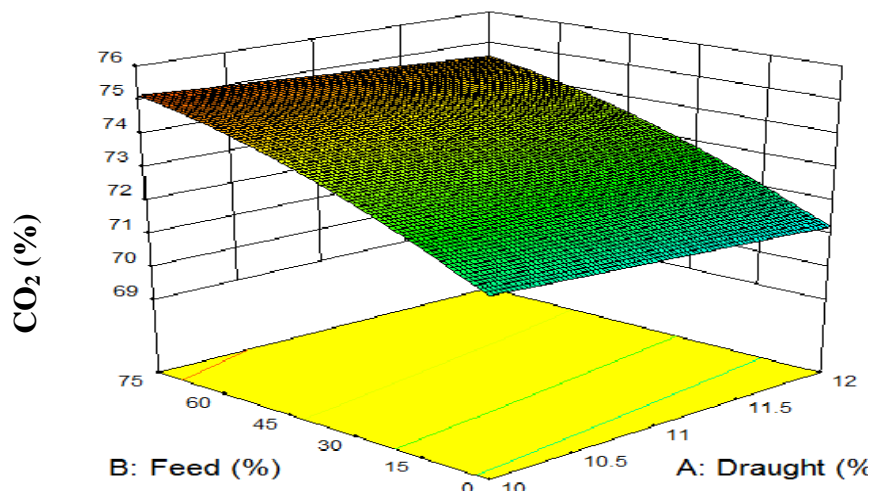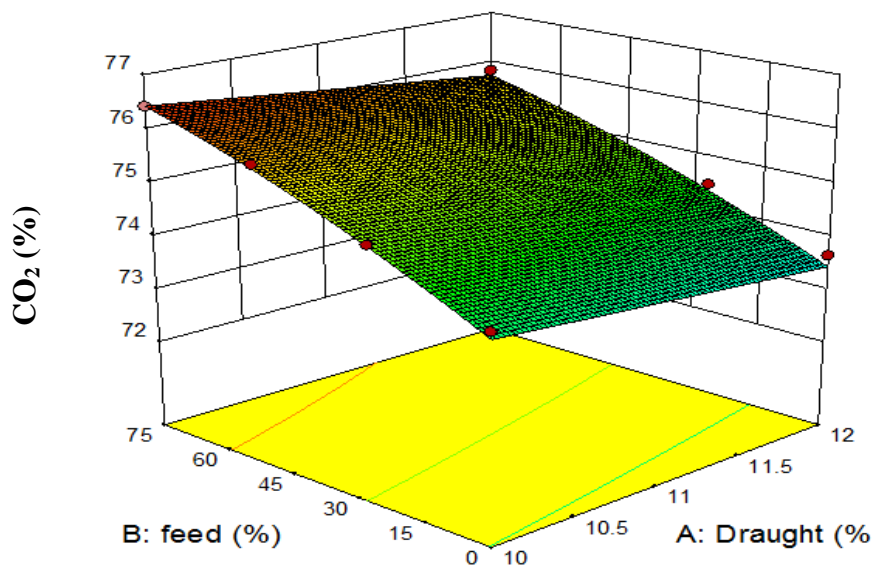

Fig.3.8 Effect of draught, feed and duration of rest on CO_2 emission during rest

Conclusions of the study are as follows:

➢ The dietary dependence has effect on the CO_2 emission. It shows increasing trend with the increase of berseem percentage in feed.

➢ The CO_2 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 CO_2 during exercise is 75.60 % at 10 % draught level and at 75 % berseem on dry matter basis during initial hour (o h) of exercise.

➢ CO_2 concentration in exhaled gas was found increasing with the increase in duration of rest period after exercise.

➢ The maximum concentration of CO_2 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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