Effective management of pigeon pea (*Cajanus cajan*) in a crop/livestock integrated farming system in northern Ghana

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SUMMARY

Efficient management of pigeon pea, *Cajanus cajan* var. Katinga, as a resource in crop/livestock integration in northern Ghana was studied. Pigeon pea plots with row lengths averaging 11 m and a planting geometry of 80 cm × 50 cm, were either pruned at 60 or 100 cm above ground level or not pruned. Pruning was done at 11 or 16 weeks after planting. Early pruning at a height of 60 cm above ground gave significantly higher ($P<0.05$) seed, pod, and husk yields. Feeding experiments were conducted to compare pigeon pea hay to urea treated rice straw as supplementary feed for Djallonke castrates. Diet 1 (*Cajanus*-N) consisted of pigeon pea hay, cassava peels, and untreated straw while Diet 2 (Urea-N) consisted of 4 per cent urea-treated straw and cassava peels. Total daily supplementary feed dry matter (DM) intake was 365 and 300 g/head for Diet 1 and Diet 2, respectively. DM digestibility was similar in both groups of animals (67.1 - 67.8 per cent). Weight gain was the same for both treatments but *Cajanus*-N enhanced lean tissue deposition.

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RÉSUMÉ

KARBO, N., BRUCE, J., NYAMEKYE, A. L. & FIANU, F. K.: *L' exploitation efficace de pois de pigeon (*Cajanus cajan*) dans un système d' agriculture intégré de culture-bétail dans le nord du Ghana.* L' exploitation efficace de pois de pigeon comme une resource dans l' intégration de culture-bétail dans le nord du Ghana, était étudié. Les terrains de pois de pigeon avec des longueurs moyennes de rang de 11 m et une géométrie de plantation de 80 cm par 50 cm, étaient soit taillés à 60 ou 100 cm au-dessus du sol soit ne pas taillés. La taille était fait à 11 ou 16 semaines après la plantation. La taille tôt à 60 cm de haut au dessus du sol donnait un rendement de graine, de cosse et de gousse considérablement plus élevé ($P<0.05$). Des expériences se sont déroulées pour comparer le foin de pois de pigeon à la paille du riz traitée d' urée comme une ration supplémentaire pour les Castrats Djallonke. Ration 1 (*Cajanus* - N) comprenait le foin de pois de pigeon, les pelures de manioc et la paille non traintée alors que Ration 2 (*Uree*-N) comprenait 4 pour cent de paille traitée-d' uree et les pelures de manioc. La totalité quotidienne de la consommation de matiére séche (MS) de ration supplémentaire de était 365 et 300 g/tête respectivement pour Ration 1 et Ration 2. MS digestible était semblable dans les deux groupes d' animaux (67.1 - 67.8 pour cent). La prise du poids était semblable pour les deux traitements mais *Cajanus-N* améliorait la déposition de tissu maigre.

Introduction

With increases in population, more and more land is being put to arable cropping. As a result, grazing land is reduced and land degradation is increased. In the search for alternatives to aid in the feeding of livestock without further degrading the land, multipurpose tree/shrubs (browse plants) have been identified as meeting all necessary criteria (Kategile, 1992). The trees, which are basically leguminous in nature, contribute to improving soil fertility through nitrogen fixation, can alleviate the dry season feed crises and are economically beneficial. Pigeon pea, *Cajanus cajan*, is a perennial crop with several uses: as grain, a vegetable, animal feed, green manure, and firewood (Böhringer, Tamo & Dreyer, 1994). Dry matter yields are high in both the wet and dry seasons, with yields exceeding 6 t/ha in the dry season (Barnes & Addo-Kwafo, 1995). The shrub is used in the existing farming systems of northern Ghana as a border crop. The local (traditional) varieties are well suited to intercropping because they do not offer competition to other crops such as maize in the rainy season due to their slow initial development (Sipkens & Marfo, 1988). Marfo (1990) identified pigeon pea as one of the four most important feed legumes in northern Ghana. Waste material generated after threshing to obtain the grain is used as fodder while the stalks are used as fencing material or firewood (for household needs).

Sheep and goats selectively browse pigeon pea in preference to other legume shrubs in a choice-feeding situation (Karbo, Barnes & Ruchat, 1996). However, the full potential of pigeon pea as a fodder crop has not been exploited. The traditional practice has been the harvesting of other browse plant species from the wild for supplementary feeding of sheep and goats. This increasing practice adversely affects browse species availability and the environment. The harnessing of prunnings of pigeon pea forage on farms for livestock feeding is limited to the early rains. Ratoonings of the few surviving plants from the previous growing season occurs after fuelwood gathering, and considerable damage by bush fires and animals on free range.

As one of the viable entry points for a well-integrated crop-livestock system in the northern Guinea savanna, some feed supplementation studies involving the use of fertilizer-grade urea to improve feed quality and the productivity of animals by using senescent forages (cereal crop residues) have been carried out (Annor & Adongo, 1992; Karbo & Alhassan, 1993). However, there is little or no information on the use of locally available legume shrubs/trees in the cropping systems for the same purpose.

This study therefore aimed to evaluate pigeon pea (*Cajanus cajan* var. Katinga) in a comparative feeding trial with urea-treated rice straw, and to provide a management system that can be adopted by farmers in effectively managing pigeon pea for grain and fodder.

Materials and methods

Agronomic studies

Six plots measuring 11 m × 13 m were seeded with pigeon pea in mid-June 1995. Each plot consisted of 13 rows, 11 m in length with a row spacing of 80 cm. Within-row spacing was 50 cm. An average plant population of about 50 per row was maintained with two plants per hill. Weeding was done twice. The total rainfall recorded during the season from May to October was 981.2 mm.

The plots were either not pruned (Treatment 1), simulating farmers' practice, or pruned at a height of 60 cm (Treatment 2) or 100 cm (Treatment 3) above ground level. Two plots were randomly assigned to each treatment. For Treatments 2 and 3, one plot each was pruned 11 weeks after planting while the other was pruned 16 weeks post-planting. Ten rows were randomly selected per plot and the following data recorded: biomass yield, plant height at harvest, number of tillers (branches), and pod weight. Pods were threshed to determine seed and husk yields.

Feeding trials

Feeds. Cajanus cajan hay was prepared from the plots. The green herbage was harvested, tied into bundles, and shade-dried by hanging in a well-ventilated room. It was then chopped into pieces 5 - 6 cm in length and stored in sacks. Rice straw was treated with fertilizer-grade urea as described by Alhassan *et al.* (1991). The straw was chopped into 30-40 mm pieces and ensiled with 4 per cent (W/W) of urea dissolved in water. The quantity of water used was 50 per cent of the weight of the straw to be treated and the duration of ensiling was 7 days.

Animal performance and feeding manage-

ment. Eight Djallonke castrates aged, on average, 14 months were paired according to weight and divided into two groups of four. Average initial weights were 17.8 and 17.85 kg for the two groups. One group was randomly assigned to a diet of urea-treated rice straw fed *ad libitum,* and the other group fed untreated straw *ad libitum* plus 0.20 kg pigeon pea hay/day. Both groups were fed dry cassava peels at a rate of 0.10 kg per head/day.

All the animals were individually housed and were put on the treatment diets as supplement from 7.30 a.m. to 12.30 p.m. after which they were released for 3 - 4 h on free-range grazing. The animals were penned at 4.30 p.m. and again had access to the supplement. Salt lick and clean drinking water were provided *ad libitum* to all animals. All the animals were dewormed and weighed at the start of the feeding trial. Subsequent weight monitoring was done weekly. Feed and water leftovers were collected for three consecutive days after every fortnight to determine intake. A faecal bag was used for a 14-day digestibility trial in the last quarter of the experimental period. The feeding trial lasted 110 days in the dry season from January to April 1996.

Slaughter experiment

Three of the four pairs of castrates, three in each group, were bought by a butcher and slaughtered at the end of the feeding trial. Lean meat and fat deposition were visually assessed. The dressed carcass, internal (perirenal and omental) fat, and the visceral organs were weighed. These were used in the computation of dressing percentage and relative weights of the internal organs.

Laboratory and chemical analyses

Standard AOAC (1980) procedures were used for proximate analyses of rice straw (urea-treated and untreated), pigeon pea hay, and cassava peels at the Animal Research Institute Nutrition Laboratory. The procedures of Tilley & Terry (1963) were used to estimate *in vitro* dry matter digestibility (IVDMD) at the University of Ghana Nutrition Laboratory.

Statistical methods

The differences between treatments were examined by analysis of variance (ANOVA) as outlined by Little & Hills (1972). Mean separation was done by the Least Significant Difference (LSD) method at a 5 per cent level of significance when the F-value was significant.

Results

Agronomic studies

Fodder yields were highest when plots were pruned at 16 weeks after planting (Table 1). Early pruning (11 weeks post planting) at a height of 60 cm gave significantly higher (P<0.05) yields of dried seed compared to early pruning at 100 cm. Virtually no seeds were obtained when plots were pruned at 16 weeks, although pods were formed.

TABLE 1

Effect of Time and Height of Pruning on Fodder and Grain Yields of Cajanus cajan

	Control	*Early pruning (11 weeks)*		*Late pruning (16 weeks)*			
Parameter	*0 cm*	*60 cm*	*100 cm*	*60 cm*	*100 cm*	*Mean*	*LSD (P<0.05)*
Pruned fodder, kg DM/row	-	0.660^{a}	0.084^{b}	1.412^{c}	1.440^{c}	0.899	0.140
Dried seed, kg/row	0.155^{ab}	0.170^{a}	0.115^{b}	0.000^{d}	0.050^{c}	0.098	0.044
Plant height at harvest, cm	2.017^{a}	1.902^{b}	1.976^{ab}	1.091^{d}	1.397^{c}	1.677	0.094
Pod wt., kg/row	0.335^{a}	0.335^{a}	0.225^{b}	0.135^{c}	0.252^{ab}	0.262	0.085
Husk wt., kg/row	0.180^{a}	0.170^{a}	0.140^{ab}	0.130^{b}	0.200^{a}	0.164	0.054
Av. number of tillers/hill	4.2^{a}	5.4^{ab}	5.7^{b}	7.2^{c}	7.3^{c}	5.96	1.3

Means in the same row with different superscripts are significantly different (P<0.05)

Pod and husk yields were also significantly higher (P<0.05) with early pruning at 60 cm compared to all other treatments, except the control and late pruning at 100 cm. Higher tiller formation was observed as a result of pruning.

Feeding trial

Chemical composition and nutrient digestibility. High crude fibre content was observed for pigeon pea hay (Table 2). The lowest crude fibre content was observed for cassava peels. Treatment of rice straw with urea increased its crude protein level almost threefold over that of the untreated straw.

TABLE 2

Nutrient Composition (g/kg DM) of Supplemental Feedstuffs

Feedstuff	*Dry matter*	*Crude protein*	*Crude fibre*	*Calcium (Ca)*	*Phosphorus (P)*
Pigeon pea hay	859.0	131.8	312.6	14.0	0.8
Treated rice straw	870.2	124.1	401.0	5.5	0.8
Untreated rice straw	883.2	41.7	391.5	5.3	0.4
Dry cassava peels	863.3	45.9	124.6	3.7	ND

ND - Not determined

In vitro dry matter digestibility (IVDMD) was lowest (43.6 per cent) for pigeon pea hay compared to 57.0 per cent for treated straw, 51 per cent for untreated straw, and 75.5 per cent for cassava peels. Nutrient digestibilities (faecal) were comparable between the two groups, except for the slightly higher crude fibre digestibility (Table 3) observed in castrates fed urea-treated straw.

TABLE 3

Nutrient Digestibility in Castrates Fed Supplementary Fibrous Diets Containing Urea-treated Straw or Pigeon Pea Hay

Parameter (%)	*Urea straw*	*Untreated straw + pigeon pea hay*
Dry matter	67.1	67.8
Organic matter	66.4	67.7
Crude fibre	73.5	69.6
Crude protein	56.4	58.6

Supplementary feed and water intake. Rice straw intake was 245 g/head/day for urea-treated straw and 170 g/head/day for untreated straw. All pigeon pea and cassava peel offered was consumed. Total daily dry matter (DM) intake of the supplementary feeds were 365 and 300 g/head for castrates on pigeon pea hay and urea-treated straw, respectively. Average daily gain (ADG) for animals on both diets was between 53 and 57 g/head for the first 2 months of supplementation. In the 3rd month, this dropped to between 35 and 40 g/head.

The average daily water consumption was 1.71and 1.67 l/head for animals on the urea-treated straw and pigeon pea hay, respectively. Generally, the water intake pattern was similar in both groups, and significantly higher (0.940 vrs 0.750 l/head) during the morning compared to the evening.

Performance and slaughter measurements

There were no significant differences (P>0.05) in liveweight gains between the two dietary treatments (Table 4). Carcass dressing percentages were found to be similar for both treatment groups. Internal organs weighed more for castrates fed legume hay compared to those on treated straw. Internal fat deposition was 28.5 per cent higher in castrates fed urea-treated straw compared to pigeon pea hay.

Discussion

Yields obtained from pigeon pea are highly dependent on variety, plant spacing, management practices, and the farming systems used. High yields of herbage dry matter obtained in the study were accompanied by low grain yields (Table 1). This agrees with the findings of Böhringer, Tamo & Dreyer (1994) and Jain, Faris & Reddt (1987), who tested different varieties of pigeon pea and indicated contrasting yield patterns of herbage, wood, and grain. Thus, recommendations for the use of pigeon pea will depend on how it will be

TABLE 4

Growth and Slaughter Measurements of Djallonke Castrates Fed Urea-treated Rice Straw or Untreated Rice Straw plus Pigeon Pea Hay

Parameter	Urea -treated straw	Untreated straw + pigeon pea hay	As % change of treated straw
Growth			
Number of animals	4	4	-
Days on feed	68	68	-
Av. initial weight, kg	17.85	17.80	-
Av. final weight, kg	21.75	21.40	-
Weight gain, kg	3.90	3.60	-
Average daily gain, kg	0.057	0.053	-
Carcass yield			
Weight at slaughter, kg	21.70	22.20	2.3
Carcass weight*, kg	9.33	9.93	6.4
Dressing percentage	43.0	44.7	4.0
*Visceral organs***			
Heart, g	5.4	6.0	11.1
Spleen, g	2.3	3.0	30.4
Kidneys, g	3.6	3.8	5.6
Internal fat			
Total, g	48.2	37.5	-28.5

*Dressed carcass minus head, feet, and viscera

**Relative weights (g/kg liveweight)

used, that is, as firewood, green manure, livestock feed, or grain production. Local harvesting methods of pruning in January and threshing whole plants is appropriate for 2nd year seed and potential green manure yields of the local Katinga variety (Sipkens & Marfo, 1988). However, pruning at a height of 60 cm, 11 weeks after planting, as in this study, gave good fodder and slightly better seed yields compared to the present traditional practice of non-pruning. This may be due to higher tiller formation as a result of pruning.

Under coastal savanna conditions, dry season fodder yields were as high as 6 t DM/ha with pruning in the 2nd year at a height of 30 cm above ground (Barnes & Addo-Kwafo, 1995). The overall low fodder yields of 675 kg DB/ha obtained in this study can be attributed to the harsher dry season in the northern savanna, and to pruning in the same year of planting at a minimum height of 60 cm above ground level. Under the conditions of early pruning in this study, fodder yield from a plot of 0.4 ha would feed 10 head of sheep supplementing at the rate of 0.2 kg/head/day for about 4.5 months. If late pruning is practiced, fodder yields would be sufficient to feed 20 sheep over a similar period. This agrees with the findings of Karbo *et al.* (1995), who indicated that under northern savanna conditions, a farmer planting *C. cajan* at a spacing of 0.75 m × 0.4 m on a 0.4-ha plot would in the 1st year harvest enough DM to supplement 20 Djallonke sheep at 0.2 kg/head/day for 5 months in the dry season.

Farmers observed that inter- and intra-row spacing must exceed 1 m for good seed yields. This is supported by the relatively low seed yields in the study where inter- and intra-row spacing were 80 and 50 cm, respectively. Seed yields of 174.5 kg/ha under early pruning at 60 cm above ground were, however, comparable to the 157.5 kg/ha recorded under the non-pruning control treatment.

The 2 per cent unit apparent increase recorded in crude fibre composition for treated rice straw compared to the untreated straw could be relative rather than absolute. When alkalis were used in straw treatment, soluble organic matter (nitrogen-free extracts) was lost (Musimba, 1981). The pigeon pea hay used in the feeding trials had a high level of fibre due to the woody stems of the plant. This could have resulted in the low IVDMD compared to the other feedstuffs. However, as animals selectively fed on the leaves rather than the stems, dry matter digestibility was higher than IVDMD. Furthermore, *in vitro* digestibility methods are known to measure largely, the solubility rather than digestibility *per se*. The supplementary dietary mixtures and mineral licks provided to sheep, thus improving rumen medium and microbial activity, could have accounted for the discrepancy in DM digestibility. Urea, when used in treatment of straw, releases ammonia which can act on plant cell walls, thereby weakening the hemicellulose and lignin linkages for easy breakdown by rumen microflora (Tubei & Said, 1981). This could partly explain the observed tendency for sheep on urea-treated rice straw to digest crude fibre better than their counterparts on untreated rice straw supplemented with protein-nitrogen from pigeon pea hay.

The relatively higher ADG experienced during the first 2 months of the trial agrees with the findings of Abban as cited by Fianu *et al.* (1992). The lower ADG in the 3rd month was most probably due to inadequate feed for grazing which is characteristic of March and April in the late dry season in the zone. The complete confinement of animals for the digestibility trails during that period could have also been a contributory factor.

The higher internal fat observed in castrates on the urea-treated straw diet indicates that the non-protein nitrogen (NPN) fed was less efficiently used for lean meat deposition. The amounts of NPN that microbes can use are directly related to the amount of available energy from fermentation (Macrae & Reeds, 1980). The inclusion of cassava peels, a bypass energy source, in the supplemental diets most probably influenced the low efficiency of capture of NPN by microbes anterior to the duodenum and also the use of nutrients in the tissue.

Nitrogen is a constraint in the use of abundant cellulosic energy by ruminants in the zone. The choice of N source in the typically cereal crop-livestock farming system should settle for pigeon pea than urea which may have high cost implications beyond the economic reach of farmers. Pigeon pea could serve a better link in the crop/livestock production systems, thus providing grain for food and fodder from prunnings for livestock. However, the need is to further investigate the management of the crop in the farm system in relation to maintaining long-term sustainable soil fertility, because some quantities of nutrients will be taken out in grains for human consumption as well as in fodder to feed livestock.

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