Trop. Anim. Hlth Prod. (1996) 28, 183–190

RESPONSES TO SUPPLEMENTATION IN WHITE FULANI CATTLE UNDER AGRO-PASTORAL MANAGEMENT IN NORTHERN NIGERIA. 1. PHOSPHORUS

D. A. CAMPBELL[1], O. A. IKUEGBU[2], E. OWEN[3] and D. A. LITTLE[2]

[1] *Badia Research and Development Programme, Higher Council for Science and Technology, Amman, Jordan;* [2] *ILCA, PMB 2248, Kaduna, Nigeria;* [3] *Department of Agriculture, The University, Earley Gate, Reading RG6 2AT, England*

SUMMARY

Using on-farm supplementation trials with a P rich block (Phos) and a salt block (Salt), deficiency of P in White Fulani cattle in Nigeria was investigated. There was some evidence, significant in some locations but nonsignificant overall, that P supplemented dams produced heavier calves and supported greater calf growth. Dam mean weight gains, 9 to 1 months pre-partum *were 6·9 kg/month on Phos (s.d. = 5·0, n = 50) and 3·8 kg/month on Salt (s.d. = 4·7 n = 54) (P > 0·05). Overall least squares means of calf weights at 12 months were 105·2 kg (n = 29, s.e. 9·3) on Phos and 91·5 kg (n = 37, s.e. 6·3) on Salt (P > 0·05). In animals below 2 years of age, mortalities were 6·8% on Phos and 13·6% on Salt (n = 179, Chi-square P < 0·01). No response to supplementation was observed in older and non-pregnant cattle.*

INTRODUCTION

Kapu (1975) described northern Nigerian herbage as deficient in phosphorus (P). The mineral supplement most often used by the northern Nigerian (Fulani) cattle keepers, a naturally occurring flour potash, only has a P content of 6 g/kg (Mohamed-Saleem and Otsyina, 1987). Thus, there may be a case for P supplementation in northern Nigerian cattle production. Because of the difficulty of measurement of P intake and status of grazing cattle, ARC (1980) concluded that the only true assessment of P status is by eliciting a response to supplementation. In view of the above, the response to the use of a P rich supplement in northern Nigerian cattle under agro-pastoral management was investigated.

MATERIALS AND METHODS

Cattle

White Fulani, a dual purpose milk-meat animal, were used while under the control and management of their owners.

Supplementation

The 2 supplements compared in this study were a P rich block (Phos) which contained 100 g/kg P and 85 g/kg calcium (Ca), and a sodium chloride block (Salt). The P source was monocalcium phosphate, the balance of the block being largely sodium chloride. The salt block consisted of sodium chloride mixed with binders and contained less than 3·5 g/kg each of P and Ca. The blocks were supplied to the herders from September 1987 onwards and were put out at night where the animals were corralled, giving the animals at least 12 hours access.

Study site

The study was carried out from September 1987 to July 1990 at 3 sites in Nigeria (approximately 10°N, 8°E) separated by about 100 km. The locations, Kurmin Biri, Madauchi and Ganawuri respectively, represented cropping intensities of 15, 24 and 33% of total area under crops. Seasons in the study area were defined as:

Early dry: November to January
Late dry: February to April
Early wet: May to July
Late wet: August to October

Rainfall averaged 1,200 to 1,500 mm/year.

Trial in 12 herds

Four herds were used at each site, 2 each receiving either Phos or Salt supplementation. At the beginning of the experiment the 6 herds receiving Phos contained a total of 171 animals whilst the 6 herds receiving Salt contained 159 animals. Herds were mixed for males, females and immature animals.

Information on births, deaths, sales and other exits was recorded in addition to the monthly morning weighings carried out using a movable vee race in conjunction with 12 volt electronic weigh beams.

Six animals (below 200 kg) from each herd were selected to be sampled quarterly for serum. Samples were transported to the laboratory and frozen until analysed for inorganic P using Gommori molybdo-vanadate colorimetry (Gowenlock *et al.*, 1988).

Samples of grazed vegetation were collected by following cattle.

Within herd trial

A further trial was carried out to assess the effect of a daily dose of Phos over 4 weeks at Kurmin Biri within a herd on matched animals. Twelve animals had access to the Salt blocks in the usual way, whilst another 12 animals received additionally a drench of a rough suspension of the Phos block (80 g/head.day suspended in 120 ml water). At the beginning and end of the period, half of the animals in each treatment group were bled. Due to the many missing values and unbalanced nature of the data, for the analysis of variance the General Linear Models (GLM) available on SAS (Freund and Littel, 1981) was used for the analysis of non-frequency data. A mixed model was used, herd being a random effect; the variation between herds, as assessed by comparing pairs of herds within treatments and locations, was used as the error term. This gave a more conservative estimate of statistical significance than the general error term.

RESULTS

Calf birth weights

Intakes of the Phos block, calculated from rate of block use, were equivalent to 2 to 3 g of P a day per animal. Although in all locations the treatment effect was in the same direction, overall effects were not significant ($P > 0{\cdot}05$). Birthweight least squares means (l.s.m) across all locations were 20·7 kg ($n = 50$, s.e. 1·1) on Phos and 19·6 kg on Salt ($n = 75$, s.e. 0·9), $P > 0{\cdot}05$.

TABLE I

Calf growth rates (kg/month) at the three sites, first year of growth

	Treatment								
	Phos			Salt			All		
Location	n	mean	s.d.	n	mean	s.d.	n	mean	s.d.
Ganawuri	8	7·8	3·2	6	7·3	3·1	14	7·6	3·1
Kurmin Biri	39	8·3	1·6	32	5·4	1·2	71	7·0	2·0
Madauchi	13	7·9	2·6	27	6·8	1·6	40	7·1	2·0
All	60	8·1	2·1	65	6·1	1·8	125	7·1	2·2

TABLE II

Dam weight change, 9 to one months pre-partum *(kg/month)*

	Treatment								
	Phos			Salt			All		
Location	n	mean	s.d.	n	mean	s.d.	n	mean	s.d.
Ganawuri	9	7·8	5·8	8	5·1	6·8	17	6·5	6·2
Kurmin Biri	28	6·9	5·5	14	1·5	5·8	42	5·1	6·1
Madauchi	13	6·5	3·2	32	4·5	3·3	45	5·1	3·4
All	50	6·9	5·0	54	3·8	4·7	104	5·3	5·1

TABLE III

Effect of interaction of season and treatment on weight gain (kg/month) in dams 5 to one months pre-partum

	Treatment					
	Phos			Salt		
Season of calving	n	l.s.m.	s.e.	n	l.s.m.	s.e.
Early dry	17	3·5	1·4	11	0·0	1·8
Late dry	14	1·5	1·9	20	0·7	1·8
Early wet	5	0·4	2·9	6	2·0	2·2
Late wet	7	11·8	2·4	11	3·0	1·8

Calf growth rates

Phos had a positive influence on growth to 12 months in all locations (Table I). Twelfth month weights reflected growth rates; effects at Kurmin Biri were significant ($P < 0·05$) where l.s.m. were 115·3 kg (n = 23, s.e. 6·5) on Phos and 85·6 kg (n = 20, s.e. 7·4) on Salt l.s.m. Overall l.s.m. for 12 month weights were not significantly ($P > 0·05$) different, however, being 105·2 kg (n = 29, s.e. 9·3) on Phos and 91·5 kg (n = 37, s.e. 6·3) on Salt ($P > 0·05$). Unlike the first 6 months of growth, in the second 6

months season-treatment interactions were significant ($P < 0.001$). This indicated more positive effects of Phos occurred in the wet season but unbalanced numbers of data made comparison of individual season-treatment values difficult.

Dam weights

Phos had a positive effect on dam weight gain *pre-partum*, but this was only at $P = 0.1$ (Table II). Animals in Kurmin Biri on Phos gained significantly more weight than those on Salt ($P < 0.05$).

Analysis of the effect of Phos in different seasons on weight gain in the last 5 months of pregnancy indicated a possible seasonal interaction ($P = 0.054$) (Table III). The positive effect of Phos on weight gain was greatest in dams calving in the late wet season. Dams calving in the early wet season appeared to have a depression of weight gain associated with Phos. This indicated that during the late dry season, the effect of Phos was negative.

There were no clear effects on post-partum weight changes. There was no significant effect of Phos on non-pregnant animals over one year old during any season, even during the peak growth period (May to August) when growth rates were 370 g/day.

Calving percentages

No significant effects of treatment on calving percentages were observed but Phos did appear to reduce observed intervals between calves ($P > 0.05$). Intervals were 487 days on Phos ($n = 19$, s.d. 162) and 674 days on Salt ($n = 13$, s.d. 122). This data was, however, biased by the short duration of the experiment.

Analysis of the effect of treatment on the seasonality of conceptions indicated that Phos supplementation may increase the percentage of conceptions in the late dry season (Table IV).

Mortalities

Although no effects were noted in mature animals, in animals below 2 years of age Phos did reduce mortalities. Mortalities were 6·8% on Phos and 13·6% on Salt ($n = 179$, Chi-square $P < 0.01$).

TABLE IV

Frequency of conceptions in different seasons, effect of treatment on all locations

	Season of conception				
	Late dry	Early wet	Late wet	Early dry	Total
Phos					
Frequency	34	22	6	14	76
Expected[1]	26	27	7	16	
χ^2	2·6	1·0	0·1	0·4	
% of total	45	29	8	18	
Salt					
Frequency	24	39	9	23	95
Expected[1]	32	34	8	21	
$\chi 2$	2·1	0·8	0·1	0·3	
% of total	25	41	10	24	

[1]Expected–expected frequency if homogeneity were true, χ^2 is the contribution of each individual value to the total χ^2 statistic, overall P is 0·065.

TABLE V

Analysis of phosphorus in plant material from all sites (g/kg DM)

	Location								
	Ganawuri			Kurmin Biri			Madauchi		
Plant category	n	mean	s.d.	n	mean	s.d.	n	mean	s.d.
Browse	13	2·6	1·1	19	1·5	0·8	29	2·7	1·1
Browse legume	2	0·5	0·1	7	1·7	0·6	3	2·2	1·9
Crop residue	8	1·2	0·9	14	1·0	0·9	4	0·8	0·5
Grass	11	1·2	0·8	16	1·2	1·0	8	1·8	0·7
All	34	1·7	1·2	56	1·3	0·9	44	2·3	1·2

Serum levels

Analysis of inorganic P in serum samples collected early in the experiment did not show any treatment effects. Serum inorganic P levels did not fall below 40 mg/litre, the level below which is indicative of P deficiency (Read *et al.*, 1986a).

At the end of the trial samples taken in May/June 1990 did show significant effects (serum inorganic P means were 71·9 mg/litre on Phos vs. 59·7 mg/litre on Salt, $n = 53$ $P < 0·05$). Herds on Phos supplementation at Kurmin Biri had the highest serum P levels, the same herds outperforming the Salt supplemented herds in terms of calf and dam growth.

Drenching experiments

In the drenching experiments, no significant treatment effect on weight was observed. Mean weight gains were 19·1 kg/month on Phos (s.d. 11·6) and 15·1 kg/month on Salt (s.d. 8·0) ($P > 0·05$).

Blood P levels were significantly raised by Phos drenching. Serum P l.s.m. were 56·6 and 66·9 mg/l for animals on Phos and Salt respectively at the beginning of the trial ($P > 0·05$), and 78·0 and 57·1 mg/l at the end of the trial ($P < 0·01$).

Levels of P in vegetation

Using the critical P concentration often quoted, 1·2 g/kg DM (Little, 1980), P levels observed in browse (Table V) were well above requirements. P in crop residues and grasses was at more marginal levels, especially at Kurmin Biri. Ratios of Ca to P in the herbage ranged from 3·5:1 to 4·9:1.

DISCUSSION

Phosphorus intakes achieved in the study represent realistic, if not optimistic, levels likely to be observed in herds under local management. In assessing treatment effects, it is useful to discuss why calves and pregnant dams appeared to respond to supplementation while lactating dams and other mature animals did not.

Analysis of effects on calves and dams had the advantage of reduction of variation by arrangement of data with reference to the calving date; this was not possible for older animals which had no birth dates.

From both NRC (1976) and ARC (1980) it is apparent that total P requirements are lower for older (larger) animals. Calves observed to be growing at 0·205 to

0·235 kg/day in their first year, therefore had higher P requirements than older animals growing at 0·245 kg/day in the wet season. Calves continued to grow in the dry season, at 0·140 to 0·200 kg/day in the first year of life. Animals over one year of age lost 0·020 kg/day in the dry season. Thus, whereas older animals only have a maintenance requirement for half of the year, calves still have a requirement for growth in the dry season when herbage P levels are lower.

Although blood P levels are not incontrovertible evidence, these indicated that P status was adequate in the mature animals at least. Although raised blood P levels were observed in supplemented animals, these are not always associated with increased weight gain (Butterworth, 1985).

The fact that dam milk supply was the more important nutrient source in the first 6 months of calf life may explain the lack of seasonal interaction with treatment at this stage. In the second 6 months of growth response to Phos was linked to the wet season, this effect was also observed in pregnant dams. In the dry season Phos had a less positive or even negative effect on growth. This result would be predicted if the positive influence of Phos on calves and pregnant dams were mediated by an increase in appetite. It is established that appetite mediated responses to Phos are more likely to be observed in the wet season (Winks, 1990).

ARC (1980) and NRC (1976) estimates for pregnant or lactating cattle are higher than those of non-breeding animals growing at 0·25 kg/day. Pregnant or lactating dams have higher P demands right through the dry season than those non-breeding mature animals which lose weight through that period.

There is no evidence in terms of requirements that a response should have been observed in pregnant as against lactating cattle. Any response in lactating dams may have been masked by variability in lactation patterns. The small response to P observed in early calf growth, may have been the manifestation of a response to Phos in lactating dams.

From NRC (1980) and ARC (1976) estimates of required dietary P concentration, P was inadequate in the herbage samples except for browses. Such estimates of minimum dietary P concentration may be too generous for tropical forages. Using the Minson and McDonald (1987) equation for intake of tropical forages and ARC (1980) daily P allowances, lower required dietary P concentrations can be calculated. At growth rates observed in this study ($< 0{\cdot}25$ kg/day) the required dietary P concentrations approach those of 1·2 g/kg DM quoted by Little (1980).

The importance of browses and selective grazing should be noted. Bayer (1990) produced a list of abundant browse species preferred by the Fulani. Of the top 7 species listed, 5 were sampled in this study; the average P content of these 5 was 3·4 g/kg DM ($n = 8$, s.d. = 1·2). If the Fulani are regularly using such browses and 10% of annual and 30% of dry-season grazing is spent on browse (Bayer, 1986), then the contribution to P in the diet is likely to be substantial.

Read *et al.* (1986b) observed responses to P supplementation when herbage concentrations were 0·3 to 1·5 g/kg DM. In a similar location, but where herbage concentrations were 0·6 to 1·6 g/kg DM, Read *et al.* (1986b) found no responses to P supplementation. Small variations in herbage P may therefore explain responses to supplements, it may be significant that browse P content was lower in Kurmin Biri. One may also expect small differences in requirements in different categories of animals to produce variability in response.

Conception responses to Phos were apparent in the late dry-season conceptions; these were associated with grazing of P-poor crop residues. Conception responses

to P have been reported elsewhere (Doyle *et al.*, 1988). Holroyd *et al.* (1977) reported depression of conception with P supplementation in the dry season; however, in the present study the dry season is a period of variable nutrition. Previously lactating dams may have low body P reserves (Read *et al.*, 1986c), especially by the time the dry season crop residue peak is triggering conception.

From the results of the present study, the authors would recommend that the targets for P supplementation should be pregnant and lactating dams as well as calves (below 12 months). Such a scheme would tie in with the Fulani production aims of increasing conceptions, milk output, calf growth and reducing calf mortality.

The problems of low intake and high costs of the P blocks indicate the need for a suitable alternative to be found. At present the level of supplementation is likely to depend on the farmers' finances.

ACKNOWLEDGEMENTS

The authors would like to thank the staff of ILCA at Kaduna and Addis Ababa, NVRI, Nigeria for assistance in analysis of materials and Mr Sam Magaji for assistance in the forage sampling.

Accepted for publication June 1995

REFERENCES

ARC (AGRICULTURAL RESEARCH COUNCIL). (1980). **The Nutrient requirements of Ruminant Livestock.** Commonwealth Agricultural Bureaux, London.

BAYER, W. (1986). Agropastoral herding practices and the grazing behaviour of cattle. In: **Livestock Systems Research in Nigeria's Subhumid Zone.** (Eds R. von Kaufmann, S. Chater and R. Blench). International Livestock Centre for Africa, Addis Ababa, pp 427–440.

BAYER, W. (1990). Use of native browse by Fulani cattle in central Nigeria. *Agroforestry Systems*, **12**, 217–228.

BUTTERWORTH, M. H. (1985). **Beef Cattle Nutrition and Tropical Pastures.** Longman, London.

DOYLE, J. L., HUSTON, J. E. & SPILLER, D. W. (1988). The influence of phosphorus and trace mineral supplementation on reproductive performance of beef cattle under range conditions. *Journal of Animal Science, Proceedings of the 80th Annual Meeting*, (Paper 574) 462.

FREUND, R. J. & LITTEL, R. C. (1981). **SAS For Linear Models, a Guide to ANOVA and GLM Procedures.** SAS Institute, North Carolina.

GOWENLOCK, A. H., MCMURRAY, J. R. & MCLACHLAN, D. M. (eds). (1988). **Varleys Practical Clinical Biochemistry.** 6th ed. Heinemann Medical, London.

HOLROYD, R. G., ALLAN, P. J. & O'ROURKE, P. K. (1977). Effect of pasture type and supplementary feeding on the reproductive performance of cattle in the dry tropics of North Queensland. *Australian Journal of Experimental Agriculture and Animal Husbandry*, **17**, 197–206.

KAPU, M. M. (1975). The natural forages of Nigeria. 1. Nitrogen and mineral composition of grasses and browse from northern Guinea savanna and standing hays from different zones. *Nigerian Journal of Animal Production*, **2**, 235–246.

LITTLE, D. A. (1980). Observations on phosphorus requirements of cattle for growth. *Research in Veterinary Science*, **28**, 258–260.

MINSON, D. J. & MCDONALD, C. K. (1987). Estimating intake from growth of beef cattle. *Tropical Grasslands*, **21**, 116–122.

MOHAMMED-SALEEM, M. A. & OTSYINA, R. (1987). Effect of naturally occurring salt, Kanwa, as a fertilizer on productivity of Stylosanthes in subhumid zone of Nigeria. *Fertilizer Research*,**13**, 3–11.

NRC (NATIONAL RESEARCH COUNCIL) (1976). Nutrient Requirements of Domestic Animals. No. 4 Beef Cattle. National Academy of Sciences, Washington D. C.

READ, M. V. P., ENGELS, E. A. N. & SMITH, W. A. (1986a). Phosphorus and the grazing ruminant. 4. Blood and faecal grab samples as indicators of the P status of cattle. *South African Journal of Animal Science*, **16**, 18–22.

READ, M. V. P., ENGELS, E. A. N. & SMITH, W. A. (1986b). Phosphorus and the grazing ruminant. 2. The effects of supplementary phosphorus on cattle at Glen and Armoedsvlakte. *South African Journal of Animal Science*, **16**, 7–12.

READ, M. V. P., ENGELS, E. A. N. & SMITH, W. A. (1986c). Phosphorus and the grazing ruminant. 3. Rib bone samples as an indicator of phosphorus of cattle. *South African Journal of Animal Science*, **16**, 13–17.

WINKS, L. (1990). Phosphorus and beef production in northern Australia. 2. Responses to phosphorus by ruminants. *Tropical Grasslands*, **24**, 140–158.

EFFETS DE SUPPLEMENTS ALIMENTAIRES CHEZ LES BOVINS WHITE FULANI DANS UNE STRUCTURE AGRO-PASTORALE DU NORD DU NIGERIA. 1. PHOSPORE

Résumé–Des procédés d'apports nutritifs avec des blocs enriches en phospore (Phos) ou en sel (Salt) furent utilisés pour suivre la déficience en phosphore chez la race White Fulani au Nigeria. Il est apparu parfois significatif dans certaines zones, mais non significatif dans l'ensemble, que l'alimentation des mères, enrichie en phosphore produisait des veaux plus gros et permettait une croissance plus forte. Le gain moyen en poids pour les mères entre 9 mois et 1 mois avant la naissance, fut de 6,9 kg/mois pour le phosphore (s.d. = 5,0; n = 50) et 3,8 kg/mois pour le sel (s.d. = 4,7; n = 54) ($p > 0,05$). Les moyennes carrées pour le poids des veaux de 12 mois fut au moins de 105,2 kg (n = 29, s.e. = 9,3) pour le phosphore et 91,5 kg (n = 37, s.e. = 6,3) pour le sel ($p > 0,05$). Pour les animaux de moins de 2 ans la mortalité fut de 6,8% pour le phospore et 13,6% pour le sel (n = 179, χ^2 $p < 0,01$). Il ne fut pas observé de changement dû aux suppléments alimentaires pour le bétail plus agé ou non gravide.

RESPUESTAS A LA SUPLEMENTACION EN VACUNO DE RAZA FULANI BLANCA EN CONDICIONES AGRO-PASTORALES EN NIGERIA. FOSFORO.

Resumen–Se investigó la deficiencia de fósforo en ganado vacuno de raza Fulani Blanca en Nigeria suplementando a los animales en la granja con bloques ricos en fósforo o con bloques de sal. En algunas áreas las vacas suplemantadas con fósforo parieron terneros significativamente más pesados y con un crecimiento más rápido que las vacas suplementadas con sal. Sin embargo, considerando el conjunto de todos los animales estas diferencias no fueron significativas. La ganancia de peso media de las vacas 9–11 meses antes de parto fue de 6·9 kg/mes en los animales suplementados con fósforo (sd = 5·0, n = 50) y de 3·8 kg/mes en los animales suplementados con sal (sd = 4·7, n = 54) ($P > 0·05$). Las medias de los mínimos cuadrados de los pesos de los terneros a los 12 meses de edad fueron de 105·2 kg (n = 29, se 9·3) en el grupo suplementado con fósforo y de 91·5 kg (n = 37, se 6·3) en el grupo suplementado con sal. En animales de menos de 2 años de edad, la mortalidad fue del 6·8% en el grupo suplementado con fósforo y del 13·6 en el grupo suplementado con sal (n = 179, $P < 0·01$ según test Chi cuadrado). En animales más viejos y en vacas no preñadas no se observó ninguna respuesta a la suplementación.