Feed costs about 60–70% of total cost of production in bovines and improvement in feed efficiency will lead to reduction in input costs and increased profitability. Little attention has been given to improve feed efficiency and reducing feed cost while it is mainly focused on output traits (growth, milk production, fertility etc). Feed utilisation efficiency in farm animals calculated as a function of individual intake, body weight (BW) and weight gain can be appraised by several ways; one of them is gross feed efficiency. But, actions taken to improve gross feed efficiency can inadvertently lead to financial losses rather than gains (Gaines et al. 2012). This is due to the fact that single-minded actions taken to improve feed efficiency may affect other aspects of the enterprise and most important is the cost of feed. Gross feed efficiency also may reflect an animal’s energy requirement for maintenance. In growing cattle, maintenance energy costs represent approximately 70–75% of the total annual energy requirements (ICAR 2013). Measurement of RFI gives more precise way of feed conversion. By this measure, animals which eat less than expected have a negative RFI and are considered more efficient. It is expressed as the difference between actual feed intake and the feed an animal is expected to consume based on its body size and growth rate (Koch et al. 1963). Thus, RFI is a measure of the variation in feed intake beyond that which is needed for maintenance and growth requirements (Archer et al. 1999). Cattle identified as having low RFI have lower feed intakes and FCR when compared to cattle identified as having high RFI (Herd et al. 2002, Basarab et al. 2003) and have same level of production as high RFI cattle (Arthur et al. 2001, Nkrumah et al. 2007). Although negative consequences of selection for RFI are uncertain, like cattle selected for low RFI have shown small associations with a reduction in carcass fat content (Richardson et al. 2001). RFI can be used as a tool to identify the most efficient animals. Previous research reported that RFI influenced insulin and glucose concentrations in beef heifers (Yelich et al. 1996). Yambayamba et al. (1996) reported that serum concentrations of glucose, insulin, and IGF-I were similar in both the groups. From present study, it could be concluded that low RFI animals were more efficient in feed conversion.

**Keywords**: Biochemical parameters, Nutrient utilization, Residual feed intake, Sahiwal calves

---

**ABSTRACT**

This study was conducted to evaluate the differences in efficiency of feed utilisation in Sahiwal calves with low and high residual feed intake (RFI) by comparing feed intake, nutrient digestibility, growth traits and blood biochemical parameters. Eighteen growing male Sahiwal calves (aged 12 months, average body weight 120.04 kg) were selected and fed individually total mixed ration as per their requirements for a period of 60 days. Fifty per cent of maize grains in concentrate mixture containing 33% maize grains were replaced by fresh potatoes (DM basis). Based on linear regression models involving dry matter intake (DMI), average daily gain (ADG) and mid test metabolic body size, calves were assigned into low and high RFI groups. Residual feed intake (RFI) values were calculated for individual calves and the calves were divided into low (~0.20) and high (+0.18) RFI groups. Low RFI animals consumed less dry matter than the expected or predicted one indicating their more efficiency of feed utilization. The intakes of DM and CP were 4.95 and 6.47% lower in low RFI animals compared to high RFI animals while average daily gain was higher in low RFI group. The digestibility of DM, OM, CP, EE, total carbohydrates, NDF and ADF were similar in low and high RFI groups, however, nitrogen retention was higher in low RFI group. Values of alanine amino transferase (25.85 vs. 35.72 IU/L), aspartate amino transferase (80.33 vs. 100.57 IU/L), total protein (7.34 and 8.24 mg/dL), blood urea nitrogen (15.45 and 22.22 mg/dL) and creatinine (1.27 and 1.78 mg/dL) were higher for high RFI as compared to low RFI group. The concentration of growth hormone, insulin and IGF-1 were similar in both the groups. From present study, it could be concluded that low RFI animals were more efficient in feed conversion.
creatinine. Physiological changes can influence blood hormone and metabolite levels so the relationship of selected blood metabolites and hormones with RFI requires detailed investigation.

Accurate measurement of the RFI of cattle is time consuming, difficult and very expensive process to collect data on relatively large number of animals. By correlating with some biomarkers, we can differentiate between animal with high or low RFI within short period of time. So, it was pertinent to find out the differences in RFI in the different animals and study related biochemical parameters. This study compared the nutrient utilisation efficiency, growth performance and blood metabolites of Sahiwal calves during selection to identify individual calves with low RFI (more efficient calves) and high RFI (less efficient calves) and related biochemical parameters in male Sahiwal calves.

MATERIALS AND METHODS

The use of the animals and the experimental procedure were approved by the Institutional Animal Ethics Committee (IAEC).

Experimental site: Experiment was conducted at Livestock Research Centre, ICAR-NDRI, Karnal, Haryana, India situated at an altitude of 250 metre above mean sea level, latitude and longitude position being 29° 42′ E, respectively. The maximum ambient temperature in summer comes down to about 4ºC with a diurnal variation to the order of 15–20ºC. The average annual rainfall was 696 mm, most of which was received from early July to mid September.

Animals, management and feeding: Eighteen male Sahiwal calves of 12 months of age (average weight =120.04 kg) were selected from Livestock Research Centre, ICAR-NDRI, Karnal, Haryana, India and housed in the experimental sheds of NDRI, Karnal with well ventilated individual pens to facilitate individual feeding. Proper cleanliness and healthy surroundings were ensured throughout the experimental period. Deworming of the animals was done before the start of feeding trial. All the animals were fed total mixed ration (TMR) comprising of green berseem (Trifolium alexandrinum) fodder, wheat (Triticum aestivum) grains 16.5%, potato (Solanum tuberosum) tubers 16.5%, soybean (Glycine max) meal 21%, mustard (Brassica compestris) oil cake 12%, wheat (Triticum aestivum) bran 20%, de-oiled rice (Oryza sativa) bran 6%, bajra 5%, mineral mixture 2% and common salt 1%. It is worth mentioning that 50% of maize grain was replaced by fresh potato on DM basis in the concentrate mixture. Refusals of feed were removed daily and weighed was replaced by fresh potato on DM basis in the concentrate mixture. All the animals were weighed at 7:00 AM at fortnightly intervals before giving access to feed and water. Clean and fresh drinking water was made accessible ad lib. twice daily at 11:00 h and 16:30 h. The feed offered was adjusted weekly to account for changes in DM and BW.

Metabolism study: A metabolism trial with an adaptation period of 4 d followed by a collection period of 7 d was conducted at the end of feeding trial. Animals were weighed before and after the trial consecutively for 2 days. Feeds were offered to meet their requirements. Fresh and clean drinking water was provided twice a day and the quantity was measured to calculate the total water intake. The feed, faecal and feed residue samples were dried at 65°C in hot air oven for two consecutive days and ground to pass through 1.0 mm sieve. Intake of feeds, output of faeces and urine were recorded daily for each animal. The faecal and urine samples were preserved using 25% H2SO4 for N estimation.

Laboratory analysis: The proximate principles (DM, OM, CP, EE and TA) and cell wall constituents (NDF and ADF) were determined in feeds, residues and faecal samples were determined using procedures of AOAC (2005) and Van Soest et al. (1991), respectively. Nitrogen content in faeces and urine samples were estimated (AOAC 2005). The digestibility coefficient of nutrient (DM, OM, CP, EE, total CHO, NDF and ADF) was calculated from the nutrient intake and nutrient outgo in faeces during metabolism trial as following:

\[
\text{Digestibility} \, [%] = \left(\frac{\text{Nutrient intake} \, [\text{kg}]}{\text{Faecal excretion} \, [\text{kg}]}\right) \times 100
\]

During 60 days of experimental period, blood samples (10 mL) were collected from all the animals by jugular puncture in heparinised vacutainer thrice (at the beginning, middle and end of feeding trial) and plasma was separated by centrifugation at 3,000 rpm for 15 min. The plasma samples were stored at −20°C for further estimation of different blood metabolites and hormones. The levels of total protein, glucose and BUN were estimated in blood plasma samples using GOD-POD kits (Span Diagnostics Ltd., India). The activity of alanine aminotransferase (ALT) and aspartate aminotransferase (AST) in blood plasma was determined (Reitman and Frankel 1957). The concentration of creatinine was determined using an initial rate assay test kit (Span Diagnostics India, Ltd.). The concentration of plasma growth hormone was determined using Bovine GH ELISA test kit, Endocrine Technologies, New York, USA), insulin by Bovine Insulin ELISA test kit, Endocrine Technologies, New York, USA) and IGF-I by Bovine IGF-I ELISA test kit, Endocrine Technologies, New York, USA).

Calculation of residual feed intake: Growth of the Sahiwal calves was modelled by linear regression of body weight data against time and the regression coefficients were used to describe the growth of each animal (Archer et al. 1997).

The equation fitted was

\[ Y_i = b_0 + b_1 x_i + e_i \]

where \( Y_i \), weight of the animal at observation \( i \); \( b_0 \), intercept (weight at start of test); \( b_1 \), regression coefficient (i.e. average daily gain); \( x_i \), number of days on test at observation
The estimates of the regression coefficients obtained were used to calculate the average daily gain during the test and the mid-test metabolic body weight. Average DMI for the 60 days feeding period was regressed on mid-test metabolic BW (BW^{0.75}) and ADG (Archer et al. 1997, Kelly et al. 2010). Residual feed intake was computed for each animal and was assumed to represent the residuals from a multiple regression model regressing DMI on ADG and MBW. The base model used was:

\[ Y_j = \beta_0 + \beta_1 MBW_j + \beta_2 ADG_j + e_j \]

where \( Y_j \) is DMI of the jth animal; \( \beta_0 \), regression intercept; \( \beta_1 \), regression coefficient on MBW; \( \beta_2 \), regression coefficient on ADG and \( e_j \), uncontrolled error of the jth animal (RFI).

The actual DMI minus the predicted DMI corresponded to the RFI meaning thereby that a more efficient animal had a negative RFI (observed feed intake was less than predicted feed intake) and a less efficient animal had a positive RFI (observed feed intake was greater than predicted feed intake).

Statistical analysis: The data were analyzed by general linear model procedure according to a complete randomized design using statistical software SPSS (version 16.0). Individual animals were considered as experimental units and RFI group as a fixed parameter. When ANOVA was significant (P<0.05), differences among means were examined by the Tukey ‘t’ test.

RESULTS AND DISCUSSION

Chemical composition of diets, residual feed intake and nutrient intake: The chemical composition of feed/fodders used for the animal feeding are given in Table 1. After completion of 60 days, 18 growing male Sahiwal calves were divided into two groups, i.e. low and high RFI group (Fig. 1). The dots below line (Fig. 1) indicated that 9 animals were considered as low RFI animals whereas the dots above the line indicated that 9 animals were considered as high RFI animals. RFI value was –0.20 and 0.18 kg DM/d for low and high RFI, respectively (Table 2).

The values of DMI during metabolic trial were 3.53 and 4.10 kg/d for low and high RFI groups, respectively (Table 4). It was found that low RFI group consumed 13.48% less DM than its requirement (NRC 2001) while high RFI group consumed 5.94% more DM than their expected. Also, the DMI (kg/100 kg BW/day) was lower (P<0.05) in low RFI (2.39) group compared to high RFI (2.63) group animals.

The overall mean DMI during whole experimental period were 3.26±0.08 and 3.43±0.08 kg/d in low and high RFI groups, respectively (Table 2). Similar results of lower DMI in low RFI buffalo calves than that of high RFI group (1.9 kg/d vs 2.4 kg) has been reported (Sharma et al. 2016).

Table 2. Feed intake and feed conversion ratio in low and high RFI groups of Sahiwal calves

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of animals</td>
<td>Low RFI 9</td>
</tr>
<tr>
<td></td>
<td>High RFI 9</td>
</tr>
<tr>
<td>RFI value</td>
<td>–0.20±0.07</td>
</tr>
<tr>
<td></td>
<td>0.18±0.08</td>
</tr>
<tr>
<td>Mean DMI (kg/d)</td>
<td>3.26±0.08</td>
</tr>
<tr>
<td></td>
<td>3.43±0.08</td>
</tr>
<tr>
<td>Mean DMI (kg/100 kg BW)</td>
<td>2.45±0.10</td>
</tr>
<tr>
<td></td>
<td>2.77±0.12</td>
</tr>
<tr>
<td>Initial body weight (kg)</td>
<td>124.23±14.78</td>
</tr>
<tr>
<td></td>
<td>115.85±15.83</td>
</tr>
<tr>
<td>Final body weight (kg)</td>
<td>154.89±16.91</td>
</tr>
<tr>
<td></td>
<td>144.20±18.09</td>
</tr>
<tr>
<td>Metabolic weight (kg W^{0.75})</td>
<td>41.4±1.48</td>
</tr>
<tr>
<td></td>
<td>40.0±0.92</td>
</tr>
<tr>
<td>ADG (kg/d)</td>
<td>0.539±0.06</td>
</tr>
<tr>
<td></td>
<td>0.499±0.05</td>
</tr>
<tr>
<td>FCR (kg consumed/ kg of BW gain)</td>
<td>6.19±0.83</td>
</tr>
<tr>
<td></td>
<td>7.03±0.96</td>
</tr>
</tbody>
</table>

Table 3. Digestibility of nutrients (%) and nitrogen balance in low and high RFI groups of Sahiwal calves

<table>
<thead>
<tr>
<th>Item</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low RFI</td>
</tr>
<tr>
<td></td>
<td>High RFI</td>
</tr>
<tr>
<td><strong>Nutrient digestibility</strong></td>
<td></td>
</tr>
<tr>
<td>DM</td>
<td>59.6±1.2</td>
</tr>
<tr>
<td></td>
<td>59.1±1.4</td>
</tr>
<tr>
<td>OM</td>
<td>61.3±3.6</td>
</tr>
<tr>
<td></td>
<td>60.5±1.4</td>
</tr>
<tr>
<td>CP</td>
<td>63.78±1.9</td>
</tr>
<tr>
<td></td>
<td>63.28±1.5</td>
</tr>
<tr>
<td>Total CHO</td>
<td>55.95±2.0</td>
</tr>
<tr>
<td></td>
<td>55.69±3.0</td>
</tr>
<tr>
<td>EE</td>
<td>64.43±4.1</td>
</tr>
<tr>
<td></td>
<td>63.18±1.5</td>
</tr>
<tr>
<td>NDF</td>
<td>55.84±3.9</td>
</tr>
<tr>
<td></td>
<td>54.62±2.3</td>
</tr>
<tr>
<td>ADF</td>
<td>44.01±4.8</td>
</tr>
<tr>
<td></td>
<td>42.96±2.3</td>
</tr>
</tbody>
</table>

| **Nitrogen balance**                     |              |
| N intake (g/d)                          | 78.56±1.22   |
|                                        | 83.80±1.19   |
| Faecal N (g/d)                          | 30.90±1.02   |
|                                        | 35.48±1.21   |
| Absorbed N (% of intake)                | 60.66±1.43   |
|                                        | 57.66±1.13   |
| Urinary N (g/d)                         | 28.70±1.25   |
|                                        | 31.42±1.24   |
| Total N loss (g/d)                      | 59.60±2.27   |
|                                        | 66.90±2.45   |
| N balance (g/d)                         | 18.96±1.43   |
|                                        | 16.90±1.26   |
| % of intake N                           | 24.13±3.24   |
|                                        | 20.16±2.29   |
| % of absorbed N                         | 31.81±3.99   |
|                                        | 25.26±2.98   |

a,bMeans bearing different superscripts in the same row differ significantly (P<0.05).
Intake of CP was also significantly higher (P<0.05) in high RFI Group compared to low RFI Group (Table 4) and it was observed that low RFI group consumed 7.53% less and high RFI group consumed 1.35% more CP than expected requirements (NRC 2001). Similar was the case with TDN intake, i.e. low RFI group consumed less than expected while high RFI groups consumed more than expected intake. Total water intake (L/d) was also observed during the trial and it was found 24.88 and 24.60 in low and high RFI groups, respectively.

**Performance and efficiency measures:** The digestibility values for DM, OM, CP, total CHO, EE, NDF and ADF were 59.68 and 59.14, 61.38 and 60.61, 63.78 and 63.28, 55.95 and 55.69, 64.43 and 63.18, 55.84 and 54.62 and 44.01 and 42.46% in low and high RFI group, respectively (Table 3) and they were similar in both the groups. The digestibility of DM between high and low RFI was similar (Cruz et al. 2010). Nkrumah et al. (2006) showed that RFI tended to be negatively associated (P<0.10) with apparent digestibility of DM (r=−0.33) and CP (r=−0.34). Animal variation in RFI is associated with variation in apparent nutrient digestibility. Heifers with low RFI consumed 23% less DMI and had 20% lower feed: gain ratios than heifers with high RFI. Nkrumah et al. (2006) reported that apparent digestibility in low and high RFI group was 70.87 and 75.33% for DM, 69.76 and 74.70% for CP, 17.29, 31.49% for NDF and 3.26 and 14.67% for ADF. The low-RFI Brangus heifers fed a roughage based diet had 3% higher apparent digestibility than Brangus heifers with high RFI (Krueger et al. 2009). The low RFI Angus heifers and bulls tended to show a higher DM digestibility compared to high RFI Angus bulls and heifers (Richardson et al. 1996) and RFI was negatively correlated with DM, NDF, ADF and CP digestibility. Heifers with low RFI had higher DM, NDF, ADF and CP digestibility.

The data on intake, absorption, excretion and retention of N in low and high RFI groups have been presented in Table 3. The intake of N, N voided in faeces and urine and total N loss was lower (P<0.05) in low RFI group but N retention (% of N intake and N absorbed) was higher (P<0.05) in low RFI group than the high RFI group. Negative RFI cows would have greater apparent digestibility of N than the positive RFI animals. Intakes of N did not differ between negative RFI and positive RFI cows (Richardson et al. 1996). Negative RFI cows had a greater apparent N digestibility (77.2 vs. 75.5%) and a tendency toward greater DM and OM digestibility. The negative RFI cows had a lower faecal N output (126 vs. 138 g/d) and a lower partition of feed N to faecal N (23.1 vs. 24.7%) compared with positive RFI animals (Richardson et al. 1996). Urinary N as well as daily urine production was similar in low and high RFI animals (Nkrumah et al. 2006, Bose et al. 2014).

The ADG was 0.539 and 0.498 kg in low and high RFI groups, respectively which was similar in both the groups. Basarab et al. (2003) found that low RFI steers consumed 10.4% less and had a 9.4% lower FCR with no differences...
in BW or ADG. Almeida et al. (2004) reported that animals such as Nellore heifers of 26 months of age high RFI consumed 26% more than the most efficient cattle but the ADG was similar (1.3 kg/d). Basarab et al. (2003) reported that there was no significant relationship between RFI and ADG indicating that variation in RFI reflected animal’s maintenance requirements rather than growth, size and appetite. Kelly et al. (2010) also showed that there was no significant difference in ADG for high RFI (1.52 kg) and low-RFI (1.54 kg) groups of animals. The relationship between RFI and FCR indicated that low RFI animals consumed less feed for each kg gain in BW than the high RFI group (Fig. 2). Hegarty et al. (2007) observed no difference in ADG between low and high RFI steers although low RFI steers ate 41% less DM each day and expressed improved feed conversion efficiency relative to high RFI steers. Homm et al. (2007) reported that ADG and body weight during the test period was not correlated with ADG.

Blood metabolites: The means of all blood variables (Table 5) studied were within the normal range reported for cattle by Kaneko et al. (1997) and Dias et al. (2006). Blood glucose values similar (P<0.05) in both the groups. Sharma et al. (2014) also reported similar values of blood glucose level in low (60.48 mg/dL) and high (59.52 mg/dL) RFI growing male Sahiwal calves while Kolath et al. (2006) observed that high RFI steers had greater concentrations of glucose in their blood. Richardson et al. (2004) found that at the beginning of the RFI test period, plasma glucose concentrations were positively correlated with RFI in Angus steers. Kelly et al. (2010) observed that circulating glucose was not associated with RFI. The concentration of creatinine (mg/dL) was 1.27 and 1.78 and for BUN (mg/dL) were 15.45 and 22.22 mg/dL, respectively in low and high RFI groups and these were higher (P<0.05) in high RFI group compared to low RFI group. The concentration of total protein in blood plasma averaged 7.34 and 8.24 g/dL in low and high RFI groups, respectively and these values being higher (P<0.05) in high RFI group. Richardson et al. (1996) also demonstrated a significant increase in total plasma protein in high RFI steers compared to low RFI steers (70.05 vs. 65.20 g/L). Richardson et al. (2004) found greater blood concentrations of urea in less efficient genotypes. This may be due to greater protein intake in high-RFI animals, a greater rate of body protein degradation, or deviation in the supply of AA due in part to variation in the efficiency of microbial protein production in the rumen (Lush et al. 1991, Kahn et al. 2000). Harvey et al. (1993) observed that inefficient steers (high RFI) had higher concentrations of serum urea nitrogen compared to efficient steers (low RFI) during the finishing phase. Carstens et al. (2002) also found a higher concentration of BUN in high RFI steers.

The values for ALT activity were 25.85 and 35.72 IU/L in low and high groups with corresponding values of 80.33 and 100.57 IU/L for AST. The levels of these enzymes were higher (P<0.05) in high RFI group compared to low RFI group of Sahiwal calves. The plasma insulin level was 1.37 and 1.47 IU/L in low and high RFI group, respectively with corresponding values of 1.08 and 1.11 ng/mL for IGF-I. The values of IGF-1 were higher (P<0.05) in calves of low RFI groups (Dudi and Chander Datt 2015). Brown et al. (2004) found a positive correlation between IGF-1 and RFI in which low RFI steers and bulls had 29 and 25% lower concentrations of serum IGF-I compared to high RFI steers.

### Table 5. Blood biochemical and physiological parameters in low and high RFI groups

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulin (ng/mL)</td>
<td>Low RFI: 1.37±0.27</td>
</tr>
<tr>
<td>IGF-I (ng/mL)</td>
<td>Low RFI: 1.08±0.007</td>
</tr>
<tr>
<td>GH (ng/mL)</td>
<td>Low RFI: 4.53±0.12</td>
</tr>
<tr>
<td>ALT (IU/L)</td>
<td>Low RFI: 25.85±1.21</td>
</tr>
<tr>
<td>AST (IU/L)</td>
<td>Low RFI: 80.33±1.91</td>
</tr>
</tbody>
</table>

**Blood metabolites:**

- **Glucose (mg/dL)**: Low RFI: 60.48±0.99, High RFI: 59.52±1.07
- **Creatinine (mg/dL)**: Low RFI: 1.27±0.01, High RFI: 1.78±0.01
- **Total protein (g/dL)**: Low RFI: 7.34±1.23, High RFI: 22.2±1.21
- **BUN (mg/dL)**: Low RFI: 15.45±1.23, High RFI: 22.2±1.21

**AB**: Means bearing different superscripts in the same row differ significantly (P < 0.05).
(> 0.5 SD) steers and bulls. However, Richardson et al. (1996) found no significant differences in concentrations of IGF-I between high and low RFI cattle. Results in beef cattle showed that circulating levels of IGF-1 are genetically associated with growth and finishing performance of beef cattle and may prove useful as a genetic predictor of carcass and feed efficiency traits (Johnston et al. 2001, 2002; Herd et al. 2002). A genetic and economic evaluation of the use of IGF-1 as an indirect selection criterion in beef cattle showed that it can increase the profitability of selection decisions and would best used as a screening test to identify animals to be placed into RFI tests in a two-stage selection program (Wood et al. 2002). The GH concentration was 4.53 and 4.24 ng/mL in the respective groups. Walker et al. (2010) documented there were no significant main effects of glucose, insulin for the low, medium, and high RFI group of cattle.

Calves of low RFI group consumed less feed than high RFI group whereas no differences existed for the average daily gain. Therefore, selection of low RFI animals would be expected to result in reduced feed inputs without altering growth rate and daily weight gain. However, a significant association was found between some plasma biochemical parameters and RFI. Thus, it is likely that measurement of these metabolic indicators (alanine amino transferase, aspartate amino transferase, total protein, blood urea nitrogen and creatinine) will be useful in the early identification of efficient animals. Therefore, selection of animals based on RFI would be an effective tool in livestock production system.

ACKNOWLEDGEMENT

The authors are thankful to the Director, ICAR-National Dairy Research Institute, Karnal, Haryana, India for providing necessary facilities to carry out this research work.

REFERENCES


October 2020] RESIDUAL FEED INTAKE AND EFFICIENCY OF FEED UTILIZATION 1429


ICAR. 2013. Nutrient Requirements of Cattle and Buffalo. 1st edn. Indian Council of Agricultural Research, New Delhi, India.


SPSS. 2010. Statistical Package for Social Sciences. version 16.0., Chicago, IL, USA.


