COMPARATIVE ENERGETIC AND ECONOMIC EFFICIENCY OF INDIGENOUS AND IMPROVED BREED OF BUFFALO AND CATTLE FOR MILK PRODUCTION IN EASTERN GANGETIC PLAINS

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ABSTRACT

Animal husbandry is the mainstay of economy of resource poor farmers' in Eastern Indo-Gangetic Plains (EIGP). Average milk yield of indigenous cattle was recorded only 2.75±0.66 kg/day compared to 7.55±1.20 kg/day in improved cattle. Accordingly, milk yield was recorded to be 3.06±0.86 and 5.12±1.71 kg/day in indigenous and improved buffalo. Rearing of improved livestock resulted into 2-fold higher energy inputs compared to indigenous ones. However, energy output was highest through milk in case of indigenous as well as improved breeds of cattle and buffalo. Economic analysis revealed that cost of human labour was highest (>40%) for rearing of indigenous livestock, followed by dry fodder (>25%). In case of improved livestock, cost of concentrate feed had maximum input (>30%). On average, 2000 to 2100 m^2 of fodder area is required to feed one unit of improved livestock in EIGP. Net monetary benefit was highest for improved cattle (US$ 523.10), followed by improved buffalo (US$ 135.68). The data indicated that animal husbandry is an important food production system in EIGP besides food crops and both the systems have been found complimentary to one another through emphasis on resource recycling.

Keywords: buffalo, *Bubalus bubalis*, farming system, milk, energy efficiency, economic analysis

INTRODUCTION

The Indo-Gangetic Plains is among the most extensive fluvial plains of the world and covers several states of the northern, central and eastern parts of India (Pal *et al*., 2009). EIGP being most important agricultural eco-regions occupies 19.01 million ha net sown area and produces about 40% of total food grains of India (Bhatt *et al*., 2011a). EIGP covers Lower and Middle Gangetic Plains with a total geographical area of 34.78 million ha. The region is thickly populated with a total population of 306.04 million which is 2.26-fold higher population density compared to national average of 382 nos/sq. km (Bhatt *et al*., 2013). More than 80% households are rural. The climate of EIGP is characterized as hot sub humid with a mild winter and high precipitation. Of the total human population of 306.04 million, about 119 million population is below poverty line who depends mainly on livestock and poultry farming

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for their subsistence (Bhatt *et al*., 2013). Agriculture is the mainstay of economy in EIGP with Rice-Wheat as the major cropping system, followed by livestock farming, backyard poultry and fisheries (Bhatt *et al*., 2011a). Efficient use of resources is, therefore, one of the major criteria for eco-efficient and sustainable production, particularly in thickly populated EIGP, where farmers' are, by and large, marginal and resource poor having small and fragmented land holdings (Bhatt *et al*., 2016). Similar was the case with livestock density. EIGP has 111.5 million nos. of total livestock population, i.e., 21.8% of the total livestock population of the country (Anonymous, 2014). The data on per cent contribution of livestock indicated that EIGP possess 43.6% cattle population, followed by goat (32.46%) and buffalo (17.95%). Indigenous cattle and buffalo are mainly reared in traditional animal husbandry practices which is also evidenced from the fact that EIGP has only 17.14% of improved cattle population (Bhatt, 2016). Of the total milk production of 22.04 million tonnes in EIGP, middle Gangetic Plains (MGP) alone contribute its 73.7%.

Though, crop-livestock mixed farming is the mainstay of economy in EIGP, average size of fragmented land holdings in Lower Gangetic Plains (LGP) and Middle Gangetic Plains (MGP) is accounted for 0.86 and 0.47 ha, respectively, as against national average of 1.15 ha (Bhatt, 2016). Shrinking per capita land holdings, particularly in MGP, has forced the farmers for livestock rearing to achieve livelihood security (Bhatt *et al*., 2016). Even the livelihood of landless farmers depends mainly on livestock farming. Keeping in view the importance of livestock in livelihood improvement of marginal, sub-marginal and landless farmers on the one hand and to sustain the agricultural production system on the other, the present study has been conducted keeping in view the following objectives:

- Production performance of indigenous and improved buffalo and cattle in EIGP
- Energy use efficiency of buffalo production system as compared to cattle.
- Net monetary returns through buffalo farming and
- Synergetic role of buffalo in crop-livestock mixed production system

MATERIALS AND METHODS

The experiment was conducted for three consecutive years (during 2013 to 2015) at the experimental farm of the ICAR Research Complex for Eastern Region, Patna, India (Located between 25^{o} 11' N latitude, 85^{o} 32' E longitude, and an altitude of 53 m asl) and also at Institute adopted village (Khajuri, Patna district, MGP). A total of 30 nos. of Holstein Friesian (improved cattle) and 30 nos. of Murrah buffalo (improved) were divided into three groups to record the production performance, productivity, energy and economic efficiencies. Similar no. of indigenous cattle and buffalo (non-descript breed of cattle and buffalo) were selected in the village for comparing the data. The adopted village was situated adjacent to the institute and thereby represent similar environmental conditions.

During the study period, mean annual rainfall was recorded 895.82±86.5 mm indicating a shortfall of 231.47 mm than the normal rainfall. On average, highest precipitation was received during August to September in all the three years of experimentation. Mean monthly minimum temperature ranged from 6.5^{o}C (January) to 29.6^{o}C (August) whereas, maximum temperature varied from 18.7^{o}C (January) to 38.14^{o}C (May) at the experimental site.

To estimate the fodder production, perennial forage like Napier (*Pennisetum purpureum)*, Setaria (*Setaria* sp.), Para grass (*Brachiaria mutica)* and Guniea (*Megathyrsus maximus*), summer/rainy season forage such as Sorghum (*Sorghum vulgaris)*, maize (*Zea mays)*, Bajra (*Pennisetum glaucum)*, Jowar (*Sorghum bicolor)*, Cowpea (*Vigna unguiculata)* and rice bean (*V. umbellata*) and winter forage like oat (*Avena sativa)*, berseem (*Trifolium alexandrinum)* and annual rye (*Lolium multiflorum*) were cultivated in ten replications in complete Randomized Block Design at the experimental farm of the institute following standard cultivation procedure (Gupta *et al*., 2014). The plot size for each replication was 100 m^2, i.e., 10 m × 10 m.

Dung of each category of animals were collected and weighed for 24 h in summer, rainy and winter season to calculate total manure production in farmers' field and experimental farm of the institute. The sample of fresh dung was oven dried at 100±5°C for 24 h to compute the dry matter content. Analysis of manure was also carried out following standard procedures (Anderson and Ingram, 1989).

Time spent in grazing by indigenous livestock was calculated in the village ecosystem and the actual quantity of manure was corrected deducting the amount of manure excreted during grazing/browsing in case of indigenous cattle/ buffalo (Dey *et al*., 2012). Feed and fodder fed to livestock and residue left were measured at both the experimental sites to record the actual consumption, for consecutive four days in summer, rainy and winter season. Feed and fodder were subjected to chemical analysis following standard methodology (AOAC, 1995). The estimation of the feed/fodder consumed by livestock was based on a daily ration consumed by the animal, and converted to its energy equivalent by multiplying quantities consumed with standard values (Table 1). Gross energy values of feeds and fodder was measured with the help of an adiabatic bomb calorimeter (IKA-C 400), following the standard procedure (AOAC, 1995).

Periodic growth of indigenous and improved livestock was measured. The body weight of improved cattle and buffalo was measured using digital balance, however, weight of indigenous cattle was calculated following modified Shaffer's formula as- W = G2 x L / 300 (W = live body weight of animal [in pounds]; G = Heart Girth [in inches] and L = length from the point of shoulder to the point of pin bone [in inches]). Finally the body weight was converted from pound to Kg (Khan *et al*., 2003). Likewise, the body weight of buffalo was calculated as- X = 25.156 (Y) - 360.232 (X = body weight [in pounds] and Y = heart girth [in inches] (Mullick, 1950).

The various inputs in livestock production system include seed and planting material, human labour, and dry and green fodder whereas, the outputs were consisted of milk and manure. Other inputs such as feed and fodders, used in the production system, were converted into energy values, expressed in mega Joules (MJ). The calculation of the human labour energy was based on per hr energy expenditure of 0.418 MJ for sedentary work, 0.488 MJ for moderate work and 0.679 MJ for heavy work for an adult male, and of 0.331 MJ for sedentary work, 0.388 MJ for moderate work and 0.523 MJ for heavy work for an adult woman (Gopalan *et al*., 1978). The Energy pay-back time (EPBT) was calculated dividing the input energy by the annual energy output (Sarkar and Tiwari, 2006). Economic efficiency of each category of livestock was worked out based on the prevailing prices of cost inputs and outputs in terms of milk and manure (Bhatt and Bujarbaruah, 2011b).

RESULTS

The average body weight of indigenous and improved strains of buffalo and cattle was measured for a period of 24 months. The average birth weight of indigenous and improved cattle was measured as 18.60±3.58 and 28.70±0.25 kg, respectively. After 24 months of age, body weight was recorded at 118.60±9.11 and 312.60±8.60 kg in indigenous and improved cattle, accordingly. The data indicated daily gain of 138.9±35.20 g in indigenous cattle as against 394.3±32.20 g in improved breed (Figure 1).

The mean body weight of indigenous and improved buffalo at birth was recorded as 27.21±1.12 and 28.80±1.22 kg and attains the total weight of 202.98±1.56 and 230.60±11.19 kg after 24 months of rearing. The daily weight gain of 240.0±0.60 and 280.28±22.20 g was recorded, respectively in indigenous and improved buffalo (Figure 2).

The dairy animal was reared on low input feeding under traditional animal husbandry at Khajuri village. Grazing was allowed on an average 4-5 hrs daily (1300±11.2 to 1575.0±14.1 h/year) to livestock. Wheat and rice straw and green fodder (mainly local grasses, collected through cut and carry system) constitute large part of diet of cattle and buffalo in traditional animal husbandry practices. Average fodder consumption to cattle was estimated to be 1220.25±67.50 and1706.66±56.01 kg/yr of dry and green fodder, respectively. The corresponding values were worked out to be 1997.54±81.54 and 1866.20±73.01 kg/year in case of buffalo. Rice and wheat bran, mustard cake, broken rice and pulse by-product was fed as concentrate to indigenous livestock. On average, concentrate feed was fed by 10.7 and 17.0% of the total ration, respectively, to indigenous cattle and buffalo.

Annual consumption of concentrate feed in improved cattle was accounted for 1825.0±84.62 kg/yr besides dry fodder consumption of 1642.76±52.12 kg and green fodder of 6570.40±157.08 kg, respectively. The concentrate feed ingredients include crushed maize (30%), rice bran (30%), mustard cake (19%) and pulse by-product (18%).

Annual energy supplement was more than 2-fold higher in improved cattle and buffalo compared to indigenous ones. In improved cattle, balanced feed alone contributed more than 37% of the total energy input. On the other hand, dry fodder shared more than 60% of annual energy supplement to indigenous cattle and buffalo. Energy output was highest (15348.75 MJ/year) for improved buffalo, followed by improved cattle (12851.21 MJ/year) (Table 2). Similar to energy inputs, output was 2-fold higher for improved breeds compared to indigenous ones. On average, more than 50% of the total output was contributed by milk alone.

Followed by manure. The energy requirement per kg of milk production in indigenous and improved cattle was estimated to be 31.37 and 35.30 MJ. Similar was the case for buffalo milk production.

Total monetary inputs ranked in the order of human labour > dry fodder > concentrate feed in case of indigenous strains. Whereas, improved breeds followed the trend as: concentrate feed > human labour > green fodder > dry fodder. Of the total monetary inputs, labour alone contributed

> 40% in indigenous livestock. Concentrate feed required > 30% of the total monetary inputs in improved livestock. Total monetary inputs were highest (US$ 1259.97) for improved buffalo, followed by improved cattle (US$ 1161.12). Net monetary gains were, however, recorded highest (US$ 523.10) for improved cattle (Table 3).

DISCUSSION

The data indicated that rearing of improved cattle is economically most viable, followed by improved buffalo. EIGP has 47.41 million cattle and 16.18 million buffalo population, respectively, with more than 80% indigenous strains (Anonymous, 2014). Buffalo rearing is mainly confined in MGP for milching purpose. However, in LGP, swamp buffalo are mainly reared for meat and draft purpose (Dey *et al*., 2012). The significant growth of crossbred cattle population has been observed in MGP because of implementation of Artificial Insemination Programme by State Milk Federation (Anonymous, 2014). A small land holdings in the region also compelled small holders to depend on livestock farming for livelihood security. On average, animal husbandry contributes 15 to 40% of total household income (Dey *et al*., 2012).

Compared to 7.77 million ha area under organized fodder production in India, the region possess only 0.32 million ha. *Pennisetum purpureum*, *Setaria* sp., *Brachiaria mutica* and *Megathyrsus maximus* are cultivated as perennials with highest fodder productivity in *Pennisetum purpureum* (250 to 280 t/ha) and lowest (115 to 120 t/ha) in *Setaria* sp. *Sorghum vulgaris*, *Zea mays*, *Pennisetum glaucum*, *Sorghum bicolor*, *Vigna unguiculata* and *V. umbellata* are cultivated as annual crop during summer/rainy season. Multi cut *Sorghum vulgaris* showed highest productivity (65 to 90 t/ha), followed by *Zea mays* (45 to 55 t/ha). Lowest yield was, however, recorded in *Vigna umbellate* (32.1 t/ha). During winters, *Trifolium alexandrinum*, *Avena sativa*, *Lolium multiflorum* and *Zea mays* are the important fodder crops with highest fodder productivity (60 to 65 t/ha) in *Lolium multiflorum* and lowest (30 to 35 t/ha) in *Avena sativa*.

In the present investigation, daily weight gain in indigenous cattle was observed to be 0.139 kg. Earlier findings of Roy *et al*. (1996); Sreedhar (2015) reported the daily weight gain in cattle from 0.166 to 0.36 kg/d from Eastern India and coastal region of Southern India. These variations might be due to difference in feeding system, climatic factors and periodical use of anti-parasitic drugs.

The average yield of cattle milk was 2.75±0.66 and 7.55±1.20 kg/day, respectively, in indigenous and improved breeds. Accordingly, buffalo milk yield was 3.06±0.86 and 5.12±1.71 kg/day in indigenous and improved strains. Similar values of milk production of indigenous and crossbred cattle, and buffalo were reported by Roy and Saha (2003); Singh *et al*. (2005) in different eastern states. However, Dhara *et al*. (2006) reported slightly higher milk yield (6.0 to 7.0 kg/d) in crossbred cattle than the present findings in LGP, which might be due to genetic potential of crossbred cattle, stage of lactation, parity and variations in feeding practices.

Per capita availability of milk in LGP and MGP has been found to be 110.0 and 240.0 g/day as against the national average of 311.6 g/day. However, milk availability is continuously increasing since the implementation of operation flood on account of improved technological changes on breeding, feeding, health care and management, and creation of market linkages in

EIGP (Ravishankar and Birthal, 1999). Besides milk, annual manure production ranged from 821.0 to 1277.5 kg (D.W. basis) in indigenous and improved livestock, respectively. Accordingly, annual production of dung was recorded to be 1164.35 to 1445.40 kg in indigenous and improved buffalo. On average, cattle rearing in EIGP could contribute 14.68, 8.40 and 3.78 kg of N, P and K through manure into the soil. Accordingly, buffalo manure was able to contribute 20.29, 11.90 and 6.26 kg of the same nutrients into the soil.

The study revealed that feed resources used by the farmers have not been found balanced to meet out the protein and energy requirements in traditional animal husbandry practices. The gap between demand and availability of nutrients was, therefore, a major challenge to the livestock farmers, especially during summer season (Feroze *et al*., 2010). Similar type of feeding practices of cattle and buffalo has been reported by Gupta *et al*. (2014) in EIGP. In an earlier study, Singh *et al*. (2005) quantified the nutritional requirement of dairy cattle in LGP and MGP which indicated the deficiency of protein and energy intake to the extent of 18 and 42%, respectively.

Further, the resource poor farmers do not have access to quality semen or quality bull and due to inbreeding, growth and production in indigenous population is reduced (Dey *et al*., 2012). Even the improved breeds of livestock have the reproductive problems due mainly to under feeding, and mineral and vitamin deficiencies. On average, 2000 m^2 area was required to cultivate dry (1500 m^2 area of rice-wheat cropping system) and green fodder (500 m^2 area) to rear one unit of improved cattle. Similarly, an area of 2365 m^2 (1825 m^2 for dry and 540 m^2 for green fodder) was required for rearing one unit of improved buffalo. The average productivity of dry and green fodder was estimated as 12.0±0.67 and 135.12±3.13 t/ha, respectively.

Considering energy as a currency, it was observed that rearing of indigenous livestock was most viable. However, no significant differences were obtained in energy efficiency of indigenous and improved breeds. The energy cost for milk production has been observed lowest in case of indigenous cattle, followed by improved cattle. Earlier finding of Ranjhan (2001) also indicate that energy use efficiency of indigenous cattle was highest as compared to improved ones.

In terms of monetary gains, however, improved cattle rearing was economically most viable with net monetary gains of US$ 523.10, followed by improved buffalo (US$ 135.68). The data indicated 3.86-fold higher monetary profit by rearing of improved cattle than buffalo. Indigenous breeds showed the net monetary gain of US$ 113.52 and US$ 121.48, respectively, in cattle and buffalo. Present study showed the energy efficiency ratio between 0.13 to 0.18, highest monetary gains through improved cattle. These values are well within the range as reported by Bhatt and Bujarbaruah (2011b) for cattle rearing in eastern Himalayas. Economic benefit in improved dairy production has also been reported by many workers in EIGP (Aziz, 1998; Islam *et al*., 2008; Singh *et al*., 2012).

Islam *et al*. (2008) reported the benefit cost ratio of 1.38 for livestock production system in EIGP, which also supports to the present findings. However, Singh *et al*. (2012) have analysed the lower cost of milk production in crossbred cattle as compared to buffalo and indigenous cattle indicating higher profitability, which corroborates with the present findings.

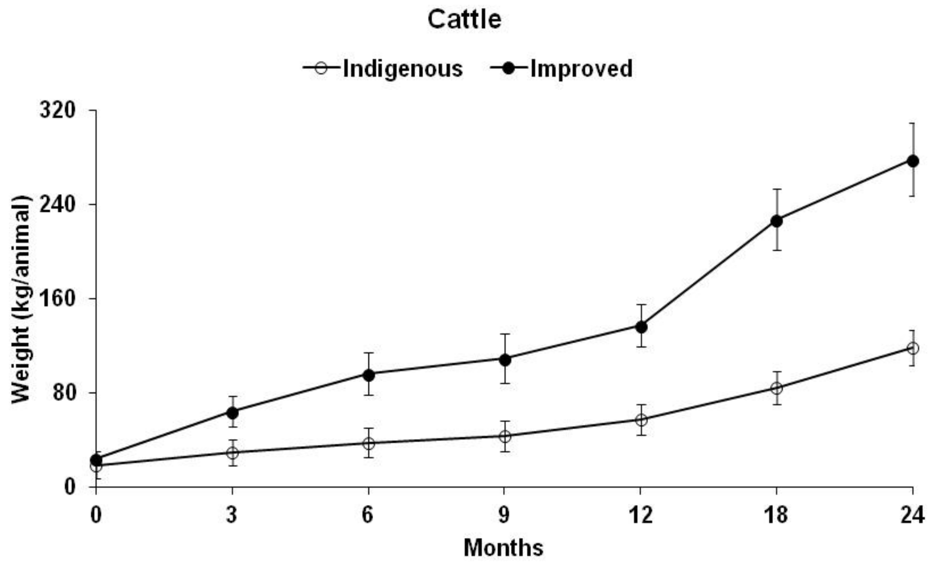

Figure 1. Average body weight of non-descript and improved cattle in eastern India.

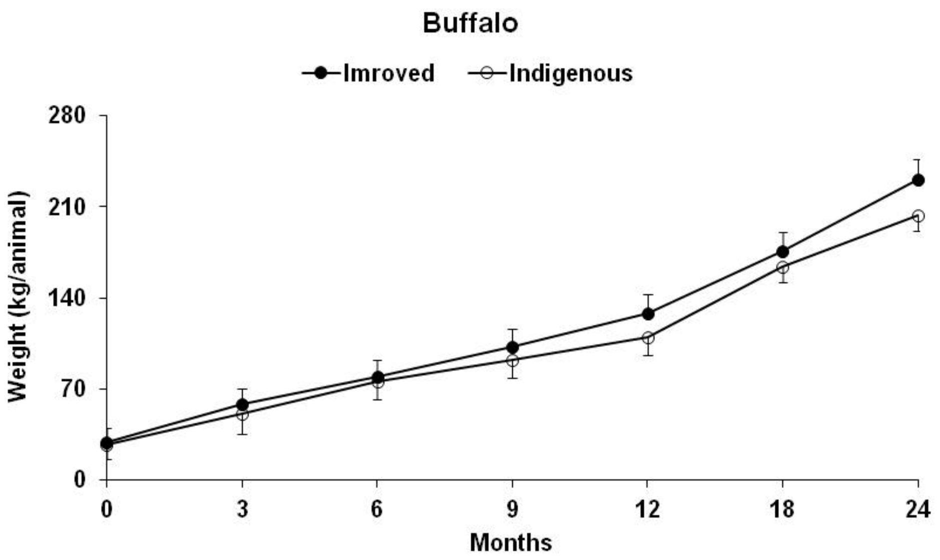

Figure 2. Average body weight of non-descript and improved buffalo in eastern India.

Table 1. Energy values for different items (values expressed as dry wt. mega joule equivalent).

Energy source	**Energy equivalent (MJ/kg)**
Electricity (kWh)[1]	10.59
Diesel (lts.)[2]	56.31
Irrigation (cubic meter)[3]	0.63
Rice straw[4]	14.00
Wheat straw[4]	16.33
Green fodder[4]	15.80
Farmyard manure (DM)[4]	7.32
Grain[4]	16.74
Mustard oil cake[4]	26.60
Rice and wheat bran[4]	16.44
Pulse by-product[4]	17.10
Nitrogen (kg)[5]	60.60
Cow milk[6]	2.81
Buffalo milk[6]	4.63
Cattle manure[4]	2.01
Liquid manure[7]	0.30

After: [1]Canakci and Akinci; [2]Singh *et al*., 2002; [3]Gundogmus, 2006; [4]Mitchell, 1979; [5]De *et al*., 2001; [6]Saini *et al*.,1998; [7]Measured values (AOAC, 1995)

Table 2. Annual energy outputs/ inputs (MJ/year) in indigenous and improved livestock.

Energy input(s)	Indigenous cattle	Improved cattle	Indigenous buffalo	Improved buffalo
Human labour	279.259	378.96	416.09	557.47
Dry fodder	19926.81	24908.51	32619.92	29890.22
Green fodder	8089.60	31141.80	9515.55	34602.0
Grain	304.67	9165.15	611.01	9165.15
Rice and wheat bran	1800.18	9000.90	6000.60	9010.90
Mustard oilcake	1165.08	9223.55	1941.80	9223.55
Pulse by product	102.60	5617.35	256.50	5617.35
Electricity	-	2361.99	-	2361.99
Diesel	-	884.55	-	1431.17
Seed	96.42	348.19	104.88	164.72
Farmyard manure	2108.16	936.96	2108.16	8637.60
Nitrogen	1047.17	3199.68	1047.17	2198.87
Irrigation	2.21	151.20	2.27	2778.30
Total input (s)	34922.16	97318.79	54623.95	115639.30
Output				
Milk	2818.43	6669.94	5153.19	9260.00
Manure	1650.51	2567.77	2339.60	2904.45
Liquid manure	821.25	3613.50	2409.40	3832.50
Total output	5290.19	12851.21	9902.19	15996.95
Energy ratio	0.15	0.13	0.18	0.14
Energy payback period (yr)	6.6	7.57	5.51	7.22

Table 3. Economic analysis of indigenous and improved livestock (US$)*.

Particulars	Indigenous cattle	Improved cattle	Indigenous buffalo	Improved buffalo
Cost of shed	27.86	46.21	30.80	60.88
Cost of livestock	16.75	50.28	46.10	104.78
Dry fodder	139.21	174.01	198.54	189.25
Green fodder	-	192.75	-	204.39
Concentrated feed	69.89	441.72	118.48	428.48
Electricity consumption	-	18.51	-	18.51
Human labour	233.00	234.12	291.92	250.16
Veterinary expenses	1.76	3.52	1.76	3.52
Total	488.47	1161.12	687.60	1259.97
		Output (return)		
Milk	525.70	1536.98	685.73	1232.22
Manure	66.25	103.07	93.91	116.58
Liquid manure	10.04	44.17	29.44	46.85
Total	601.99	1684.22	809.08	1395.65
Net monetary gains	113.52	523.10	121.48	135.68
B:C ratio	1.23	1.45	1.18	1.11

*1US$ = 68.17 INR as on 09/01/2017

CONCLUSION

From the present study, it may be concluded that the one ha area under rice-wheat system can support five improved cattle or four buffalo with allocation of 20.0 to 23.6% area for round the year fodder production. The energy cost for production of milk was observed lowest in indigenous cattle followed by improved cattle. Similar was the case for buffalo rearing. Economic return was observed highest for improved cattle. Manure has been observed as important source of fertilizer. The data indicate that one adult cattle could supplement 28.78 kg of urea, 7.98 kg DAP and 5.25 kg MOP into the soil. Similarly, buffalo dung could save 39.54 kg of urea, 11.34 kg DAP and 8.70 kg MOP per year. On average, cattle and buffalo expends 268.94 and 373.43 kW/year, respectively, for manure production.

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