CARIBBEAN
FOOD
CROPS SOCIETY

27

Twenty Seventh
Annual Meeting 1991

DOMINICA

Vol. XXVII

SILAGE PRODUCTION FROM GRASS-LEGUME SYSTEMS IN THE CARIBBEAN

M. B. Adjei

Agricultural Experiment Station
University of the Virgin Islands
St. Croix, U.S.V.I. 00850

ABSTRACT

Livestock production in the Caribbean Basin is largely based on grazing native pastures. However, alternate wet and dry seasons lead to an abundance of feed during ghe rainy season and acute feed shortages during the dry season. Forage from grass-legume systems that is produced in the rainy season and stored as silage proivdes an option for overcoming the dry season feed constraint to livestock performance. The yield, quality, disease resistance, and silage pH of forage from monocultures of three sorghum varieties and a millet-elephantgrass hybrid were compared with those from alley-cropping systems with native legumes (*Leucaena leucocephala* and *Desmanthus virgatus*). Total (grass + legume) dry forage yield from two harvests was not affected by cropping system in the initial year. The highest yield for sorghum was obtained from Puerto Rico 5BR forage sorghum (PR5BR) (6.4 tons per acre (T/A) compared with 5.6 T/A each from Dekalb forage sorghum (FS25A) and Haygrazer sudangrass. About 7 T/A total dry forage of the millet-elephantgrass (M-E) hybrid was produced in monoculture and 5.5 T/A in mixed cultures ($P < 0.05$). It also provided two additional harvests of 1.5 T/A each during the dry season. Legumes contributed approximately 10% of the total dry forage in the mixed-cropping ystems. Crude protein (CP) concentration (8.18%) and in vitro organic matter digestibility (IVOMD) (60%) of forage was similar for all grasses and was not affected by cropping system. Despite its shrubby morphology, forage quality of Leucaena (21.7% CP and 60% IVOMD) was consistently superior ($P < 0.01$) to that of Desmanthus (14.2% CP and 45% IVOMD). The head/stover ratio was highest for PR5BR (40:60) and least for M-E hybrid (13:87). Dekalb FS25A was the most susceptible, and PR5BR and M-E hybrid the least susceptible, to sorghum rust and target spot. The pH of forage samples ensiled with (3%) and without molasses addition for 90 days were 4.7 and 4.0, respectively ($P < 0.05$). The preliminary data indicate a potential for selecting from available grasses to provide compatible grass/legume mixtures for silage. The ensilage procedure used can be modified to suit the small-scale farmer.

INTRODUCTION

The livestock population in the Caribbean region consists of approximately 0.5 million cattle, 1 million sheep and 2.5 million goats (FAO, 1984). Meat and milk are staple foods but, with few exceptions, supplies have fallen behind increased demand. Livestock products and animal feeds are imported into many islands at great expense (Holst and Whitelaw, 1980) and increased local production could readily substitute imports.

The ruminant livestock industry in the Caribbean Basin is largely supported by grazing native pastures which are dominated by guineagrass (*Panicum maximum*) and leucaena (*Leucaena leucocephala*) in productive areas, but by less desirable species such as hurricane grass (*Bothriochloa pertusa*) and casha (*Acacia* spp.) in degraded sites. Alternate wet and dry seasons characterize the climate of most islands. This causes severe seasonal feed deficiencies both in quantity and quality, which results in reduced livestock performance. On the U.S. Virgin Islands, for example, the period of severe feed deficiency can extend from January to the end of April (120 d).

Forage conservation either as hay or silage provides an option for resolving the dry season feed constraint. Ensilage aims at preserving fresh succulent forage by partial fermentation and is less dependent on weather conditions than hay production. The preservation of high moisture forage by ensiling is based on reduced pH under anaerobic conditions. A high hydrogen ion concentration prevents the adverse effects of microbes and plant enzymes. Together with anaerobiosis, an adequate supply of fermentable substrates, such as soluble carbohydrates in forage or a sugar additive, is a major prerequisite for preservation. In the past, sorghum (*Sorghum* spp.) silage produced under conventional tillage was used to stockpile forage for dry season supplement for dairy cattle in St. Croix (Conje and Padda, 1976). However, the concept of incorporating native legumes in cropping systems to reduce fertilizer (Ismaili and Weaver, 1986; Atta-Krah and Kang, 1990) and pesticides (Caswell and Raheja, 1972; IRRI, 1974; Hayward, 1975) inputs and improve protein content of conserved forage (Jones, 1979) has not been fully explored. Also greater attention needs to be paid to the quality of the conserved forage.

In this investigation, three varieties of sorghum and a millet-elephant-grass hybrid were evaluated for dry matter yield, seasonal forage distribution, forage quality, head/stover ratio, disease resistance and silage pH, both from mono- and mixed-cropping cultures with Desmanthus and Leucaena. Details of silage characteristics and nutritive value (ensilage phase) will be presented in a separate paper. The feeding value of the silage to sheep (Utilization phase) is presented elsewhere in these proceedings (Wildeus et al., 1992).

MATERIALS AND METHODS

Experimental design for the field study was a split randomized complete block with three replicates. Main plots consisted of three cropping systems: 1) Desmanthus alleycrop, 2) Leucaena alleycrop, and 3) Grass monoculture. The subplots consisted of: 1) Dekalb forage sorghum hybrid 25A (FS25A), 2) Puerto Rico forage sorghum hybrid 5BR (PR5BR), 3) Haygrazer sudangrass; and 4) a millet-elephantgrass (M-E) interspecfic hybrid #1 (*Pennisetum americanum* (A line) x *P. purpureum*).

Double rows, 6.6 ft apart, of eigher Desmanthus of Leucaena were seeded at the rate of 5 lb/A, in the center of subplots measuring 16.5 x 20 ft, in early July 1990. Alleys between established legume hedgerows were interseeded with grass varieties (3 rows each, 20 in interrow spacing) at a rate of 10 lb/A in late August. The remaining area of each subplot was seeded to the same grass variety to provide borders (Fig. 1). Grass monoculture was seeded at the same seeding rate and 20 in row spacing to cover the entire subplot. All grass rows were thinned to approximately 4 in intrarow plant spacing when the grass reached 6 in high. Nitrogen from sulfate of ammonia, phosporus from triple superphosphate and potassium from sulfate of potash were applied at a rate of 54-36-54 (N-P_2O_5-K_2O) lb/A soon after thinning. Weeds between the rows were controlled with one application of gramoxone (paraquat) at the rate of 1 qt/A. No irrigation water, insecticides or fungicides were applied to any of the crops.

The main foliar diseases encountered in St. Croix were target spot (Bipolaris sorghicola) and sorghum rust (Puccinia purpurea). Whole plants were visualy rated on a scale of 0 to 5 for insect and disease damage on the leaves when sorghum was at the soft dough stage of maturity. Zero rating represented complete absence of leaf lesions; 0.5, very slight infection, one or two restricted lesions on lower leaves; 1, slight infection, a few scattered lesions on lower leaves; 2, light infection, moderate number of lesions on lower leaves; 3, moderate infection, abundant lesions on lower leaves and few on middle leaves; 4, heavy infection, lesions abundant on lower and middle leaves and extending to upper leaves; and 5, very heavy infection, lesions abundant on all leaves.

The initial crop was harvested in mid-November when sorghum was at the soft dough stage of maturity. To reduce border effects in yield assessment, an area 10 ft long and 6.6 ft wide from the center of each subplot was harvested. The havested width was made to intercept one legume and three grass rows for alleycrops and four grass rows for monocrops (Fig. 1). The other legume row was used to mulch the alley of mixed cultures. Total green weight was measured separately for grass and legume components. Subsamples of each conponent were dried, weighed, ground and analyzed for crude protein (CP) concentration (Gallaher et al., 1975; 1976) and in vitro organic matter digestibility (IVOMD) (Moore et al., 1972).

Approximately 15 lb of fresh subsamples from each harvest were hand-chopped (0.5- to 1-in pieces) and ensiled with or without the addition of 3% molasses in sealed 5-gal plastic buckets. Molasses were dissolved in an equal weight of water to facilitate thorough mixing with chopped plant material before ensiling. Chopped forage was hand-packed into the buckets, covered with a 6 mil plastic sheet and then sealed with a plastic bucket lid. Silage fro each bucket was thoroughly mixed after 90 days of storage and sampled for pH and quality analyses.

All plots were cut back to a 6-in stubble after the initial harvest and grasses were given a second application of 24 lb/A N. A second (ratoon) crop was harvested at the end of January 1991.

Data were subjected to analysis of variance and means were separated using Duncans New Multiple Range Test.

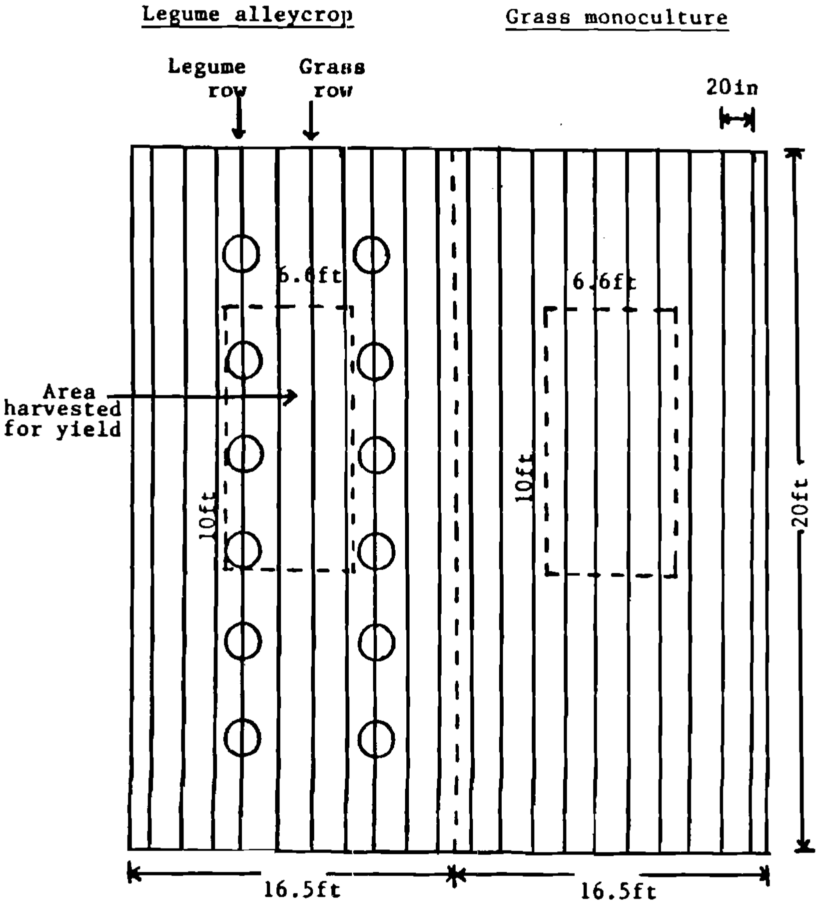

Figure 1. Plot arrangement of legume hedgerows and grass rows with an indication of area harvested for yield.

RESULTS AND DISCUSSION

Forage yield.

Dry forage yield of sorghum varieties from the initial harvest averaged 3.9 T/A compared to only 2.9 T/A for the M-E hybrid (Fig. 2(1). The M-E hybrid, the only perennial grass, was slow to establish, resulting in a lower ($P < 0.05$) initial yield. Yield of the second harvest was highest ($P < 0.05$) for the M-E hybrid (2.8 T/A) and lowest for FS25A. The FS25A exhibited the poorest ratooning ability; yield in the second harvest was only 30% of initial yield. By comparison, second harvest yield was 49, 57 and 97% of yield from initial harvest for Haygrazer, PR5BR and the M-E hybrid, respectively. Additionally, the grasses performed differently at each harvest under the various cropping systems. Yield of grasses such as PR5BR and Haygrazer was not affected by cropping system in the establishment year (Fig. 2(1)), because of compensatory growth in size of plants in the mixed cultures. However, the initial forage yield of FS25A and both the initial and ratoon yields of the M-E hybrid obtained from monoculture system decreased substantially ($P < 0.05$) when alleycropped with legumes (Fig. 2(1)). The FS25A sorghum, in addition to poor ratoon ability, also had low germination and poor stands, allowing greater competition from legumes, initially. Slow establishment of the perennial M-E hybrid allowed greater legume competition which reduced yield of that grass under the alleycropping system compared to its monoculture. However, as a perennial, this grass produced two additional harvests of 1.5 T/A each during the dry season. A fifth harvest was expected before the next regular growing season.

Yield from the legumes during the establishment year was generally low. It ranged from 0.1 to 0.8 T/A for the first two harvests depending on the associated grass variety (Fig. 2(2)). The initial legume yield was lower ($P < 0.05$) when grown with aggressive grasses such as PR5BR or Haygrazer as compared with FS25A or the M-E. Also, the initial forage production from Desmanthus was greater ($P < 0.05$) than from Leucaena, which is well known for low establishment (Proverbs, 1985; Paterson, 1990). There were no major differences observed in legume yield attributable to grass variety for the second harvest (Fig. 2(2)), since legume recovery rate following harvest was generally slower than the grasses. The overall average legume dry forage yield was 7 to 10% of the grass yield. It will be determined from silage analyses whether inclusion of legumes at such a low level is sufficient to improve silage quality.

Cumulative total (grass + legume) yield from the two harvests averaged across cropping systems was 5.6 T/A for Dekalb FS25A sorghum and Haygrazer sudangrass but 6.4 T/A ($P < 0.05$) for PR5BR forage sorghum (Fig. 3). About 7 T/A dry forage (2 harvests only) was obtained from the monoculture of the M-E hybrid as compared with 5.5 T/A ($P < 0.05$) from its alleycrops with legumes. Production by sorghum varieties in this study was comparable to their performance in Puerto Rico (Méndez-Cruz et al., 1990).

Forage Quality.

The CP conncetration (8.17%) and IVOMD (60%) of grasses were not affected ($P > 0.05$) by association with legumes during the first cropping

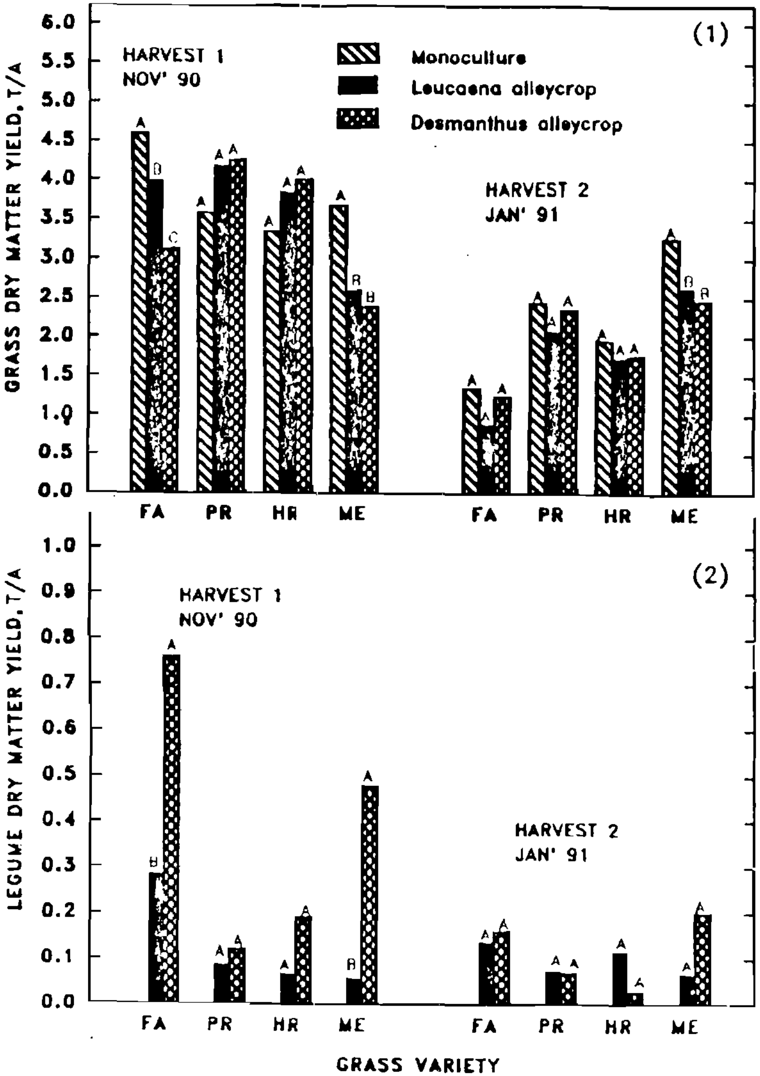

Figure 2. Dry matter yield of grass (1) and legume (2) components from various cropping systems in a November and January harvest in St. Croix. (FA=Dekalb FS25A; PR=Puerto Rico 5BR; HR= Haygrazer; and ME= Millet-elephantgrass hybrid). Bars within a grass variety with the same letter are not significantly different at P=0.05.

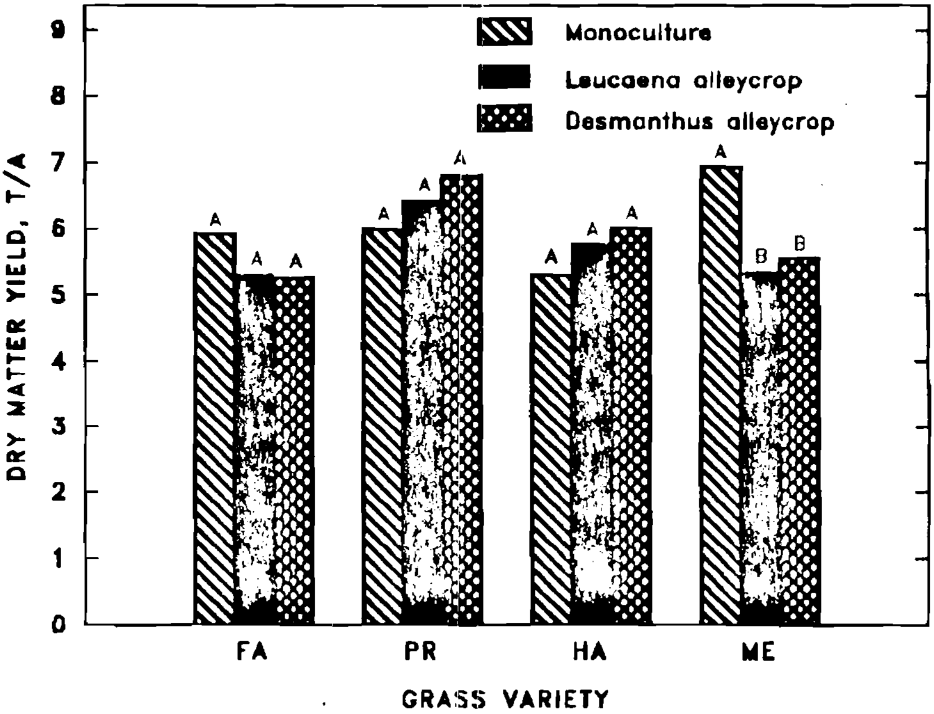

Figure 3. Cumulative total (grass + legume) dry matter yield from two harvests as influenced by cropping system and grass variety in St. Croix. Bars within a grass variety with the same letter are not significantly different at P=0.05.

year (Fig. 4). However, this trend is expected to change in subsequent years as mineralized nutrients from legume mulch become available to grass crops. Despste its shrubby morphology, the CP concentration (21.7%) and IVOMD (58%) of Leucaena was consistently superior ($P < 0.01$) to those (14.2% CP and 45% IVOMD) of Desmanthus, irrespective of associated grass (Fig. 5). This indicates the great potential of Leucaena for forage and alleycrop hedgerow within the Caribbean region. Our receet assessment suggests that the low IVOMD of Desmanthus is attributable to its high tannin content.[1]

The head/stover ratio (dry matter basis) approximates the proportion of fermentable carbohydrates in the total grass forage and is an important factor to consider when selecting varieties of sorghum or corn for silage. Head/stover ratio for sorghum varieties in the first harvest (Fig. 6) appeared to be inversely related to sorghum dry matter yield (Fig. 2(1)). The ratio was highest (40:60) for PR5BR indicating the suitability of that variety for silage. The very low head/stover ratio for the M-E hybrid (Fig. 6) suggests that additives such as molasses may be required for proper ensilage. Preliminary data from pH analyses of silage samples seem to support that contention. The final pH of silage decreased ($P < 0.01$) from 4.7 to 4.0 when molasses was added to the fresh material before ensiling.

Diseases.

Dekalb FS25A was the grass entry most susceptible to diseases. It suffered moderate to heavy infection of sorghum rust and target spot on lower and middle leaves during both the November and January harvests (Fig. 7). Infection of the initial crop of Haygrazer sudangrass was slight, but moderate lesions occurred on lower leaves of the ratoon crop. The PR5BR and the M-E hybrid were the most disease-resistant grasses. Incidence of sorghum diseases was completely independent of cropping system during the first cropping year.

CONCLUSIONS

The preliminary data on yield, quality, head/stover ratio and disease resistance seem to favor Puerto Rico 5BR forage sorghum as offering the greatest potential for alleycrop silage on St. Croix. The millet-elephantgrass hybrid combined the advantages of pereniality (multiple harvests) with excellent disease resistance. It may be more suitable for a forage bank than silage because of its low grain production. The ubiquitous Leucaena appeared to provide a good legume germplasm for alley-cropping. However, the final determination of which grass/legume combination to recommend for silage will have to await long term yield, quality and animal performance results.

---

[1] Albrect, K., Personal communication, 1991.

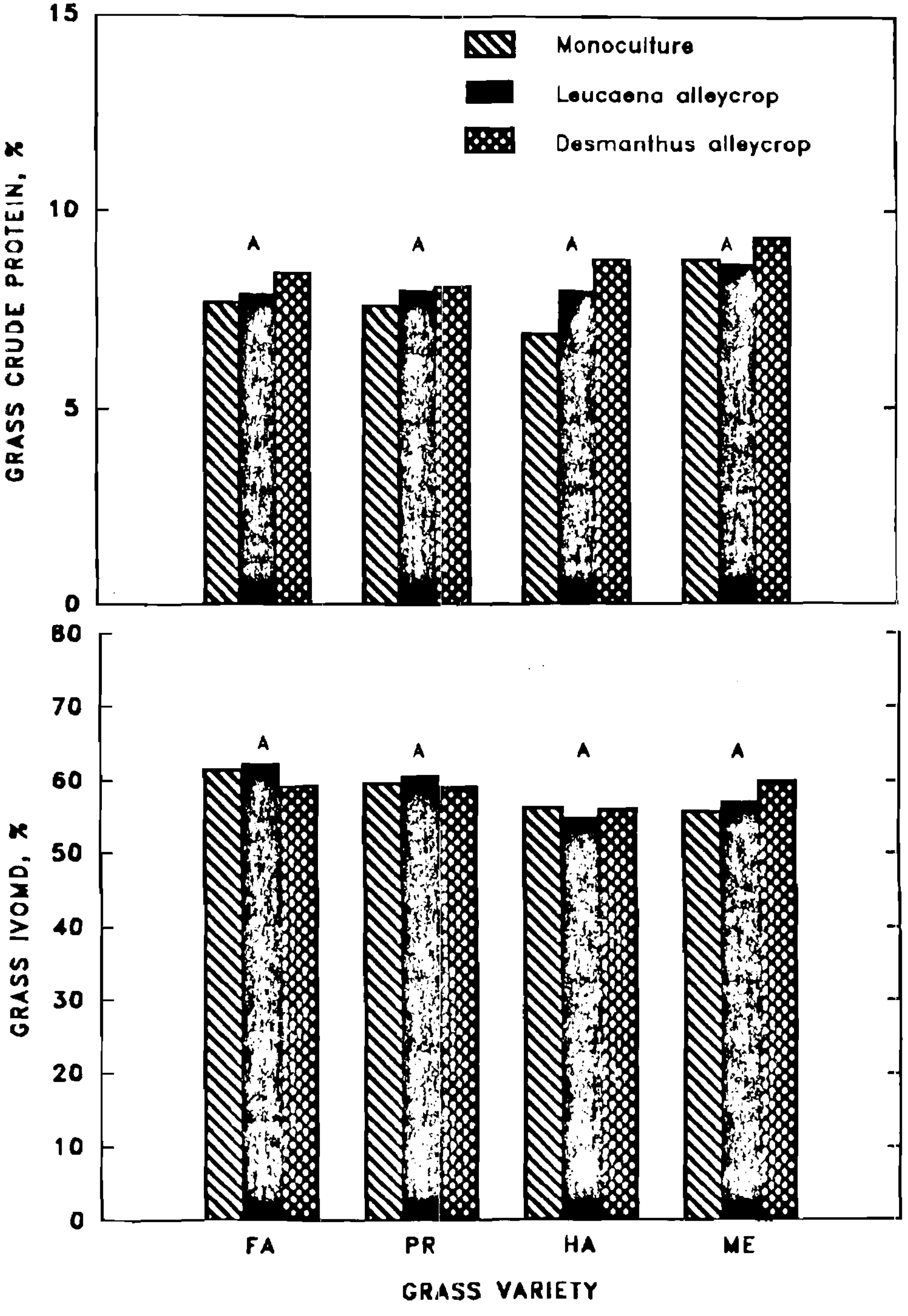

Figure 4. Crude protein content and in vitro organic matter digestibility of grasses from a November harvest as influenced by cropping system. Means of grasses with the same letter are not significantly different at P=0.05.

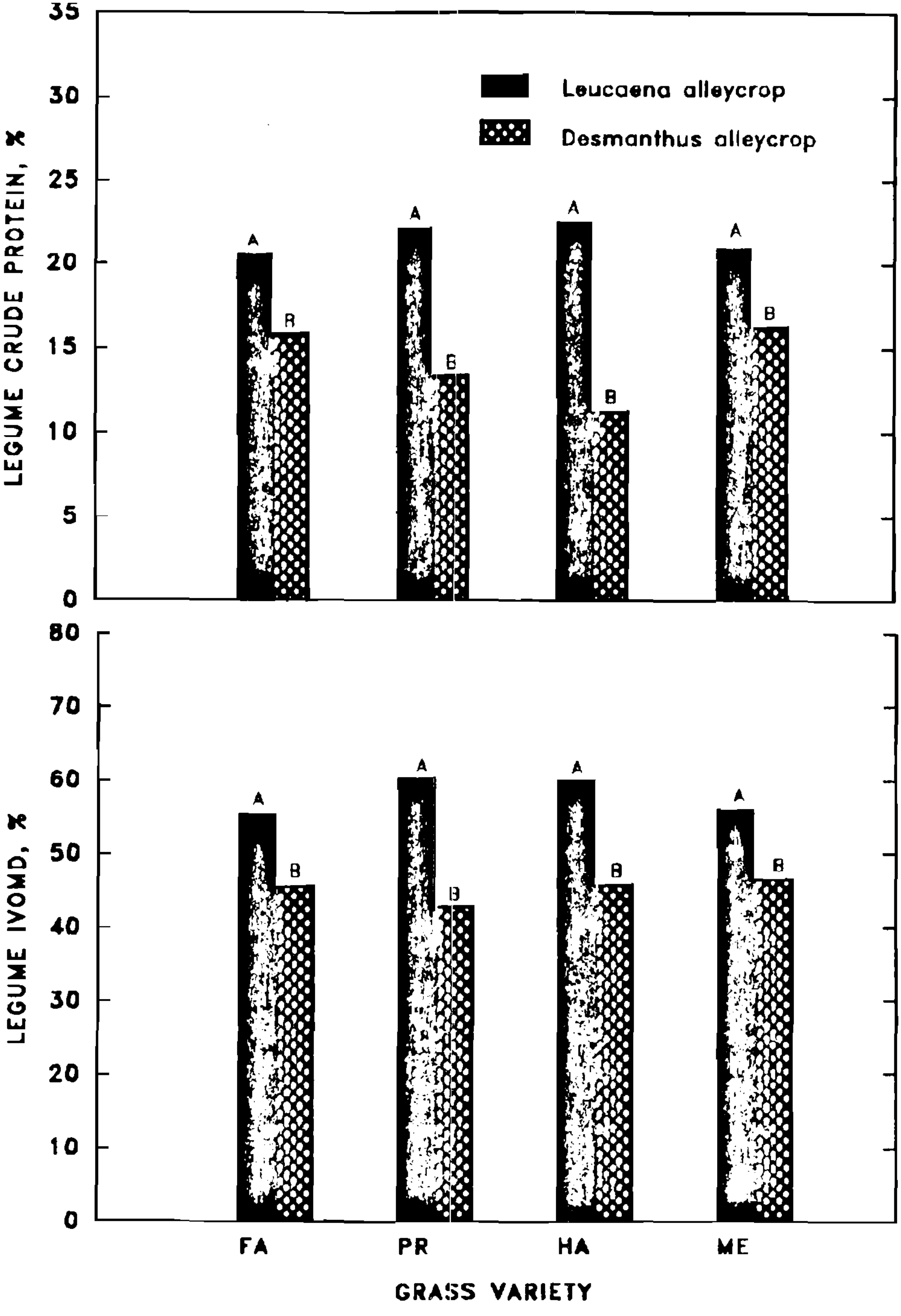

Figure 5. Crude protein content and in vitro organic matter digestibility of legumes from a November harvest as influenced by grass variety. Bars with the same letter are not significantly different at P=0.01.

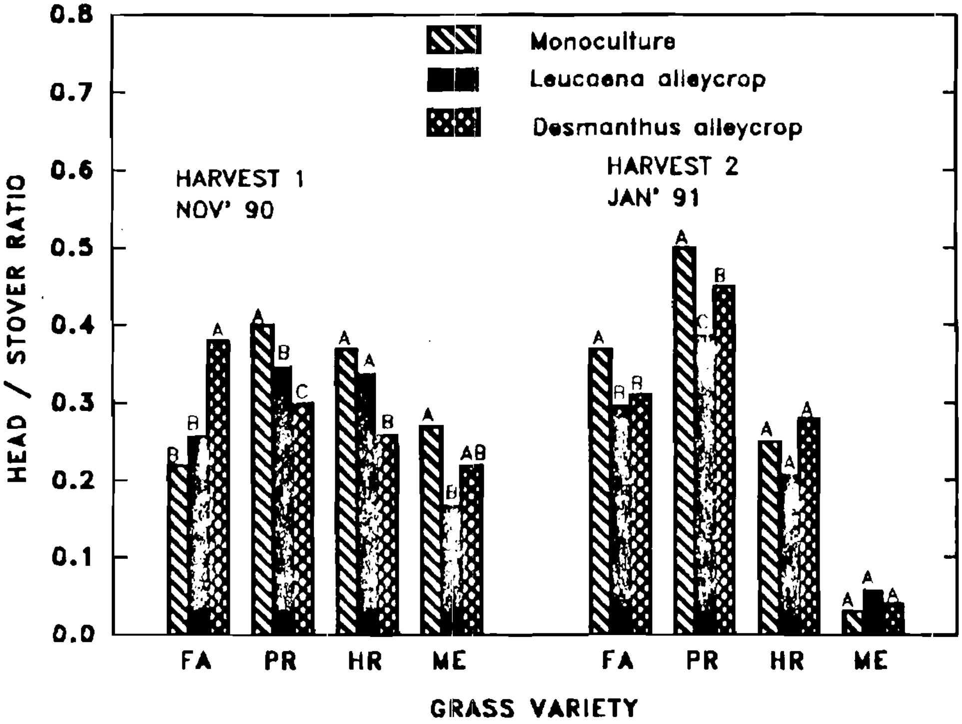

Figure 6. The ratio of reproductive to vegetative parts of grasses during a November and January harvest as influenced by cropping system in St. Croix. Bars within a grass variety with the same letter are not significantly different at P=0.05.

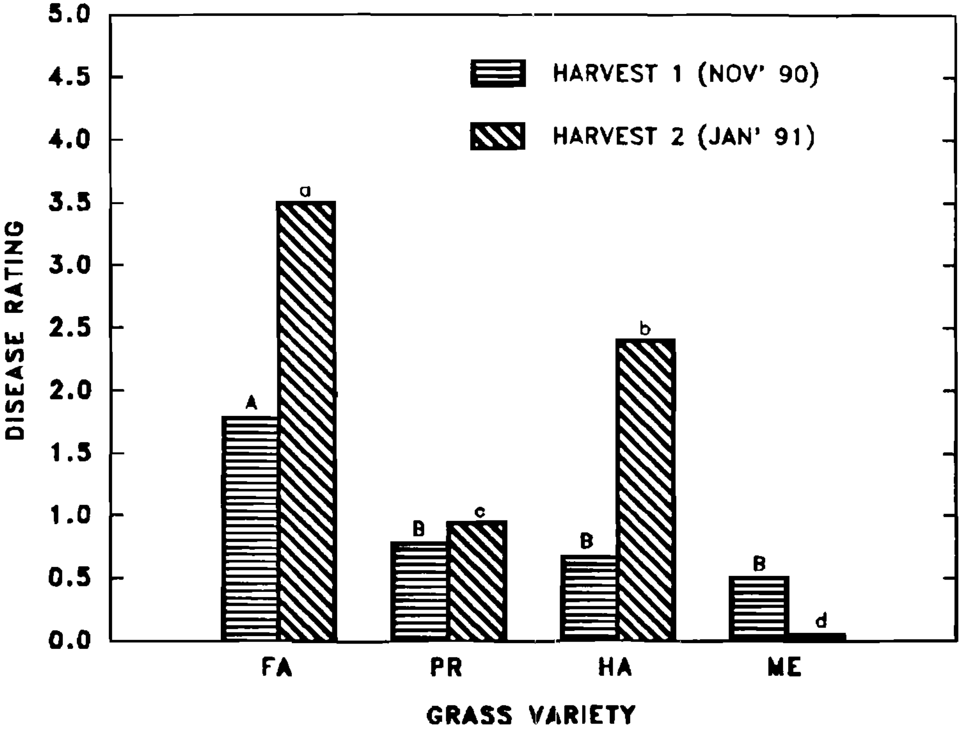

Figure 7. Incidence of sorghum rust and target spot on grasses at the soft dough stage in a November and January harvest (0, no infection, absence of lesions on all leaves; 0.5, very slight infecion, one or two restricted lesions on lower leaves; 3, moderate infection, abundant lesions on lower leaves and few on middle leaves; 4, heavy infection, lesions abundant on lower and middle leaves and extending to upper leaves). Bars within a harvest with the same letter are not significantly different at P= 0.05.

REFERENCES

Atta-Krah, A.N. and Kang, B.T. 1990. Alley farming as an agricultural production system for the humid tropics. Agron. Abstr. ASA. Madison, WI.

Caswell, G.H. and Raheja, A.K. 1972. Report to the Board of Governors. Inst. for Agric. Res., Samaru,Nigeria. 15p.

Conje, A.J. and Padda, D.S. 1976. Sorghum in the Virgin Islands. Univ. of the Virgin Islands Agric. Expt. Sta. Farmers Bull. #2. 16p.

F.A.O. 1984. F.A.O. Production Yearbook. Vol. 37. Food and Agriculture Organization. Rome.

Gallaher, R.N., Weldon, C.D., and Futral, J.E. 1975. An aluminum block digester for plant and soil analysis. Soil Sci. Soc. Am. Proc. 39: 803-806.

Gallaher, R.N., Weldon, C.D., and Boswell, F.C. 1976. A semi-automated procedure for total nitrogen in plant and soil samples. Soil Sci. Soc. Am. Proc. 40: 887-889.

Hayward, J.H. 1975. Cropping scheme meeting. Inst. for Agric. Res., Samaru, Nigeria. 12p.

Holst, P.J. and Whitelaw, R.A. 1980. Export of goat meat from Australia. Inst. Goat Sheep Res. 1:48.

International Rice Research Institute. 1974. Annual Report. IRRI, Los Banos, The Philippines. 13p.

Ismaili, M. and Weaver, R.W. 1986. Competition between Siratro and Kleingrass for ^{15}N labelled mineralized nitrogen. Plant Soil 96: 327-335.

Jones, R.J. 1979. Value of *Leucaena leucocephala* as a feed for ruminants in the tropics. World Animal Rev. 31: 13-23.

Méndez-Cruz, A.V., Hepperly, P., Orengo-Santiago, E., Torres-Cardona, S., and Corchado-Juarbe, N. 1990. Performance of two forage sorghum hybrids in southwest Puerto Rico. J. Agric. Univ. P.R. 74(1): 1-13.

Moore, J.E., Mott, G.O., Dunham, D.G., and Omer, R.W. 1972. Large capacity in vitro organic matter digestion procedure. J. Anim. Sci. 35: 232.

Paterson, R.T. 1990. Forage production and utilization of *Leucaena leucocephala* in the English-speaking Caribbean. CFCS Proc. 26: 700-714.

Proverbs, G. 1985. *Leucaena*: A versatile plant. CARDI, St. Michael, Barbados. 30p.