

Effect of dietary supplementation of copper and phosphorus on nutrient utilization and growth in crossbred heifers

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Received: 12 August 2008; Accepted: 6 August 2009

ABSTRACT

Growing crossbred heifers (16) of 12 to 16 months age with an average body weight 155 kg were divided into 4 groups of 4 animals each in a 2 × 2 factorial completely randomized design. Heifers of 4 groups were provided 4 respective feed mixtures/dietary treatments, viz. control group 1, without copper and phosphorus supplementation, (treatment 1); group 2, copper supplemented (treatment 2); group 3, phosphorus supplemented (treatment 3); and group 4, copper and phosphorus supplemented (treatment 4). Feed (mineral) mixture containing copper sulphate to supply copper and dicalcium phosphate to supply phosphorus were supplemented as top dressed after offering the concentrate mixture to the heifers as per the requirement along with *ad lib.* mixed fodder (green oats + oats hay). Feeding trial lasted for 90 days. Average total dry matter intake, dry matter intake per 100 kg body weight and per kg metabolic body weight, average daily TDN and DCP intakes per 100 kg body weight and per kg metabolic body size and digestibility coefficient of different nutrients did not differ significantly amongst different groups of heifers. There was also no significant effect of copper and phosphorus supplementation on these parameters, however, numerically the values were increased due to interaction of copper and phosphorus in the heifers of group 4. The crossbred heifers in group 2 fed ration supplemented with copper gained highest body weight (56.84 kg). The average daily body weight gain was 552.8, 631.5, 551.9 and 567.1 g in heifers of groups 1, 2, 3 and 4, respectively, and did not differ significantly amongst the different groups. The heifers supplemented with copper gained numerically 8.5% higher weight but interaction effect of Cu and P was not significant. It was concluded that under farm condition and existing feeding practices, dietary supplementation of copper and also phosphorus is essential for improvement in the growth and nutrient utilization.

Key words: Copper supplementation, Crossbred heifers, Growth, Nutrient utilization, Phosphorus supplementation

In plain area of Uttarakhand, common livestock species are cattle and buffaloes and these are mostly reared on crop residues and dry grasses which are used in combination with locally available green fodder and small amount of concentrate mixture. Generally, the animals do not receive mineral mixture supplementation in the ration, therefore, livestock production is often badly influenced by mineral deficiency especially phosphorus and copper (Tiwary *et al.* 2007).

Phosphorus has more important functions and is required by rumen microorganisms for digestion of cellulose (Burroughs *et al.* 1951) and synthesis of microbial proteins (Breves and Schroder 1991). Phosphorus (P) deficiency is manifested by signs of unthriftiness, inappetence, poor growth rate, poor lactation performance and unsatisfactory fertility (Goff 1998). On the other hand, copper (Cu) is an

essential trace element for ruminants being the component of enzymes and essential for absorption and transport of iron for hemoglobin synthesis. The amount of dietary Cu requirement for maintenance, growth and lactation varies with age of the animals. Copper is usually supplemented as sulphate, carbonate or oxide. The Cu deficiency in cattle causes loss of hair pigmentation particularly around the eyes, anaemia, fragile bones and osteoporosis, cardiac failure, poor growth and reproductive inefficiency (Underwood 1981). The supplementation of ration with Cu and P as area specific mineral mixture under field condition helped in improving milk production and in amelioration of reproductive problems in cattle and buffaloes (Saxena *et al.* 2008). Keeping in view, the present study was conducted to know the effect of dietary Cu and P supplementation on body weight gain and nutrient utilization in crossbred heifers under farm condition.

MATERIALS AND METHODS

Crossbred heifers (16) of 12 to 16 months age with an average body weight of 155 kg were selected from the herd

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Table 1. Ingredient composition of experimental feed mixtures

Ingredients(%)	Treatment 1 (Control)	Treatment 2 (copper supplemented)	Treatment 3 (phosphorus supplemented)	Treatment 4 (copper and phosphorus supplemented)
Ground maize	54.55	54.31	30.20	30.07
Mustard cake	45.45	45.26	25.16	25.05
Di calcium phosphate	—	—	44.64	44.64
Copper sulphate	—	0.43	—	0.24
Total	100.00	100.00	100.00	100.00

Table 2. Chemical composition of feedstuffs and experimental feed mixtures (on DM basis)

Feedstuffs	Proximate principles								
	Dry matter (%)	Organic matter (%)	Crude protein (%)	Ether extract (%)	Crude fibre (%)	Nitrogen- free extract (%)	Ash (%)	P (%)	Cu (ppm)
Mixed fodder (Green oats + oat hay)	37.61	90.46	9.12	1.97	28.92	50.45	9.54	0.28	7.15
Concentrate mixture	86.52	86.94	19.30	3.06	6.46	58.12	13.06	0.32	6.78
Experimental feed mixture 1(Control)	89.36	95.09	25.17	5.61	5.23	59.07	4.91	0.45	7.62
Experimental feed mixture 2 (Cu supplemented)	88.93	95.21	23.55	5.73	5.09	60.84	4.79	0.42	67.34
Experimental feed mixture 3 (P supplemented)	92.54	84.08	15.26	3.83	4.18	60.80	15.92	5.54	6.40
Experimental feed mixture 4 (Cu and P supplemented)	91.08	82.28	14.92	3.75	3.95	59.66	17.72	5.67	68.01

of Instructional Dairy Farm of the University and were divided into 4 groups of 4 animals each in a 2×2 factorial completely randomized design. The 4 groups of heifers were provided 4 respective dietary experimental feed (mineral) mixtures/treatments (Table 1). In order to supplement, experimental feed mixtures were prepared containing copper sulphate to supply Cu and di calcium phosphate to supply P. The ingredient composition of experimental feed (mineral) mixtures is given in Table 1. The heifers in group 1 were provided experimental feed (mineral) mixture 1(control), whereas heifers in groups 2, 3 and 4 were provided experimental feed mixtures 2 (Cu supplemented), 3 (P supplemented) and 4 (Cu and P supplemented) respectively.

All the experimental heifers were fed concentrate mixture and green fodder as per Kears (1982) feeding standards for 20 days as an adaptation period followed by experimental feeding period for 90 days. All the heifers were fed concentrate mixture at 10 AM daily as per requirements. The available mixed fodder (green oats + oats hay) was provided *ad lib.* to all the heifers at 9 AM. Clean, fresh drinking water was offered to all the animals twice a day at 8 AM and 4 PM. The experimental feed (mineral) mixtures were supplemented daily at the rate of 55, 55, 100 and 100 g to each animal in groups 1, 2, 3 and 4, respectively, as top dressed just after offering the allowance of concentrate mixture. Records of daily feed intake were maintained throughout the experimental feeding trial. All the animals were weighed fortnightly before morning feeding and watering for two

consecutive days using Avery make (1 000 kg capacity) weigh bridge. However, at the start and end of the feeding trial the animals were weighed for 3 consecutive days. After 60 days of feeding, a digestion trial of 7 days was conducted during which records of daily feed intake and faeces voided were maintained and samples were drawn for further analysis. The samples of feeds and fodder and faeces voided were analysed for proximate principles (AOAC 1995). Copper content in feeds was estimated by atomic absorption spectrophotometer and phosphorus by colorimetric method (Ward and Johnston 1962). The data were analyzed statistically using 2×2 factorial completely randomized design (Snedecor and Cochran 1994).

RESULTS AND DISCUSSION

The chemical composition and Cu and P contents in feed and fodder and experimental feed (mineral) mixtures are presented in Table 2.

Dry matter intake: There was no significant difference in daily total dry matter intake among the different groups of heifers during the entire feeding trial (Table 3). The dry matter intake per 100 kg body weight and per kg metabolic body weight also did not differ significantly amongst the different groups of heifers; however, dry matter intake was little higher in heifers of groups 3 and 4 supplemented with phosphorus which is in the agreement with the findings of Mahanta *et al.* (2004). In the present study, dry matter intake/100 kg body weight ranged from 2.92 to 3.15 kg in different groups.

Table 3. Average body weight gain, dry matter consumption, concentrate: roughage ratio and feed conversion efficiency in growing crossbred heifers during feeding trial of 90 days fed rations containing copper and phosphorus supplements

Particulars	Groups/Treatments				Effect of copper supplementation		Effect of phosphorus supplementation	
	1 (Control)	2 (Cu supplemented)	3 (P supplemented)	4 (Cu and P supplemented)	Without Cu supplementation	With Cu supplementation	Without P supplementation	With P supplementation
Initial body weight (kg)	155.17±14.47	154.83±20.64	155.17±7.05	155.67±11.00	155.17±10.76	155.25±15.76	155.00±17.35	155.42±8.95
Final body weight (kg)	204.92±15.53	211.67±20.93	204.84±11.54	206.71±11.48	204.88±13.52	209.19±16.05	208.29±18.11	205.77±11.45
Total weight gain (kg)	49.75±2.54	56.84±7.82	49.67±4.62	51.04±3.33	49.71±3.18	53.94±4.24	53.29±2.86	50.36±2.82
Body weight gain/day (g)	552.78±28.27	631.50±86.92	551.86±51.38	567.14±37.03	552.32±35.31	599.32±47.08	592.14±31.83	559.50±31.33
Roughage DM intake (kg/d)	3.47±0.42	3.46±0.49	3.69±0.13	3.46±0.14	3.58±0.22	3.46±0.30	3.47±0.45	3.58±0.11
Concentrate DM intake (kg/d)	1.88±0.08	1.88±0.10	1.95±0.05	1.94±0.06	1.91±0.06	1.91±0.08	1.88±0.09	1.94±0.05
Concentrate: roughage ratio	1:1.83±0.15	1:1.82±0.17	1:1.90±0.08	1:1.79±0.05	1:1.86±0.06	1:1.80±0.09	1:1.82±0.16	1:1.84±0.06
Total DM intake (kg/d)	5.34±0.50	5.35±0.59	5.64±0.14	5.40±0.19	5.49±0.28	5.37±0.38	5.34±0.54	5.52±0.15
DM intake/100 kg body weight (kg)	2.96±0.06	2.92±0.03	3.15±0.16	3.00±0.11	3.06±0.07	2.96±0.05	2.94±0.04	3.08±0.13
DM intake/W ^{0.75} (g)	108.28±3.79	106.92±3.43	115.17±4.51	109.74±2.68	111.72±1.39	108.33±0.80	107.60±3.35	112.45±3.47
Feed conversion efficiency (DM intake/kg weight gain) (kg)	9.57±0.78	9.00±1.64	10.33±1.09	9.46±0.60	9.95±0.47	9.23±0.87	9.29±0.88	9.90±0.49

Arthington and Spears (2007) recorded greater dry matter intake in beef heifers receiving supplemental copper as compared to the control group. In the present study, however, the dry matter intakes were not significantly affected due to either Cu or P supplementation or due to their interaction.

Body weight gain and feed conversion efficiency: The data on average body weight gain and feed conversion efficiency

are presented in Table 3 and the fortnightly body weight gain is depicted in Fig 1. The crossbred heifers in group 2 fed ration supplemented with Cu gained the highest total weight (56.84 kg) and average daily body weight (631.50 g), followed by heifers in groups 4, 3 and least in group 1. However, there was no significant difference in body weight gain amongst different treatment groups of heifers and also due to Cu or P supplementation or due to their interaction. Similar findings were also reported by Attia *et al.* (1987) in water buffalo and by Tripathi *et al.* (2001) in crossbred calves. The heifers in group 3 supplemented with P consumed more dry matter per unit weight gain, whereas heifers in group 2 supplemented with Cu consumed least dry matter per unit weight gain (Table 3). This indicated that heifers in group 2 fed ration supplemented with Cu had better feed conversion efficiency than the control and P supplemented groups.

Copper and phosphorus intake: Heifers in groups 2 and 4 supplemented with Cu in the ration consumed significantly ($P<0.05$) higher Cu than the heifers of groups 1 and 3 (Table 4). The Cu intake and Cu concentration in the ration fed to heifers of groups 1 and 3 were considerably lower than that

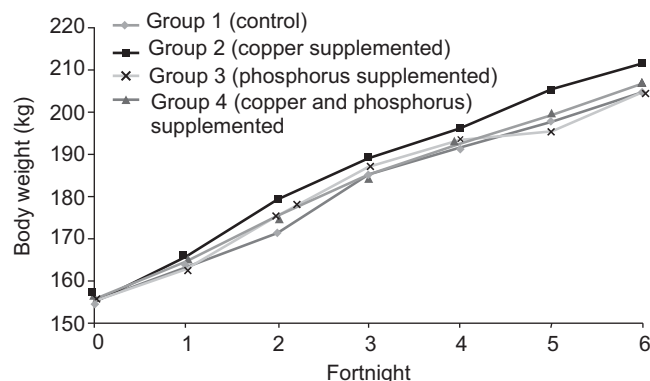


Fig. 1. Fortnightly body weight gain

Table 4. Average daily copper and phosphorus intake in growing crossbred heifers fed rations containing copper and phosphorus supplements

Particulars	Groups/Treatments				Effect of copper supplementation		Effect of phosphorus supplementation	
	1 (Control)	2 (Cu supplemented)	3 (P supplemented)	4 (Cu and P supplemented)	Without Cu supplementation	With Cu supplementation	Without P supplementation	With P supplementation
Cu intake through roughage (mg)	16.40±3.53	17.13±4.30	17.53±0.93	16.42±1.08	16.97±1.56	16.78±2.47	16.77±3.87	16.98±0.64
Cu intake through concentrate (mg)	12.23±0.52	12.26±0.69	12.43±0.31	12.38±0.42	12.33±0.41	12.32±0.55	12.25±0.59	12.41±0.36
Cu intake through experimental feed mixture (mg)	0.44±0.01	61.27±0.02	0.50±0.01	61.92±0.01	0.47±0.01	61.59±0.02	30.85±0.01	31.21±0.01
Total Cu intake (mg)**,**	29.07 ^b ±4.05	90.66 ^{a±} 4.98	30.46 ^{b±} 0.87	90.72 ^{a±} 1.36	29.77 ^{b±} 1.96	90.69 ^{a±} 3.00	59.87±4.45	60.59±0.79
P intake through roughage (g)	8.93±1.23	8.51±1.51	9.20±0.34	8.62±0.41	9.06±0.61	8.57±0.90	8.72±1.35	8.91±0.29
P intake through concentrate mixture (g)	5.84±0.25	5.86±0.33	5.94±0.15	5.91±0.20	5.89±0.19	5.89±0.26	5.85±0.28	5.93±0.17
P intake through experimental feed mixture (g)	0.22±0.01	0.21±0.01	5.13±0.02	5.16±0.01	2.67±0.02	2.68±0.01	0.21±0.01	5.15±0.02
Total P intake (g)**,**	14.99 ^{b±} 1.48	14.58 ^{b±} 1.83	20.27 ^{a±} 0.37	19.69 ^{a±} 0.56	17.63±0.79	17.14±1.16	14.78 ^{b±} 1.63	19.98 ^{a±} 0.40

^{a,b}Values bearing different superscripts in a row differ significantly, ** P<0.01.

recommended by NRC (2001) and ARC (1980) for heifers. Similarly, the heifers in groups 3 and 4 supplemented with P consumed significantly (P<0.05) higher P than heifers in groups 1 and 2, which were not supplemented with P in the ration.

Nutrients intake and digestibility: The average daily total digestible nutrients (TDN) and digestible crude protein (DCP) intakes per 100 kg body weight and per kg metabolic body size did not differ significantly amongst different groups of heifers; however, the heifers fed ration with P supplement consumed considerably higher TDN and DCP (Table 5) which might be due to fact that the dry matter intake and digestibility of nutrients in heifers of groups 3 and 4 supplemented with P were higher than in heifers of groups 1 and 2. TDN intake/kgW^{0.75} ranged from 69.64 to 82.00 g/day, whereas DCP intake ranged from 13.14 to 14.68 g/d in different groups of heifers. The heifers in group 4 (Cu and P supplemented) had numerically higher digestibility

of dry matter, organic matter, crude protein, crude fibre, ether extract and nitrogen-free extract in comparison to other 3 groups (Table 5). This showed the interaction effect numerically in group 4 supplemented with Cu and P. However, there was no significant difference in the digestibility of different nutrients amongst the different groups of heifers fed different dietary treatments and also due to either Cu or P supplementation or due to their interaction. The dry matter, organic matter and crude protein digestibilities in heifers of group 2 fed ration supplemented with Cu were similar to that of the control group. The present findings are in line with that reported by Lall and Prasad (1994), Tripathi *et al.* (2001) and Mahanta *et al.* (2004) wherein the digestibility of nutrients were not significantly influenced by Cu and P supplementation in the ration. It was concluded that under farm condition and existing feeding practices, dietary supplementation of copper and phosphorus in crossbred

Table 5. Average daily dry matter and nutrients intake and concentrate: roughage ratio during digestion trial in growing crossbred heifers fed rations containing copper and phosphorus supplements

Particulars	Groups/Treatments				Effect of copper supplementation		Effect of phosphorus supplementation	
	1 (Control)	2 (Cu supplemented)	3 (P supplemented)	4 (Cu and P supplemented)	Without Cu supplementation	With Cu supplementation	Without P supplementation	With P supplementation
<i>Nutrient intake</i>								
Average body weight (kg)	194.96±15.12	200.94±18.85	194.56±12.15	195.88±11.75	194.63±13.62	198.41±15.16	197.81±16.85	195.22±11.93
Roughage DM intake (kg/d)	4.42±0.72	4.60±0.84	4.98±0.17	4.83±0.14	4.70±0.32	4.72±0.46	4.51±0.77	4.91±0.12
Concentrate DM intake (kg/d)	1.87±0.07	1.91±0.11	1.95±0.06	1.95±0.06	1.9±0.06	1.93±0.08	1.89±0.09	1.95±0.06
Concentrate: roughage ratio	1:2.34±0.31	1:2.35±0.31	1:2.56±0.14	1:2.48±0.06	2.45±0.09	2.42±0.14	2.35±0.31	2.52±0.09
Total DM intake (kg/d)	6.29±0.79	6.51±0.95	6.93±0.16	6.78±0.18	6.61±0.38	6.78±0.54	6.40±0.86	6.86±0.14
DM intake/100 kg body weight (kg)	3.19±0.19	3.19±0.21	3.61±0.27	3.49±0.15	3.40±0.04	3.34±0.03	3.19±0.20	3.55±0.21
DM intake/W ^{0.75} kg (g)	119.40±8.97	120.24±10.30	134.24±7.88	130.10±3.81	126.82±0.78	125.17±3.32	119.82±9.61	132.17±5.82
TDN intake (kg/d)	3.68±0.55	3.80±0.67	4.24±0.18	4.23±0.19	3.96±0.29	4.02±0.41	3.74±0.60	4.23±0.16
TDN intake/100 kg body weight (kg)	1.86±0.16	1.85±0.19	2.20±0.18	2.17±0.09	2.03±0.07	2.01±0.06	1.85±0.17	2.19±0.13
TDN intake/W ^{0.75} kg (g)	69.64±7.02	69.82±8.53	82.00±5.43	81.02±2.56	75.82±2.59	75.42±3.63	69.73±7.52	81.51±3.78
DCP intake (kg/d)	0.69±0.06	0.71±0.08	0.76±0.02	0.75±0.02	0.72±0.04	0.73±0.05	0.70±0.07	0.75±0.02
DCP intake/100 kg body weight (g)	352.54±8.66	348.87±14.21	394.39±24.61	383.80±14.67	373.47±10.56	366.33±2.63	350.71±10.72	389.09±19.62
DCP intake/W ^{0.75} kg (g)	13.14±0.48	13.12±0.75	14.68±0.70	14.32±0.35	13.9±0.22	13.72±0.21	13.14±0.59	14.50±0.53
<i>Nutrient digestibility (%)</i>								
Dry matter	63.73±3.67	65.24±4.27	67.53±1.05	70.26±2.09	65.63±1.95	67.75±2.52	64.49±3.77	68.89±1.29
Organic matter	67.02±3.14	68.08±4.31	70.51±0.87	73.10±1.89	68.77±1.60	70.59±2.53	67.55±3.56	71.81±1.08
Crude protein*	87.40±0.82	87.17±1.49	88.58±0.73	89.52±0.41	87.99±0.65	88.35±0.84	87.29 ^b ±1.08	89.05 ^a ±0.56
Crude fibre	67.75±3.24	67.03±7.25	66.95±2.23	71.35±1.61	67.35±1.55	69.19±3.87	67.39±4.73	69.15±1.90
Ether extract	79.79±1.79	81.02±2.81	80.72±1.54	83.02±1.34	80.25±1.49	82.02±1.72	80.40±2.06	81.87±0.95
Nitrogen-free extract	56.11±4.68	58.09±4.94	63.28±2.26	65.58±2.70	59.69±2.49	61.83±3.05	57.10±4.65	64.43±1.40

^{a,b}Values bearing different superscripts in a row differ significantly, * P<0.05.

heifers is essential for improving the growth, immunity and nutrient utilization.

REFERENCES

- AOAC. 1995. *Official Methods of Analysis*, 15th edn Association of Official Analytical Chemists, Washington, D.C.
- ARC. 1980. *The Nutrient Requirements of Ruminant Livestock*. Agriculture Research Council Stough, England: *Commonwealth*

Agricultural Bureaux.

- Arthington J D and Spears J W. 2007. Effects of tribasic copper chloride versus copper sulfate provided in corn-and molasses-based supplements on forage intake and copper status of beef heifers. *Journal of Animal Science* **85**: 871–76.
- Attia A N, Awadalla S A, Esmail E Y and Hady M M. 1987. Role of some microelements in nutrition of water buffalo and its relation to production. *Assiut Veterinary Medical Journal* **18(35)**: 81–90.

- Breves G and Schroder B. 1991. Comparative aspects of gastrointestinal phosphorus metabolism. *Nutrition Research and Review* **4**: 125–40.
- Burroughs W A, Latone P, Depaul P, Gerlaugh P and Bethke R M. 1951. Mineral influence upon urea utilization and cellulose digestion by rumen microorganisms using the artificial rumen technique. *Journal of Animal Science* **10**: 693–97.
- Goff J P. 1998. Phosphorus deficiency. *Current Veterinary Therapy* **4**: 218–20.
- Lall D and Prasad T. 1994. Comparative evaluation of dicalcium phosphate, rock phosphate, super phosphate and EDTA supplementation in mineral mixture for nutrient utilization in growing calves. *International Journal of Animal Science* **9** (2): 347–51.
- Kearl L C. 1982. *Nutrient Requirements of Ruminants in Developing Countries*. International feedstuffs Institute, Utah Agricultural Experiment Station, Utah State University, Logan, Utah, USA.
- Mahanta S K, Khan S A and Bedi S P S. 2004. Effect of supplementation of phosphorus on nutrient utilization in buffaloes. *Indian Journal of Animal Nutrition* **21** (3): 164–68.
- NRC. 2001. *Nutritional Requirements of Dairy Cattle*. 7th revised edn. National Research Council, National Academy of Sciences, Washington, D.C.
- Saxena P C, Tiwari D P, Kumar A, Mondal B C and Sharma R J. 2008. Dietary copper and phosphorus supplementation to cattle and buffaloes on production performance under field condition in plain region of Uttarakhand. *Indian Journal of Animal Sciences* **78** (10): 1138–43.
- Snedecor G W and Cochran W G. 1994. *Statistical Methods*. Iowa State University Press Ames, Iowa, U.S.A.
- Tiwary M K, Tiwari D P, Mondal B C and Kumar A. 2007. Macro and micro mineral profile in soil, feeds and animals in Haridwar district of Uttarakhand. *Animal Nutrition and Feed Technology* **7** (2): 187–95.
- Tripathi M K, Agrawal I S, Sharma S D and Mishra D P. 2001. Effect of untreated, HCl-treated or copper and iodine supplemented high glucosinolate mustard meal on nutrient utilization, liver enzymes, thyroid hormones and growth of calves. *Animal Feed Science and Technology* **92** (1/2): 73–85.
- Underwood E J. 1981. *The Mineral Nutrition of Livestock*. 2nd edn. Slough England: Commonwealth Agriculture Bureaux.
- Ward G M and Johnston F B. 1962. *Chemical Methods of Plant Analysis*. Publ. 1064. Research Branch, Canada, Department of Agriculture.