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MODELING AND MANAGEMENT OF POST-CONCEPTION DECLINE IN MILK YIELD OF DAIRY BUFFALOES

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ABSTRACT

Dairy buffalo farmers in Pakistan avoid postpartum rebreeding due to fear in milk yield decline. Under the present study reduction in milk yield due to pregnancy was worked out using 23 pregnant and 17 non–pregnant buffaloes under field conditions and the decline was managed through feed supplementation treatments. The treatments provided were Pregnant with traditional ration (PRT), pregnant with supplemented ration (PRS) and non pregnant with traditional ration (NPRT). The animals were categorized into high milk yielder (HMY), medium milk yielder (MMY) and low milk yielder (LMY), producing 66-75, 56-65, and 46-55 liters/wk, respectively. Milk production was recorded up to 23rd week post-conception. The reduction in milk yield became significant on 7th week post-conception. The line JP8 model gave good fit (R^2 = 0.9527). In the high yielder, the predicted reduction was highest (-4.48 liters/wk) than moderate and low yielder (-2.37 and -0.94 liters/wk). In the high yielder the decline in milk yield post-conception was highest in PRT, moderate in PRS and the least in NPRT treatment. In the MMY buffaloes the supplementation support to milk yield was smaller than the higher yielders. In LMY buffaloes the decline was highest in PRT than the other two treatments. It may be concluded that the onset of pregnancy in dairy buffaloes results in a drastic decline in milk yield at an early stage and the high yielder are more sensitive. An animal becoming pregnant, if supplemented at the rate of 1 kg/2 liters of milk will retain milk yield for a longer duration post-conception.

Key words: Milk yield, pregnancy, nutrition, dairy buffalo.

INTRODUCTION

Buffaloes are significant source of milk in this sub-continent contributing as high as 68.35% of the total milk yield in Pakistan, and 56.85% in total milk production in India. In addition to the milk, the buffalo contributes about 11.52% of the total ruminant meat, and about 2.7% of all meat produced in the region. The average annual growth rate in production was about 1.3%. Undoubtedly, majority of world's buffalo meat is Asian, representing 91.89% and with volume of 3.08M tons in 2008 (FAO, 2010).

Zicarelli (2006) reported that in countries with temperate climate the cattle are able to express their genetic potential and buffalo can not compete for milk and meat production. In contrast the buffalo milk possesses greater quantity of proteins and for each protein percent point, more than 5 cheese yield points are obtained in buffalo and 3 for cows. The Indo-Pak Subcontinent possesses the best dairy buffalo breeds, named as Nili-Ravi of Pakistan and Murrah of India. It has been anticipated that the buffaloes will be increasingly used for milk and meat production in Asia, especially in the densely populated countries of Indian subcontinent and China (Ranjhan and Qureshi, 2006). The animals are kept under peri-urban and rural farming systems with the primary aim to produce milk for utilization by the urban and rural populations. This type of farming in the private sector of Pakistan has been described (Qureshi, 1995) where buffaloes are kept in peri-urban areas to meet demand of the urban population. This is a low input dairy farming, depending upon opportunity cost and assets inherited from forefathers. There is no trend of new investment for establishing farming facilities on scientific lines. No practice of feeding animals according to requirements of various nutrients exists.

Battaglia and Meschia (1978) reviewed the use of available nutrients for milk synthesis and growth of the fetus and concluded that it is minimal for the fetus because the majority of its growth occurs after the lactating cow is dried off. During the seven months of gestation about 40% of fetal growth occurs while the remaining 60% occurs during the last 2 months of gestation. Later on, an early effect of pregnancy was reported in dairy cows on milk production through a combination of hormonally mediated partitioning of nutrients away from milk production (Oltenacu *et al.*, 1980) and increased fetal demands for energy from 190 d of gestation onwards (NRC, 2001). Eley *et al.* (1978) and Prior and Laster (1979) reported an exponential growth of fetal tissues, with growth rapidly increasing after 90 d of gestation in seasonal herds. In lactating bovines, a complex interaction of several key metabolic hormones viz. growth hormone, prolactin, thyroid hormones and glucocorticoids leads to mobilization of major substrates for milk synthesis eg. acetate, glucose, amino acid and fatty acids during galactopoiesis (Tucker, 1981). Although prolactin is galactopoietic in nature, it has also been attributed to be antigonadotrophic (Tyson *et al.*, 1972 and Rolland *et al.*, 1975).

The above studies have generated useful information on pregnancy – lactation interaction in dairy cows but these can not be applied exactly to dairy buffaloes due to the species variation and the difference in climatic and socio-economic conditions of the farmers. Under the traditional farming system buffaloes are not bred with the fear that the milk production will decline and thus they remain open for longer period, hindering the replacement of lactating animals at the farm. The code of belief amongst farmers and extension people is that the post-conception metabolic adaptation in buffaloes is affecting their milk production more than the body conditions. The extent to which the pregnancy in buffaloes is affecting the production with traditional feeding is not known. This paper reports the decline in milk production of buffaloes after getting conceived and the role of feed supplementation to prevent the decline.

MATERIALS AND METHODS

The present investigations were completed at a Medium sized private buffalo farm in the central valley of KPK, Pakistan situated at 31-37º N and 65-74º E. Forty lactating buffaloes, 3-4 months postpartum were selected for this study. Climate of this region is of continental type. The first part of the study was made to model the predicted decline in milk yield after conception. The second part of this study comprised preventing decline in milk yield through feed supplementation of the pregnant group and to compare it with non-supplemented pregnant and non-pregnant animals.

The period of this study was July to December 2005. All experimental animals were stall-fed and provided green fodder *ad lib*. Water shower was provided to all animals during hot season twice a day at the farm. Drinking water was provided three times daily. Animal sheds were washed twice daily at morning and evening. Twice a day milking was practiced at 4 am and 4 pm. Vaccines against hemorrhagic septicemia and Foot and Mouth Disease were administered to all experimental animals, as per prevailing practice. Anthelmintic drench of levamisole hydrochloride plus oxychlosanide according to manufacturer instructions was provided at the start of experiment.

Basal ration comprised green fodder *ad lib* during June through October including maize, sadabahar (sorghum x sudan grass) and sorghum. During November to May, Egyptian clovers, oats, brassica and wheat straw were offered. Traditional ration comprised basal ration and a commercial concentrate; having 18% crude protein and 72% total digestible nutrients at the rate of 1.5 kg per animal irrespective of its lactation stage, milk yield level and pregnancy stage, as per routine practice under the conventional farming system in the region. This constituted ration for all the non-pregnant and one group of pregnant experimental animals. Supplemented ration included basal ration and the same commercial concentrate provided at the rate of 1 kg per 2 L of milk as recommended by Ranjhan (1994) for lactating buffaloes under tropical conditions. This ration was provided to one group of pregnant animals.

Milk production was recorded daily in liters and pooled to weekly intervals starting from the date of conception through 23rd weeks post-conception. The animals were selected, after conception and pregnancy was confirmed through milk progesterone profiles 21 days post-breeding (Qureshi *et al.*, 2000 b). Treatments included:

PRT (Pregnant-Ration-Traditional, n=12 x 23 weeks)
PRS (Pregnant-Ration-Supplemented, n=11 x 23 weeks)
NPRT (Non Pregnant-Ration-Traditional, n=17 x 23 weeks)

Production groups

HMY: High milk yielder, 66 to 75 L/wk (n=12 x 23 weeks)
MMY: Moderate milk yielder, 56 to 65 L/wk (n=16 x 23 weeks)
LMY: Low milk yielder, 46 to 55 L/wk (n=12 x 23 weeks)

Reduction in milk yield due to pregnancy was calculated as the difference between milk yield of 23 pregnant and 17 non–pregnant buffaloes. The data for milk yield reduction per week for week 1 to 23 of pregnancy were used to investigate milk yield reduction due to pregnancy. Eight different models including Straight line regression, Quadratic equation, Two straight lines with joining point at week 8, A plateau and quadratic curve with a joining point , A plateau and a straight line with a joining point b/w 5.0, 6.0, Two straight lines with joining point at week 12, A plateau and a straight line with a joining point (Draper and Smith, 1981, Neter *et al.* 1985) and Coulon model exponential function. (Coulon *et al.* 1995) were compared to calculate milk yield reduction due to pregnancy.

For dairy cows, Coulon modeled the effect of pregnancy stage on milk yield. In the present study the correction term was modified to **Pw – 5**, because the effect of pregnancy was noted after 5th week post-conception. The modified model was applied as follows:

$$\mathbf{Y = -e^{0.9602}\{(PW-5)\}\, e^{-0.15\ PW}} \qquad \mathbf{(1)}$$

Milk yield data for each week were statistically analyzed using the following linear model:

$$Y_{ijk} = \mu + \rho_i + \alpha_j + (\rho\alpha)_{ij} + \varepsilon_{ijk} \qquad \mathbf{(2)}$$

Where, $\mathbf{Y_{ijk}}$ is the kth observation of the ith group and jth treatment; $\boldsymbol{\mu}$ is over all mean; $\boldsymbol{\rho_i}$ is ith group effect; $\boldsymbol{\alpha_j}$ is jth treatment effect; $\boldsymbol{(\rho\alpha)_{ij}}$ is interaction between ith group and jth treatment; and $\boldsymbol{\varepsilon_{ijk}}$ is Random effect associated with kth animal of the ith group and jth treatment.

The milk yield data were also analyzed as combined over weeks to find out interactions among groups, treatments, and weeks. The following model was used for the combined analysis:

$$Y_{ijkl} = \mu + \rho_i + \alpha_j + \beta_k + (\rho\alpha)_{ij} + \rho\beta_{ik} + \alpha\beta_{jk} + \rho\alpha\beta_{ijk} + \varepsilon_{ijkl} \qquad (3)$$

Where, $\mathbf{Y_{ijkl}}$ is the lth observation of the ith group, jth treatment, and kth week; $\boldsymbol{\mu}$ is over all mean; $\boldsymbol{\rho_i}$ is ith group effect; $\boldsymbol{\alpha_j}$ is jth treatment effect; $\boldsymbol{\beta_k}$ is the kth week effect; $\boldsymbol{(\rho\alpha)_{ij}}$ is interaction between ith group and jth treatment; $\boldsymbol{\alpha\beta_{jk}}$ is the interaction between the ith group and kth week; $\boldsymbol{\rho\alpha\beta_{ijk}}$ is the interaction between the ith group, jth treatment, and kth week; and $\boldsymbol{\varepsilon_{ijkl}}$ is random effect associated with kth animal of the ith group and jth treatment.

Combined analysis was made for the first eight weeks, for the last 15 weeks, and for all the 23 weeks of the milk yield data, because the decline seemed to be affected by pregnancy and ration in weeks- 9 to week-23.

RESULTS

Modeling decline in milk yield: Results of eight different models applied for the calculation of milk yield reduction are presented in Table.1 Two straight lines model with a joining point at 8 weeks had an R^2 of 0.9629, while the quadratic model also gave a good fit with an R^2 of 0.9863. Empirically, the quadratic model seems to be better because of its higher R^2, but logically we prefer the model with two straight lines as the first line reflects a little decline while the second line gives a drastic decline at certain stage of gestation. In this study two straight lines even gave better fit than Coulon *et al.* (1995) model (R^2=0.9445) for the reduction of milk due to pregnancy.

The reduction initiated after 5th week of conception and became significant on 7th week as evident from the Figure 1. The linear model did not give good fit which is clear from the predicted values of the model (R^2 = 0.9237. The quadratic model though gave good fit (R^2 = 0.9863) yet predicted values seem to be slightly different from the actual values. The line JP8 (joining point at week 8) model also gave well fit (R^2 = 0.9527) and the predicted values are much closer to the actual values. The decline in milk with advancement of pregnancy was slight up to a point which we declared as joining point; thereafter the decline was much greater.

Figure 2 shows post-conception reduction in milk yield in the high, moderate and low milk yielding buffaloes. The reduction in high yielding buffaloes was slight up to 6th week but later on it became drastic. In the moderate yielding buffaloes the reduction was the least while in the low producing buffaloes the reduction was slightly greater. In the high yielders, the predicted reduction was the highest (-4.48 L/wk) followed by the moderate and low yielders (-2.37 and -0.94 L/wk), respectively during 6th week post-conception. It shows the higher sensitivity of the high yielding buffaloes to the onset of pregnancy. Total predicted reduction in milk yield due to pregnancy in the various production groups (6-23 weeks post conception) was 173.97, 100.81 and 129.14 L, respectively.

Managing decline in milk yield: The difference in weekly milk yield of buffaloes recorded from 1 to 23 week, as affected by various treatments in the three production groups, are given in Table 3. Difference among the high, moderate and low yielders was significant throughout lactation. The effect of treatment on decline after 5th week was apparent but became significant in 7th week. The group x treatment interaction affected milk yield decline on 4th, 6-9th, and 14-15th and beyond 18th week post-conception.

Milk yields of the high, moderate and low production groups of buffaloes, averaged over the 23 weeks period as affected by ration and pregnancy are presented in Figure 3. The average weekly yield of the high yielding animals was 50.0, 45.8, 50.9 L in the pregnant-ration-supplemented (PRS), pregnant-ration-traditional (PRT) and non-pregnant-ration-traditional (NPRT) buffaloes, respectively. For the moderate yielding buffaloes the values were 38.7, 36.0 and 40.6 L/wk, respectively, showing a decline in milk yield in animals, both on supplemented and traditional rations. The low yielders showed a decline pattern similar to the high yielders.

Treatments x week's interaction are shown in Figure 4 A – 4 C. In the high production group (Figure 4-A), the decline in PRS was moderate while the decline in PRT was the highest and in NPRT was the lowest. These results showed that supplementation of the pregnant animals with concentrate feed maintained milk production levels post-conception while drastic decline in milk yield was seen in pregnant buffaloes on traditional ration. In the moderate production group (Figure 4-B) the supplementation support to milk yield was smaller than the high yielding group. However, beyond the 15th week post-conception, the decline in yield in the pregnant buffaloes on traditional ration was greater. It demonstrates a little beneficial affect of feed supplementation to the moderate yielding buffaloes. In the low production buffaloes (Figure 4-C) the pregnant buffaloes with supplemented ration maintained the milk yield almost similar to the non-pregnant buffaloes on traditional ration.

Combined analysis of milk yield of the 23 weeks: The data were analyzed through combined analysis of variance for milk yield during a period of 23 weeks as shown in Table 4. The difference in milk yield among the production groups (high, moderate and low yielders) and treatments (pregnant with supplemented ration, pregnant with traditional ration and non-pregnant with traditional ration), was significant (P<0.01). Effect of post-conception weeks was also significant (P<0.01). Interaction between production groups x treatments, and treatments x post-conception weeks was significant. Interaction among the production groups x weeks x treatments was also significant. Interaction between production groups x post-conception weeks was non-significant.

Table 1. Fitting different models for reduction in milk yield (overall average)

Milk reduction due to pregnancy	JPW*	R square
Straight line regression	-	0.9237
Quadratic equation	-	0.9863
Two straight lines with joining point at	8.0	0.9629
A plateau and quadratic curve with a joining point at	5.0	0.9838
A plateau and a straight line with a joining point b/w 5.0, 6.0,	5.7	0.7026
Two straight lines with joining point at	12.0	0.8826
A plateau and a straight line with a joining point at	5.5	0.9527
Coulon model exponential function	5.0	0.9445

* Joining point week

Table 3. Changes in milk yield of buffaloes as affected by production groups and treatments

SOV[1]	DF	Week post-conception (1-12)											
		1	2	3	4	5	6	7	8	9	10	11	12
G[2]	2	***	***	***	***	***	***	***	***	***	***	***	***
T[3]	2	NS[4]	NS	NS	NS	NS	NS	***	***	*	*	*	***
G x T	4	NS	NS	NS	*	NS	*	***	***	*	NS	NS	NS
--	--	Week post-conception (13-23)											
		13	14	15	16	17	18	19	20	21	22	23	
G	2	***	***	***	***	***	***	***	***	***	***	***	
T	2	***	***	***	***	***	***	***	***	***	***	***	
G x T	4	NS	*	*	NS	NS	NS	*	**	***	***	***	

[1] SOV = Source of variation; [2] G = Groups (HMY, MMY and LMY) [3] T = Treatments (PRT, PRS and NPRT;[4] NS = Non-significant* = Significant (P < 0.05), ** Significant (P < 0.01)*** Significant (P < 0.001)

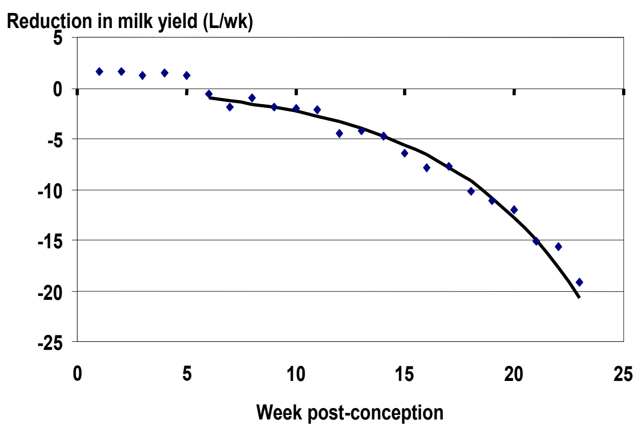

Figure 1.Change in milk yield with the advancement of pregnancy in dairy buffaloes (Y = -e0.9602 [(PW-5)] e-0.15 PW; R^2 = 0.9445)

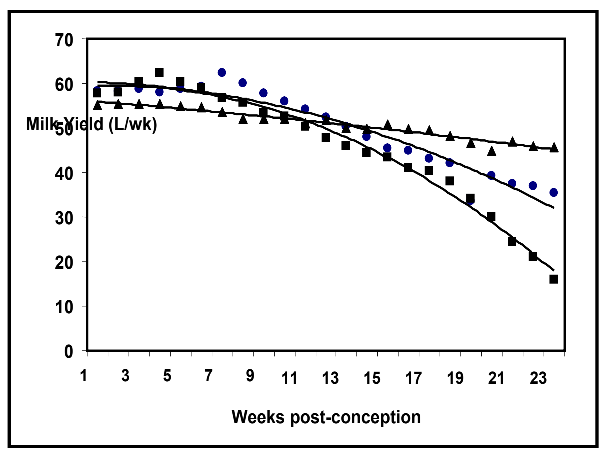

Figure 4.A.. Treatments x week's interaction in high production group (pregnant-ration-traditional; pregnant-ration-supplemented ●; non-pregnant-ration traditional ▲)

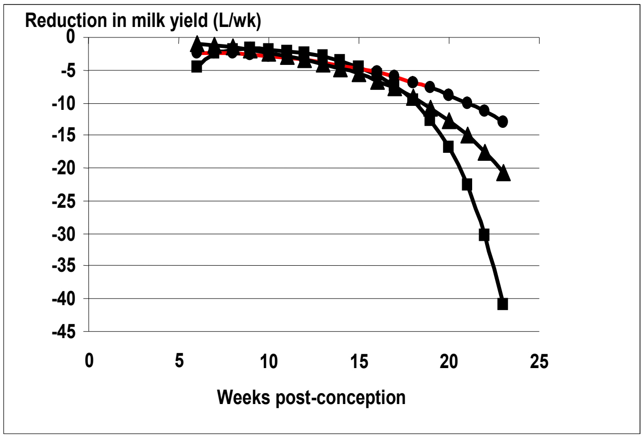

Figure 2. Change in milk yield with onset of pregnancy in dairy buffaloes in high (HMY■), moderate (MMY●) and low (LMY▲) yielding group

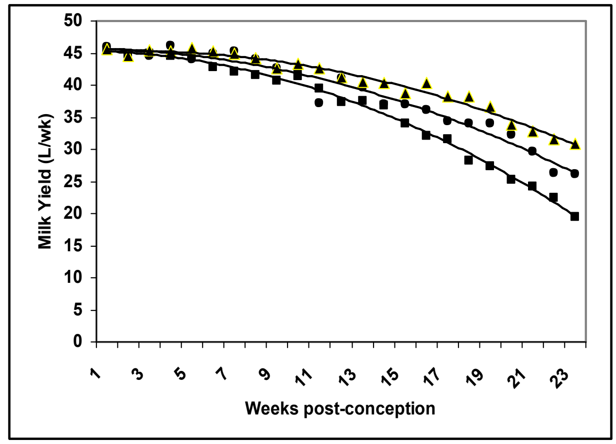

Figure4.B.. Treatments x week's interaction in moderate production group (pregnant-ration-traditional; pregnant-ration-supplemented ●; non-pregnant-ration traditional ▲)

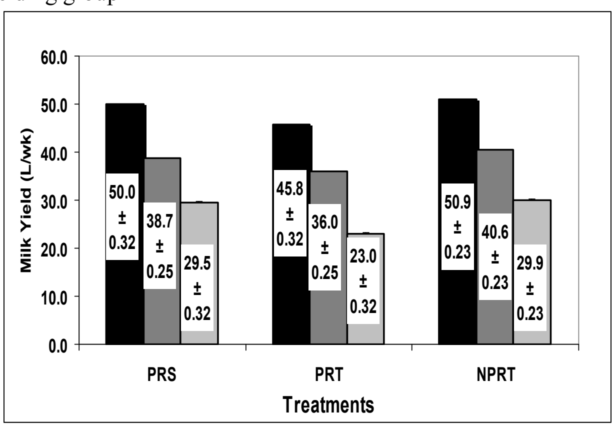

Figure 3. Milk yields of the high (HMY ■), moderate (MMY ▩) and low yielding groups (LMY ▤), of buffaloes, averaged over the 23 weeks period in Pregnant-Ration- Supplemented (PRS), Pregnant-Ration-Traditional (PRT) and Non-Pregnant-Ration-Traditional (NPRT)

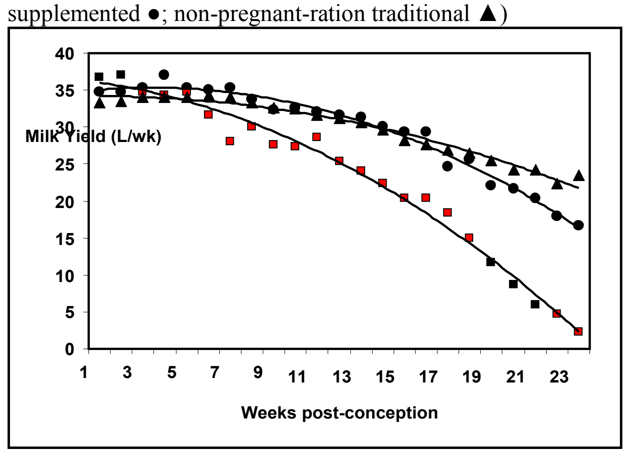

Figure 4.C. Treatments x week's interaction in low production group (pregnant-ration-traditional; pregnant-ration-supplemented ●; non-pregnant-ration traditional ▲)

DISCUSSION

The period of noticeable decline: At the medium sized private dairy farms the reduction in milk yield initiated after 5th week post-conception. This reduction is noted at a stage much earlier than the cows which is 20th week of pregnancy (Coulon *et al.*, 1995). They noted that it neither depended on the stage of lactation at the time of conception nor on the cow's characteristics, in particular their milk yield level as reported by Erb *et al.* (1952). Even an earlier decline in milk yield has been reported in dairy cows, up to one month post-conception (Bar-Anan and Genizi, 1981). Coulon *et al.* (1995), Bachman *et al.* (1988) and Genizi *et al.* (1992) reported that the effect of pregnancy became important (> 1 kg/day) after the 25th week of pregnancy in dairy cows. In our study the equivalent decline level (about 4 kg /week) can be seen on 12th week post-conception.

The present study shows the higher sensitivity of the high yielding buffaloes to the onset of pregnancy. Obviously, the high yielders are more sensitive to conception due to higher energy loss and poor nutritional status. In previous studies Khan and Lurdi, (2002) reported that pregnant goats had lower blood glucose than non-pregnant after day 84 of pregnancy. It was suggested that there may be competition for glucose between the mammary gland and the gravid uterus which would result in milk yield losses due to pregnancy in high yielder. Olori *et al.* (1997) found that in first lactation the cows were more sensitive to the stress of pregnancy in mid lactation when dairy production was greater than the later stage of lactation. It was suggested that mammary gland is generally less responsive to the onset of conception.

The resource constrained-poor-unaware farmers under the conventional buffalo farming in this region are unable to provide sufficient feeding and management support to these animals. On the other hand they are reluctant for postpartum rebreeding of their high yielding buffaloes for fear of a drastic decline. Findings of the present study have demonstrated this post-conception decline in milk yield under the traditional same-scale-feeding regime.

Buffalo does not produce at its own cost: The present study indicated that an earlier decline in milk yield post-conception than the cows (after 5^{th} week in this study on buffaloes versus 18 weeks for cows reported by Coulon *et al.*, 1995). It shows a special characteristic of buffalo, who tries to retain body condition score and manifest a decline in milk yield rather than producing higher quantities of milk, in contrary to cattle. Dairy cows produce milk at the expense of loss of body condition score while dairy buffalo does not seem doing so, leading to a decline in milk yield before it looses its condition.

The specific behavior of retaining body condition score while producing milk, appears to be linked with the adverse climatic and management conditions in the regions having buffalo dairy farming. In these regions a continental climate is prevailing where extreme cold and hot season show a variation in atmospheric temperature from -10^0 C to + 50^0 C. This is coupled with poor housing and feeding conditions where the requirements of the animals are ignored (Qureshi, 2002). In addition the ration comprise more roughages which lead to production of acetates and butyrate which are lipogenic, tending to contribute to enhancing body condition; in contrary to dairy cow in the temperate regions with higher energy diets resulting in production of propionates which is glycogenic leading to higher milk yield rather than supporting body condition.

From genetic point of view we can see that dairy cows have been selected for better traits over a long period of time, while buffaloes are raised without any scientific or commercial support. A little improvement has been made so far, for the use of buffalo as a specialized dairy animal under intensive farming conditions.

The findings of the present study indicates that the drastic decline in milk yield in buffalo as compared with cow, with the onset of pregnancy may be due to a dramatic shifts in nutrient partitioning which spared little nutrients for milk synthesis in buffaloes while maintaining better body condition.

Preventing post-conception decline in milk yield: The present study showed that an animal becoming pregnant, if supplemented with extra feed for milk production, would maintain the high yield level even after getting pregnant. Ration supplementation beyond 6^{th} week post-conception, significantly increased milk yield than the non-supplemented buffaloes. The average weekly yield of the high yielding animals was almost similar in the pregnant-ration-supplemented (PRS) and non-pregnant-ration-traditional (NPRT) while the pregnant-ration-traditional (PRT) buffaloes showed a drastic decline in yield.

There was little beneficial effect of feed supplementation to the moderate yielding buffaloes. In the low production group the pregnant buffaloes with supplemented concentrates and with traditional concentrates both had similar trend of decline in milk production. The decline trend was not very high. However, the decline in the non-pregnant buffaloes on control diet was drastic. The present study indicates that an animal becoming pregnant, if supplemented with extra feed for milk production, would maintain the high yield level even after getting pregnant, almost equivalent to another buffalo which has neither become pregnant nor supplemented with extra ration.

The present study shows that supplementation of the high yielding pregnant animals with concentrate feed maintained higher milk production levels post-conception which may be due to their larger feed requirements of the growing fetus coupled with the milk synthesis. In the moderate production group the feed requirements were less and so the feed supplementation effect was also smaller. In the low yielders the reduction in feed intake was not parallel with the decline in milk yield, leading to adverse effects of excess intake of feed. It may be explained in light of findings (Qureshi, 2002) where excess intake of protein associated with high levels of urea, was found as the cause of reduction in milk yield in dairy buffaloes. This effect of pregnancy was lacking in the moderate yielders as the nutrient intake was probably utilized for milk synthesis and there was no excess intake of protein which could exert adverse effect on milk yield.

As mentioned in introduction of this paper and previous studies (Qureshi, 1995), the farmers under field conditions practice same scale feeding irrespective of milk yield or pregnancy status. The present study has confirmed that under such conditions the pregnant non-supplemented animals are unable to maintain higher milk yields post-conception. Resultantly this decline in milk yield post-conception discourages farmers for rebreeding their animals. It delays rebreeding of buffaloes and delayed breeding becomes further uneconomical as maintaining dry buffaloes will not support their production cost.

In the high yielding buffaloes the average weekly decline was about 5 L costing Rs.250 (Rs.60=1US$), while the cost of feed supplementation to maintain this production level, was about Rs.25, which is ten times less than the loss due to milk yield decline. Based on these findings it may be recommended that feed supplementation to the high yielder will be economical under field conditions at buffalo dairy farms.

Conclusion: The onset of pregnancy in dairy buffalo results in drastic decline in milk yield. The natural increase in milk yield is prevented by the pregnancy occurrence. A noticeable decline level (about 4 L/wk) was seen on 12th week post-conception. The high yielding buffaloes are more sensitive to the onset of pregnancy and the resource constrained-poor-unaware farmer is unable to provide sufficient feeding and management support to these animals. An animal becoming pregnant, if supplemented with extra feed for milk production, would maintain the higher yield level even after getting pregnant. In the high yielding buffaloes the cost of feed supplementation to maintain this production level, was ten times less than the loss due to milk yield decline.

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